THE SEMICONDUCTOR DATA BOOK



MOTOROLA Semiconductor Products Inc.

FIFTH EDITION

THE SEMICONDUCTOR DATA BOOK AND HOW TO USE IT

One of the major problems facing workers in the electronics field is the identification and selection of semiconductor devices. Type numbers themselves are of little value since they indicate neither device parameters nor applications. Because it is difficult even to identify the many thousands of device type numbers, let alone evaluate their merits for a particular application, engineers often limit their designs to a few well-known device types – despite the fact that newer or more suitable devices may be available.

This book is designed to serve four specific functions:

1. To permit quick identification of any semiconductor device having an EIA registered 1N . . ., 2N . . ., and 3N . . ., number or special Motorola in-house number.
2. To permit quick selection of preferred devices for particular circuit applications.
3. To permit quick selection of preferred devices that best meet a desired set of electrical specifications.
4. To provide complete design data for all Motorola discrete semiconductor devices.

To accomplish these functions, the book is divided into four basic sections:

1. Device Indexes. These indexes list sequentially and in alpha-numeric sequence all EIA-registered 1N, 2N, and 3N device types and all non-registered Motorola devices. They are useful for device identification and quick determination of major specifications.

2. Selector Guides. Selector guides are presented to simplify the task of choosing the best semiconductor device for a specific application. The tables are arranged to highlight the major device specifications in easy-to-use order.

3. Complete Discrete Device Data Sheets. The data sheets are arranged in alpha-numerical sequence as follows:

1N . . . device specifications
2N and 3N . . . device specifications
Non-registered device specifications
Hardware – device mounting hardware and heat sinks

The complete discrete device data sheets are followed by condensed specifications for all Motorola integrated circuits. For detailed Integrated Circuit specifications, see the Motorola MICROELECTRONICS DATA BOOK.

4. Dimensioned Device Outlines. This section covers the case dimensions of the packages used in this book. A case number cross reference lists the JEDEC and Motorola case numbers.

The following examples demonstrate how this book can be used to solve semiconductor device selection problems.

Example 1. To identify an unfamiliar semiconductor device number . . .

Locate device type number in the proper alpha-numeric device index (either 1N, 2N and 3N, or non-registered Motorola types). The information provided in the index includes major applications as well as principal device specifications. A key to interpreting the data given in each column of the index appears at the beginning of each index.

Example 2. To determine the range of Motorola devices available in any specific semiconductor device category . . .

Turn to the Selector Guide section and locate the desired device category from the table of contents page preceding this section. The tables in the selector guides are arranged in such a way that the range of available specifications is easily determined.

Example 3. To determine which devices are best suited for a given application, or find devices that best meet a given set of specifications . . .

Proceed as in Example 2; then locate the data sheets for the preselected devices (in the alpha-numeric data sheet section) and make final comparison from the more complete specifications.

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INDEXES

1N . . . INDEX
Complete numerical index of all EIA-registered device types, with major electrical specifications

2N . . . & 3N . . . INDEX
Complete numerical index of all EIA-registered device types, with major electrical specifications

NON-REGISTERED DEVICE INDEX
Complete alpha-numeric index of all in-house non-registered device types, including device identification

SELECTOR GUIDES
(Also Glossary of Symbols and Terms)
Grouping of preferred semiconductors by major device categories (i.e. si-power transistors, zener diodes, thyristors, etc.) for quick preselection of devices best suited for specific applications. See selector-guide index on page 4-1.

DATA SHEETS

1N . . . DEVICE SPECIFICATIONS

2N . . . & 3N . . . DEVICE SPECIFICATIONS

IN-HOUSE NUMBERED DEVICE SPECIFICATIONS
Hardware-Device Mounting Hardware and Heat Sinks

MICROCIRCUIT COMPONENTS
Unencapsulated transistors, diodes, and passive devices for use in hybrid circuits. Includes processing, packaging, and inspection criteria.

DIGITAL
LINEAR } INTEGRATED CIRCUITS
Condensed catalog with major specifications of a wide range of integrated circuits, including complex functions and custom arrays. See index on page IC-2.

DIMENSIONED DEVICE OUTLINES

APPLICATION
Selection Guide
Abstracts

The Semiconductor Data Book

One of the major problems facing workers in the electronics field is the identification and selection of semiconductor devices. Type numbers themselves are of little value since they indicate neither device parameters nor applications. Because it is difficult even to identify the many thousands of device type numbers, let alone evaluate their merits for a particular application, engineers often limit their designs to a few well-known device types — despite the fact that newer or more suitable devices may be available.

This book identifies and characterizes all semiconductor devices with 1N---, 2N---, and 3N--- numbers registered with the Electronics Industries Association at the close of the production date for the book, as well as a broad line of devices with special in-house type numbers. (It provides complete data-sheet specifications for a wide range of semiconductors, and short-form specifications for integrated circuits.) And in addition, to simplify the selection of the most useful semiconductor type numbers, it contains carefully prepared selector guides with recommended devices for specific applications. Properly used, it can be a valuable aid for the design engineer, the component engineer and the purchasing agent in narrowing the broad categories of potentially useable components to those best suited for a specific project.

The information in this book has been carefully checked and is believed to be reliable; however, no responsibility is assumed for inaccuracies. Furthermore, this information does not convey to the purchaser of semiconductor devices any license under the patent rights of any manufacturer.

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The Semiconductor Data Book

DATA BOOK UPDATING SERVICE

Because of the large numbers of semiconductor devices introduced each year, provisions have been made to update the Semiconductor Data Book through the publication of Supplements. At least two Supplements will be published during the life of this Data Book edition.

The Data Book Supplements will contain complete data sheets for newly added Motorola devices, as well as short-form specifications of *all* devices registered with the EIA since the publication of the Data Book or previous Supplement.

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NUMERICAL INDEX

NUMERICAL INDEX

1N--- TYPE NUMBERS

The following table lists EIA-registered devices introduced since the publication of the Motorola Semiconductor Data Book (4th Edition). Major electrical specifications are provided for your convenience.

KEY

RECTIFIERS

V_R = DC Blocking Voltage
V_F = Average Forward Voltage Drop
I_O = Average Rectifier Forward Current
I_R = Average Reverse Current
I_{surge} = Peak Surge Current

ZENER DIODES

V_Z (min) = Minimum Zener Breakdown Voltage (Volts)
V_Z (max) = Maximum Zener Breakdown Voltage (used only when a corresponding V_Z (min) is specified. Otherwise, this column refers to V_Z (nom)* Nominal Zener Breakdown Voltage.)
Tol = Tolerance, for specified Nominal Breakdown Voltage
P_D = Maximum Power Dissipation. M = milliwatts. W = watts

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amp)	I_R (mA)	I_{surge} (Amp)	V_Z (min)	V_Z (nom)* V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
Numerical Listing of Registered Type Numbers													
	S = Silicon G = Germanium SE = Selenium												
		Type number of recommended replacement or of nearest electrical equivalent fully characterized in this book.											
			Reference device number indicates specific Data Sheet on which device is characterized.										

SHADING INDICATES SIGNAL DIODES

PRV = Peak Reverse Voltage
V_F @ I_F = Maximum Forward Voltage at Indicated Forward Current — M = milliamp, A = amp
I_R = Reverse Current — M = milliamp, * = microamp, N = nanoamp
t_{rr} = Reverse Recovery Time

SHADING INDICATES REFERENCE DIODES

TC = Temperature Coefficient
V_Z = Zener Breakdown Voltage
T (min), T (max) = Temperature Range over which indicated temperature coefficient is applicable.

The codes listed below define the listed device and indicates the appropriate specification column heading.

R* — Rectifiers
DR — Diode, Reference
DZ — Diode, Zener
DS — Diode, Signal

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N34	G			DS	60	1.0	8.5M	15*					
1N34A	G			DS	60	1.0	5.0M	30*					
1N35	G			DS	50			2.0M					
1N38	G			DS	100	1.0	7.5M	25*					
1N38A	G			DS	100	1.0	4.0M	6.0*					
1N38B	G			DS	100	1.0	4.0M	6.0*					
1N39	G			DS	200	1.0	5.0M	40*					
1N39A	G			DS	200	1.0	5.0M	40*					
1N39B	G			DS	200	1.0	4.0M	650*					
1N40	G			DS	25								
1N41	G			DS	25								
1N42	G			DS	50								
1N43	G			DS	60	1.0	5.0M	20*					
1N44	G			DS	115	1.0	3.0M	410*					
1N45	G			DS	75	1.0	3.0M	410*					
1N46	G			DS	50	1.0	3.0M	1.5M					
1N47	G			DS		1.0	5.0M	400*					
1N48	G			DS	85	1.0	4.0M	833*					
1N49	G			DS	50	1.0	4.0M						
1N50	G			DS	50	1.0	4.0M						
1N51	G			DS	50	1.0	2.5M						
1N52	G			DS	85	1.0	4.0M	150*					
1N52A	G			DS	50	1.0	5.0M	100*					
1N53	S	Microwave Ka-band Mixer: f = 34,860 MHz; NF = 13.1 to 9.0 dB											
1N53A	S	Microwave Ka-band Mixer: f = 34,860 MHz; NF = 13.1 to 9.0 dB											
1N53B	S	Microwave Ka-band Mixer: f = 34,860 MHz; NF = 13.1 to 9.0 dB											
1N53C	S	Microwave Ka-band Mixer: f = 34,860 MHz; NF = 13.1 to 9.0 dB											
1N53D	S	Microwave Ka-band Mixer: f = 34,860 MHz; NF = 13.1 to 9.0 dB											
1N54	G			DS	35	1.0	5.0M	10*					
1N54A	G			DS	50	1.0	5.0M	7.0*					
1N55	G			DS	150	1.0	3.0M	0.3M					
1N55A	G			DS	150	1.0	4.0M	500*					
1N55B	G			DS	190	1.0	5.0M	500*					
1N56	G			DS	30	1.0	15M	300*					
1N56A	G			DS	40	1.0	15M	300*					
1N57	G			DS	80	1.0	3.6M	300*					
1N58	G			DS	100	1.0	5.0M	800*					
1N58A	G			DS	100	1.0	4.0M	600*					
1N59	G			DS	250	1.0	3.0M	800*					
1N60	G			DS	50	1.0	5.0M	40*					
1N60A	G			DS	40								
1N61	G			DS	130	1.0	5.0M	300*					
1N62	G			DS	110	1.0	5.0M	700*					
1N63	G			DS	125	1.0	4.0M	50*					
1N63A	G			DS	100	1.0	4.0M	50*					
1N64	G			DS	20								
1N65	G			DS	85	1.0	2.5M	200*					
1N66	G			DS	60	1.0	5.0M	50*					
1N66A	G			DS	60	1.0	5.0M	50*					
1N67	G			DS	80	1.0	4.0M	5.0*					
1N67A	G			DS	100	1.0	4.0M	5.0*					
1N68	G			DS	100	1.0	3.0M	625*					
1N68A	G			DS	130	1.0	3.0M	625*					
1N69	G			DS	75	1.0	5.0M	50*					
1N69A	G			DS	60	1.0	5.0M	30*					
1N70	G			DS	125	1.0	3.0M	25*					
1N70A	G			DS	100	1.0	3.0M	25*					
1N71	G			DS	40	1.0	15M	0.3M					
1N73	G			DS		1.7	15M	0.05M					
1N74	G			DS		1.8	15M	0.05M					
1N75	G			DS	125	1.0	2.5M	50*					
1N76	S	Microwave X-band Detector f = 9,375 MHz, V_O = 5.0 mV to 16 mV											
1N76A	S	Microwave X-band Detector f = 9,375 MHz, V_O = 5.0 mV to 16 mV											
1N77A		Photosensitive Device; V_F = 10 V @ 10 mA, $I_{R(dark)}$ = 30 μA @ 50 V											
1N77B		Photosensitive Device; V_F = 10 V @ 10 mA, $I_{R(dark)}$ = 30 μA @ 50 V											
1N78	S	Microwave Ku-band Mixer: f = 16,000 MHz; NF = 12 to 7.5 dB											
1N78A	S	Microwave Ku-band Mixer: f = 16,000 MHz; NF = 12 to 7.5 dB											
1N78B	S	Microwave Ku-band Mixer: f = 16,000 MHz; NF = 12 to 7.5 dB											
1N78C	S	Microwave Ku-band Mixer: f = 16,000 MHz; NF = 12 to 7.5 dB											
1N78D	S	Microwave Ku-band Mixer: f = 16,000 MHz; NF = 12 to 7.5 dB											
1N78E	S	Microwave Ku-band Mixer: f = 16,000 MHz; NF = 12 to 7.5 dB											
1N78F	S	Microwave Ku-band Mixer: f = 16,000 MHz; NF = 12 to 7.5 dB											
1N79		Meter Rectifier - to 3,000 MHz											
1N81	G			DS	50	1.0	3.0M	10*					
1N81A	G			DS	40	1.0	3.0M	10*					
1N82	S	Microwave Mixer - to 1,000 MHz; NF = 16 to 14 dB											
1N82A	S	Microwave Mixer - to 1,000 MHz; NF = 16 to 14 dB											
1N82AG	S	Microwave Mixer - to 1,000 MHz; NF = 16 to 14 dB											
1N82G	S	Microwave Mixer - to 1,000 MHz; NF = 16 to 14 dB											
1N83	G			DS	225	1.0	3.0M	30*					
1N84	G			DS	12	1.0	60M	0.1M					
1N85		Photosensitive Device; $I_{R(dark)}$ = 20 μA @ 90 V, Sensitivity = 0.35 μA/mW @ 90 V											

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	ZENER DIODES V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	REFERENCE DIODES TC %/°C	V_Z	T (min) °C	T (max) °C
1N86	G			DS	70	1.0	4.0M	50*					
1N87	S			DS	23	0.25	0.1M	30*					
1N87A	S			DS	23	0.25	0.1M	10*					
1N88	G			DS	85	1.0	2.5M	0.1M					
1N89	G			DS	100	1.0	3.5M	8.0*					
1N90	G			DS	75	1.0	5.0M	800*					
1N91	G		1N91	R*	100	0.5	0.15	4.0	25				
1N92	G		1N91	R*	200	0.5	0.1	2.0	25				
1N93	G		1N91	R*	300	0.5	0.075	1.3	25				
1N94	G			R*	380	0.7	0.5	0.8	25				
1N95	G			DS	75	1.0	10M	800*					
1N96	G			DS	75	1.0	20M	800*					
1N96A	G			DS	60	1.0	40M	500*					
1N97	G			DS	100	1.0	10M	100*					
1N98	G			DS	100	1.0	20M	100*					
1N98A	G			DS	250	1.0	40M	100*					
1N99	G			DS	100	1.0	10M	50*					
1N100	G			DS	100	1.0	20M	50*					
1N100A	G			DS	80	1.0	40M	0.05M					
1N101	G			DS	150	1.0	10M	10*					
1N102	G			DS	75	1.0	15M	3.0*					
1N103	G			DS	12	1.0	30M	0.1M					
1N104	G			DS	12	1.0	30M	0.1M					
1N105	S	Microwave Switch: BV = 500 V, P_D = 8.0 W											
1N106	G			DS	300	1.0	20M	70*					
1N107	G			DS	10	1.0	150M	200*					
1N108	G			DS	50	1.0	50M	200*					
1N109	G			DS	15	1.0	1.0M	0.1M					
1N110	G	Microwave Mixer - to 1,000 MHz, NF = 10 dB											
1N111	G			DS	70	1.0	5.0M	25*					
1N112	G			DS	70	1.0	5.0M	50*					
1N113	G			DS	70	1.0	2.5M	25*					
1N114	G			DS	70	1.0	2.5M	50*					
1N115	G			DS	70	1.0	2.5M	100*					
1N116	G			DS	75	1.0	5.0M	100*					
1N117	G			DS	75	1.0	10M	100*					
1N118	G			DS	75	1.0	20M	100*					
1N118A	G			DS	60	1.0	40M	0.1M					
1N119	G			DS	60	1.0	5.0M		0.5				
1N120	G			DS	60	1.0	5.0M		0.5				
1N124	G	Microwave Mixer - to 1,000 MHz, NF = 10 to 8.0 dB											
1N124A	G	Microwave Mixer - to 1,000 MHz, NF = 10 to 8.0 dB											
1N126	G			DS	75	1.0	5.0M	50*					
1N126A	G			DS	75	1.0	25M	50*					
1N127	G			DS	125	1.0	3.0M	25*					
1N127A	G			DS	125	1.0	25M	25*					
1N128	G			DS	50	1.0	3.0M	10*					
1N128A	G			DS	40	1.0	3.0M	10*					
1N132	G			DS	25								
1N133	G			DS	5.0	0.5	3.0M	300*					
1N134		UHF Detector: f = 400 MHz											
1N137A	S			DS	36	1.0	3.0M	0.03*					
1N137B	S			DS	36	1.0	20M	0.03*					
1N138A	S			DS	18	1.0	5.0M	0.01*					
1N138B	S			DS	18	1.0	40M	0.01*					
1N139	G			DS	40	1.0	20M	1.5M					
1N140	G			DS	70	1.0	40M	300*					
1N141	G			DS	70	1.0	20M	50*					
1N142	G			DS	100	1.0	5.0M	100*					
1N143	G			DS	100	1.0	40M	100*					
1N144	G			DS	30	1.0	100M	200*					
1N145	G			DS	30	1.0	40M	100*					
1N147	G	UHF Mixer: f = 900 MHz; NF = 10 to 9.0 dB											
1N147A	G	UHF Mixer: f = 900 MHz; NF = 10 to 9.0 dB											
1N149	S	Microwave X-band Mixer: f = 9,375 MHz; NF = 8.3 dB											
1N150	S	Microwave C-band Mixer: f = 6,750 MHz; NF = 9.8 dB											
1N151	G			R*	100	0.7	0.5	2.4	25				
1N152	G			R*	200	0.7	0.5	1.9	25				
1N153	G			R*	300	0.7	0.5	1.2	25				
1N155	S	Microwave Detector: f = 9,000 MHz											
1N155A	S	Microwave Detector: f = 9,000 MHz											
1N156	S	Microwave X-band Mixer: f = 9,375 MHz											
1N158	G			R*	380	1.4	0.5	0.8	25				
1N160	S	Microwave C-band Mixer: f = 6,750 MHz; NF = 11.4 dB											
1N173A	S	UHF Mixer - to 1,000 MHz; NF = 13 dB											
1N188		Photosensitive Device; $I_{R(dark)}$ = 20 μA @ 40 V, Sensitivity = 10 μA/mW											
1N189		Photosensitive Device; R_D = 4,000 ohm, Sensitivity = 0.083%/fc											
1N190	G			DS	3.0	0.75	10M	0.8M					
1N191	G			DS	90	1.0	5.0M		0.5				
1N192	G			DS	70	1.0	5.0M		0.5				
1N193	S			DS	40	2.0	1.0M	40*	0.5				
1N194	S			DS	40	2.0	1.5M	10*	0.2				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N194A	S			DS	40	1.0	1.0M	10*	0.2				
1N195	S			DS	40	2.0	2.0M	10*	0.3				
1N196	S			DS	40	2.0	1.0M	10*	0.1				
1N198	G			DS	80	1.0	4.0M	10*					
1N198A	G			DS	80	1.0	4.0M	10*					
1N198B	G			DS	80	1.0	4.0M	10*	0.3				
1N200	S			DZ						7.5			150M
1N201	S			DZ						9.0			150M
1N202	S			DZ						11			150M
1N203	S			DZ						13.5			150M
1N204	S			DZ						17			150M
1N205	S			DZ						20			150M
1N206	S			DZ						25			150M
1N207	S			DZ						30			150M
1N208	S			DZ						37			150M
1N209	S			DZ						43			150M
1N210	S			DZ						52			150M
1N211	S			DZ						62			150M
1N212	S			DZ						75			150M
1N213	S			DZ						90			150M
1N214	S			DZ						110			150M
1N215	S			DZ						135			150M
1N216	S			DZ						170			150M
1N217	S			DZ						200			150M
1N218	S			DZ						250			150M
1N219	S			DZ						300			150M
1N220	S			DZ						370			150M
1N221	S			DZ						430			150M
1N222	S			DZ						520			150M
1N225	S	.5M8.7ZZS10		DZ						7.5	10		150M
1N225A	S	.5M9.1ZZS5		DZ							9.1*	5.0	150M
1N226	S	.5M10.5ZZS10		DZ						9.0	12		150M
1N226A	S	.5M10ZZS5		DZ							10*	5.0	150M
1N227	S	.5M12.7ZZS10		DZ						11	14.5		150M
1N227A	S	.5M12ZZS5		DZ							12*	5.0	150M
1N228	S	.5M15.7ZZS10		DZ						13.5	18		150M
1N228A	S	.5M15ZZS5		DZ							15*	5.0	150M
1N229	S	.5M19ZZS10		DZ						17	21		150M
1N229A	S	.5M18ZZS5		DZ							18*	5.0	150M
1N230	S	.5M23.5ZZS5		DZ						20	27		150M
1N231	S	.5M28.5ZZS10		DZ						25	32		150M
1N232	S	.5M34.5ZZS10		DZ						0.30	39		150M
1N233	S	.5M41ZZS10		DZ						37	45		150M
1N234	S	.5M48.5ZZS10		DZ						43	54		150M
1N235	S	.5M58ZZS10		DZ						52	64		150M
1N236	S	.5M71ZZS10		DZ						62	80		150M
1N237	S	.5M87.5ZZS10		DZ						75	100		150M
1N238	S	.5M105ZZS10		DZ						90	120		150M
1N239	S	.5M127.5ZZS5		DZ						110	145		150M
1N248	S	1N248A		R*	50	1.5	10	5.0	200				
1N248A	S	1N248B	1N248B	R*	50	1.5	20	5.0	250				
1N248B	S		1N248B	R*	50	1.5	20	5.0	250				
1N248C	S		1N248B	R*	39	1.2	20	3.8	350				
1N249	S	1N249A		R*	100	1.5	10	5.0	200				
1N249A	S	1N249B	1N248B	R*	100	1.5	20	5.0	250				
1N249B	S		1N248B	R*	100	1.5	20	5.0	250				
1N249C	S		1N248B	R*	77	1.2	20	3.6	350				
1N250	S	1N250A		R*	200	1.5	10	5.0	200				
1N250A	S	1N250B	1N248B	R*	200	1.5	20	5.0	250				
1N250B	S		1N248B	R*	200	1.5	20	5.0	250				
1N250C	S		1N248B	R*	154	1.2	20	3.4	350				
1N251	S			DS	30	1.0	5.0M	0.1*	0.15				
1N252	S			DS	20	1.0	10M	0.1*	0.15				
1N253	S	MR1121	MR1120	R*	95	1.5	1.0	0.1	4.0				
1N254	S	MR1122	MR1120	R*	190	1.5	0.4		1.5				
1N255	S	MR1124	MR1120	R*	380	1.5	0.4		1.5				
1N256	S	MR1126	MR1120	R*	570	1.5	0.2		1.0				
1N259	S	Microwave Mixer pair - to 9,000 MHz											
1N263	G	Microwave X-band Mixer: f = 9,375 MHz; NF = 7.5 dB											
1N264	S	Microwave Mixer pair: f = 3,000 MHz											
1N265	G			DS	90	1.0	3.2M	100*					
1N266	G			DS	60	1.0	4.0M	75*					
1N267	G			DS	25	1.0	3.5M	12*					
1N268	G			DS	30	1.0	2.5M	20*					
1N269	G	Microwave S-band Mixer: NF = 7.5 dB											
1N270	G			DS	80	1.0	200M	100*					
1N273	G			DS	30	1.0	100M	20*					
1N276	G			DS	50	1.0	40M	100*	0.3				
1N277	G			DS	100	1.0	100M	75*					
1N278	G			DS	50	1.0	20M	125*					
1N279	G			DS	30	1.0	100M	200*					
1N281	G			DS	60	1.0	100M	30*					

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N282	G			DS		1.0	40M	20M					
1N283	G			DS	20	1.0	200M	20*					
1N285		UHF Mixer; NF = 12.5 dB											
1N286	S	Microwave X-K band Mixer; NF = 11.3 dB											
1N286A	S	Microwave X-K band Mixer; NF = 11.3 dB											
1N287	G			DS	60	1.0	20M	1.5M					
1N288	G			DS	85	1.0	40M	350*					
1N289	G			DS	85	1.0	20M	50*					
1N290	G			DS	120	1.0	5.0M	100*					
1N291	G			DS	120	1.0	40M	100*					
1N292	G			DS	75	1.0	100M	200*					
1N294	G			DS	60	1.0	5.0M	10*					
1N294A	G			DS	60	1.0	5.0M	10*					
1N295	G			DS	40			200*					
1N295A	G			DS	40			200*					
1N296	G			DS	40			200M					
1N297	G			DS	80	1.0	3.5M	10*					
1N297A	G			DS	80	1.0	3.5M	10*					
1N298	G			DS	70	2.0	30M						
1N298A	G			DS	30	2.0	30M	250*					
1N299	G			DS		0.5	3.0M	200M					
1N300	S			DS	15	1.0	15M	0.001*					
1N300A	S			DS	15	1.0	30M	0.001*					
1N300B	S			DS	15	1.0	50M	0.001*					
1N301	S			DS	70	1.0	5.0M	0.05*					
1N301A	S			DS	70	1.0	18M	0.05*					
1N301B	S			DS	70	1.0	50M	0.01*					
1N302	S			DS	225	1.0	1.0M	0.2*					
1N302A	S			DS	225	1.0	5.0M	0.2*					
1N303	S			DS	125	1.0	3.0M	0.1*					
1N303A	S			DS	125	1.0	12M	0.1*					
1N303B	S			DS	125	1.0	50M	0.1*					
1N304	S			DS	55	1.5	2.0M	2.0*					
1N305	G			DS	60	0.8	100M	20*					
1N306	G			DS	15	0.8	100M	2.0*					
1N307	G			DS	125	1.0	100M	5.0*					
1N308	G			DS	8.0	1.0	300M	500*					
1N309	G			DS	40	1.0	100M	100*					
1N310	G			DS	125	1.0	40M	20*					
1N311	S	Microwave Mixer - to 12.000 MHz; NF = 10.5 dB											
1N312	G			DS	60	1.0	70M	50*					
1N313	G			DS	125	1.0	40M	10*					
1N314	G			DS				0.05M					
1N315	G			R*	300	0.48	0.075	0.3	25				
1N315A	G			R*	200	0.48	0.1	0.16	25				
1N316	S	1N4001	1N4001	R*	50	2.0	0.2		2.0				
1N317	S	1N4002	1N4001	R*	100	2.0	0.2		2.0				
1N318	S	1N4003	1N4001	R*	200	2.0	0.2		2.0				
1N319	S	1N4004	1N4001	R*	350	2.0	0.2		2.0				
1N320	S	1N4005	1N4001	R*	500	2.0	0.2		2.0				
1N321	S	1N4007	1N4001	R*	850	1.2	0.25	1.0	10				
1N322	S			R*	850	1.2	0.25	1.0	10				
1N323	S			R*	50	2.0	0.4		2.0				
1N324	S			R*	100	2.0	0.4		2.0				
1N325	S			R*	200	2.0	0.4		2.0				
1N326	S			R*	350	2.0	0.4		2.0				
1N327	S			R*	500	2.0	0.4		2.0				
1N328	S			R*	850	1.2	0.4	0.06	10				
1N329	S			R*	1000	1.2	0.4	0.06	10				
1N330	S			DS	32	1.0	3.0M	0.03*					
1N331	S			DS	16	1.0	5.0M	0.01*					
1N332	S	MR1124	MR1120	R*	400	2.0	0.4	0.2	10				
1N333	S	MR1124	MR1120	R*	400	2.0	0.2	0.2	5.0				
1N334	S	MR1123	MR1120	R*	300	2.0	0.4	0.2	10				
1N335	S	MR1123	MR1120	R*	300	2.0	0.2	0.2	5.0				
1N336	S	MR1122	MR1120	R*	200	2.0	0.4	0.1	10				
1N337	S	MR1122	MR1120	R*	200	2.0	0.2	0.1	5.0				
1N338	S	MR1121	MR1120	R*	100	2.0	1.0	0.2	20				
1N339	S	MR1121	MR1120	R*	100	2.0	0.4	0.1	10				
1N340	S	MR1121	MR1120	R*	100	2.0	0.2	0.1	5.0				
1N341	S	MR1124	MR1120	R*	400	2.0	0.4	0.5	10				
1N342	S	MR1124	MR1120	R*	400	2.0	0.2	0.5	5.0				
1N343	S	MR1123	MR1120	R*	300	2.0	0.4	0.5	10				
1N344	S	MR1123	MR1120	R*	300	2.0	0.2	0.5	5.0				
1N345	S	MR1122	MR1120	R*	200	2.0	0.4	0.5	10				
1N346	S	MR1122	MR1120	R*	200	2.0	0.2	0.5	5.0				
1N347	S	MR1121	MR1120	R*	100	2.0	1.0	0.5	20				
1N348	S	MR1121	MR1120	R*	100	2.0	0.4	0.5	10				
1N349	S	MR1121	MR1120	R*	100	2.0	0.2	0.5	5.0				
1N350	S			DS	70	1.0	20M	0.03*					
1N351	S			DS	120	1.0	20M	0.03*					
1N352	S			DS	170	1.0	20M	0.05*					

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N353	S			DS	225	1.0	20M	0.1*					
1N354	S			DS	325	1.0	20M	0.1*					
1N355	G			DS	100	1.0	4.0M	50*					
1N358	S	Microwave L-X-band Detector											
1N358A	S	Microwave L-X-band Detector											
1N359	S	1N4001	1N4001	R*	50	2.0	0.1		2.0				
1N360	S	1N4002	1N4001	R*	100	2.0	0.1		2.0				
1N361	S	1N4003	1N4001	R*	200	2.0	0.1		2.0				
1N362	S	1N4004	1N4001	R*	350	2.0	0.1		2.0				
1N363	S	1N4005	1N4001	R*	500	2.0	0.1		2.0				
1N364	S	1N4007	1N4001	R*	850	1.2	0.1	0.06	10				
1N365	S	1N4007	1N4001	R*	1000	1.2	0.1	0.06	10				
1N367	G			DS	15								
1N368	G			R*	200	0.5	0.1	0.3	25				
1N368A	G			R*	200	0.5	0.1	0.16	25				
1N369	S	Microwave S-X-band Detector											
1N369A	S	Microwave L-X-band Detector											
1N370	S	1N5221B	1N5221	DZ						1.5	2.2		200M
1N371	S	1N5221A	1N5221	DZ						2.0	2.7		200M
1N372	S	1N5225A	1N5221	DZ						2.5	3.3		200M
1N373	S	1N5227A	1N5221	DZ						3.1	3.9		200M
1N374	S	1N5229A	1N5221	DZ						3.7	4.5		200M
1N375	S	1N5230A	1N5221	DZ						4.3	5.4		200M
1N376	S	1N5233A	1N5221	DZ						5.2	6.4		200M
1N377	S	1N5236A	1N5221	DZ						6.2	8.0		200M
1N378	S	1N5238A	1N5221	DZ						7.5	10		200M
1N379	S	1N5240A	1N5221	DZ						9.0	12		200M
1N380	S	1N5243A	1N5221	DZ						11	14.5		200M
1N381	S	1N5246A	1N5221	DZ						13.5	18		200M
1N382	S	1N5249A	1N5221	DZ						17	21		200M
1N383	S	1N5252A	1N5221	DZ						20	27		200M
1N384	S	1N5255A	1N5221	DZ						25	32		200M
1N385	S	1N5258A	1N5221	DZ						30	39		200M
1N386	S	1N5260A	1N5221	DZ						37	45		200M
1N387	S	1N5261A	1N5221	DZ						43	54		200M
1N388	S	1N5264A	1N5221	DZ						52	64		200M
1N389	S	1N5266A	1N5221	DZ						62	80		200M
1N390	S	1N5269A	1N5221	DZ						75	100		200M
1N391	S	1N5271A	1N5221	DZ						90	120		200M
1N392	S	1N5274A	1N5221	DZ						110	145		200M
1N393	S	1N5277A	1N5221	DZ						135	180		200M
1N394	S	1N5280A	1N5221	DZ						170	210		200M
1N395	S	.5M115ZSB10		DZ						200	270		200M
1N396	S	.5M140ZSB10		DZ						250	320		200M
1N397	S	.5M170ZSB10		DZ						300	390		200M
1N398	S	.5M205ZSB10		DZ						370	450		200M
1N399	S	.5M160ZSC10		DZ						430	540		200M
1N400	S	.5M195ZSC10		DZ						520	640		200M
1N401	S			DS	1.5								
1N402	S			DS	2.0								
1N403	S			DS	2.5								
1N404	S			DS	3.1								
1N405	S			DS	3.7	1.0	225M*						
1N406	S			DS	4.3	1.0	200M						
1N407	S			DS	5.2	1.0	170M						
1N408	S			DS	6.2	1.0	130M						
1N411B	S	MR1810 SB		R*	50	1.5	50	25	525				
1N412B	S	MR1811 SB		R*	100	1.5	50	25	525				
1N413B	S	MR1813 SB		R*	200	1.5	50	25	525				
1N415B	S	Microwave X-band Mixer; NF = 11.4 to 6.5 dB											
1N415C	S	Microwave X-band Mixer; NF = 11.4 to 6.5 dB											
1N415D	S	Microwave X-band Mixer; NF = 11.4 to 6.5 dB											
1N415E	S	Microwave X-band Mixer; NF = 11.4 to 6.5 dB											
1N415F	S	Microwave X-band Mixer; NF = 11.4 to 6.5 dB											
1N415G	S	Microwave X-band Mixer; NF = 11.4 to 6.5 dB											
1N416B	S	Microwave S-band Mixer; NF = 10.3 to 5.5 dB											
1N416C	S	Microwave S-band Mixer; NF = 10.3 to 5.5 dB											
1N416D	S	Microwave S-band Mixer; NF = 10.3 to 5.5 dB											
1N416E	S	Microwave S-band Mixer; NF = 10.3 to 5.5 dB											
1N416F	S	Microwave S-band Mixer; NF = 10.3 to 5.5 dB											
1N416G	S	Microwave S-band Mixer; NF = 10.3 to 5.5 dB											
1N417	G			DS	60				0.3				
1N418	G			DS	60	1.0	7.0M		0.3				
1N419	G			DS	80	1.0	125M		0.3				
1N429	S		1N429	DR							6.2		
1N430	S	1N3156	1N3154	DR						0.002	8.4	-55	100
1N430A	S	1N3157	1N3154	DR						0.001	8.4	-55	100
1N430B	S	1N3157A	1N3154	DR						0.001	8.4	-55	150
1N431	S			DS	68	0.55	15M						
1N432	S			DS	40	1.0	10M	5.0N					
1N432A	S			DS	40	1.0	20M	5.0N					
1N433	S			DS	145	1.0	3.0M	0.1*					

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N433A	S			DS	145	1.0	10M	0.1*					
1N434	S			DS	180	1.0	2.0M	0.1*					
1N434A	S			DS	180	1.0	7.0M	0.1*					
1N435	G			DS	40			0.3M					
1N440	S	1N4002	1N4001	R*	100	1.5	0.3	0.3					
1N440B	S	1N4002	1N4001	R*	100	1.5		0.3	15				
1N441	S	1N4003	1N4001	R*	200	1.5	0.3	0.75					
1N441B	S	1N4003	1N4001	R*	200	1.5			15				
1N442	S	1N4004	1N4001	R*	300	1.5	0.3	1.0					
1N442B	S	1N4004	1N4001	R*	300	1.5		0.001	15				
1N443	S	1N4004	1N4001	R*	400	1.5	0.3	1.5					
1N443B	S	1N4004	1N4001	R*	400	1.5			15				
1N444	S	1N4005	1N4001	R*	500	1.5	0.3	1.75					
1N444B	S	1N4005	1N4001	R*	500	1.5			15				
1N445	S	1N4005	1N4001	R*	600	1.5	0.3	2.0					
1N445B	S	1N4005	1N4001	R*	600	1.5		0.002	15				
1N446	S	Microwave K-Ka-band Detector											
1N447	G			DS	30	1.0	25M	20*					
1N448	G			DS	100	1.0	25M	30*					
1N449	G			DS	30	1.0	50M	10*					
1N450	G			DS	100	1.0	50M	30*					
1N451	G			DS	150	1.0	50M	150*					
1N452	G			DS	30	1.0	100M	30*					
1N453	G			DS	100	1.0	100M	30*					
1N454	G			DS	50	1.0	200M	50*					
1N455	G			DS	30	1.0	300M	30*					
1N456	S			DS	25	1.0	40M	25N					
1N456A	S			DS	25	1.0	100M	25N					
1N457	S			DS	60	1.0	20M	25N					
1N457A	S			DS	60	1.0	100M	25N					
1N458	S			DS	125	1.0	2.0M	25N					
1N458A	S			DS	125	1.0	100M	25N					
1N459	S			DS	175	1.0	3.0M	25N					
1N459A	S			DS	175	1.0	100M	25N					
1N460	S			DS	90	1.0	5.0M	0.1*					
1N460A	S			DS	90	1.0	15M	0.1*					
1N461	S			DS	25	1.0	15M	0.5*					
1N461A	S			DS	25	1.0	100M	0.5*					
1N462	S			DS	60	1.0	5.0M	0.5*					
1N462A	S			DS	60	1.0	100M	0.5*					
1N463	S			DS	175	1.0	1.0M	0.5*					
1N463A	S			DS	175	1.0	100M	0.5*					
1N464	S			DS	125	1.0	3.0M	0.5*					
1N464A	S			DS	125	1.0	100M	0.5*					
1N465	S	1N5223A	1N5221	DZ						2.0	3.2		200M
1N465A	S	1N5223B	1N5221	DZ							2.7*	5.0	200M
1N465B	S	.5M2.7ZS1		DZ							2.7*	1.0	200M
1N466	S	1N5226A	1N5221	DZ						3.0	3.9		200M
1N466A	S	1N5226B	1N5221	DZ							3.3*	5.0	200M
1N466B	S	.5M3.3ZS1		DZ							3.3*	1.0	200M
1N467	S	1N5228B	1N5221	DZ						3.7	4.5		200M
1N467A	S	1N5228B	1N5221	DZ							3.9*	5.0	200M
1N467B	S	.5M3.9ZS1		DZ							3.9*	1.0	200M
1N468	S	1N5230A	1N5221	DZ						4.3	5.4		200M
1N468A	S	1N5230B	1N5221	DZ							4.7*	5.0	200M
1N468B	S	.5M4.7ZS1		DZ							4.7*	1.0	200M
1N469	S	1N5232B	1N5221	DZ						5.2	6.4		200M
1N469A	S	1N5232B	1N5221	DZ							5.6*	5.0	200M
1N469B	S	.5M5.6ZS1		DZ							5.6*	1.0	200M
1N470	S	1N5235B	1N5221	DZ						6.2	8.0		200M
1N470A	S	1N5235B	1N5221	DZ							6.8*	5.0	200M
1N470B	S	.5M6.8ZS1		DZ							6.8*	1.0	200M
1N471	S	.5M3.4ZZS10		DZ						3.0	3.9		200M
1N471A	S	.5M3.3ZZS5		DZ							3.3*	5.0	200M
1N472	S	.5M4.1ZZS10		DZ						3.7	4.5		200M
1N472A	S	.5M3.9ZZS5		DZ							3.9*	5.0	200M
1N473	S	.5M4.8ZZS10		DZ						4.3	5.4		200M
1N473A	S	.5M4.7ZZS5		DZ							4.7*	5.0	200M
1N474	S	.5M5.8ZZS10		DZ						5.2	6.4		200M
1N474A	S	.5M5.6ZZS5		DZ							5.6*	5.0	200M
1N475	S	.5M7.1ZZS10		DZ						6.2	8.0		150M
1N475A	S	.5M6.8ZZS5		DZ							6.8*	5.0	200M
1N476	G			DS	90	1.0	2.5M	11*					
1N477	G			DS	90	1.0	2.5M	11*					
1N478	G			DS	90	1.0	5.0M	7.0*					
1N479	G			DS	90	1.0	5.0M	7.0*					
1N480	G			DS	60	1.0	5.0M		0.5				
1N481	G			R*	200	0.5	0.1	1.9	25				
1N482	S			DS	36	1.1	100M	0.25*					
1N482A	S			DS	36	1.0	100M	25N					
1N482B	S			DS	36	1.0	100M	25N					
1N483	S			DS	70	1.0	100M	25N					

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N483A	S			DS	70	1.0	100M	25N					
1N483B	S			DS	70	1.0	100M	25N					
1N484	S			DS	130	1.1	100M	0.25*					
1N484A	S			DS	130	1.0	100M	25N					
1N484B	S			DS	130	1.0	100M	25N					
1N485	S			DS	180	1.1	100M	0.25*					
1N485A	S			DS	180	1.0	100M	25N					
1N485B	S			DS	180	1.0	100M	25N					
1N486	S			DS	225	1.1	100M	0.25*					
1N486A	S			DS	225	1.0	100M	0.05*					
1N486B	S			DS	225	1.0	100M	0.05*					
1N487	S			DS	300	1.1	100M	0.25*					
1N487A	S			DS	300	1.0	100M	0.1*					
1N487B	S			DS	300	1.0	100M	0.1*					
1N488	S			DS	380	1.1	100M	0.25*					
1N488A	S			DS	380	1.0	100M	0.1*					
1N488B	S			DS	380	1.0	100M	0.1*					
1N490	G			DS	90	1.0	5.0M		0.5				
1N497	G			DS	30	1.0	100M	20*					
1N498	G			DS	60	1.0	100M	25*					
1N499	G			DS	75	1.0	100M	30*					
1N500	G			DS	80	1.0	100M	40*					
1N501	G			DS	100	1.0	100M	40*					
1N502	G			DS	120	1.0	100M	50*					
1N503	S			R*	50	1.2	0.33	0.5					
1N504	S			R*	100	1.2	0.33	0.5					
1N505	S			R*	200	1.2	0.33	0.5					
1N506	S			R*	300	1.2	0.33	0.5					
1N507	S			R*	400	1.2	0.33	0.25					
1N508	S			R*	600	1.2	0.33	0.25					
1N509	S			R*	800	1.2	0.33	0.25					
1N510	S			R*	1000	1.2	0.33	0.25					
1N511	S			R*	50	1.2	1.0	0.5					
1N512	S			R*	100	1.2	1.0	0.5					
1N513	S			R*	200	1.2	1.0	0.5					
1N514	S			R*	300	1.2	1.0	0.5					
1N515	S			R*	400	1.2	1.0	0.25					
1N516	S			R*	600	1.2	1.0	0.25					
1N517	S			R*	800	1.2	1.0	0.25					
1N518	S			R*	1000	1.2	1.0	0.25					
1N519	S			R*	50	1.2	1.25	0.5					
1N520	S			R*	100	1.2	1.25	0.5					
1N521	S			R*	200	1.2	1.25	0.5					
1N522	S			R*	300	1.2	1.25	0.5					
1N523	S			R*	400	1.2	1.25	0.25					
1N524	S			R*	600	1.2	1.25	0.25					
1N525	S			R*	800	1.2	1.25	0.25					
1N526	S			R*	1000	1.2	1.25	0.25					
1N527	G			DS	10	0.3	1.0M	50*					
1N530	S	1N4002	1N4001	R*	100	2.0	0.3	0.003	3.0				
1N531	S	1N4003	1N4001	R*	200	2.0	0.3		3.0				
1N532	S	1N4004	1N4001	R*	300	2.0	0.3	0.01	3.0				
1N533	S			R*	400	2.0	0.3	0.015	3.0				
1N534	S	1N4005	1N4001	R*	500	2.0	0.3		3.0				
1N535	S	1N4005	1N4001	R*	600	2.0	0.3	0.02	3.0				
1N536	S	1N4001	1N4001	R*	50	0.5	0.25	0.4	15				
1N537	S	1N4002	1N4001	R*	100	0.4	0.25	0.5	15				
1N538	S	1N4003	1N4001	R*	200	0.3	0.25	0.5	15				
1N539	S	1N4004	1N4001	R*	300	0.5	0.25	0.3	15				
1N540	S	1N4004	1N4001	R*	400	0.5	0.25	0.3	15				
1N541	G			DS	45	2.2	10M	18*					
1N542	G			DS									
1N543	S			R*	1000	10	0.005	0.1					
1N543A	S			R*	1000	8.0	0.025	0.1					
1N544	S			R*	1000	10	0.015	0.1					
1N544A	S			R*	1000	10	0.075	0.1					
1N547	S	1N4005	1N4001	R*	600	1.1	0.25	0.35	15				
1N548	S			R*	900	1.1	0.3	0.35	15				
1N549	S			R*	1200	1.1	0.3	0.35	15				
1N550	S	MR1121	MR1120	R*	100	1.5	0.5		4.0				
1N551	S	MR1122	MR1120	R*	200	1.5	0.5	0.001	4.0				
1N552	S	MR1123	MR1120	R*	300	1.5	0.5		4.0				
1N553	S	MR1124	MR1120	R*	400	1.5	0.5		4.0				
1N554	S	MR1125	MR1120	R*	500	1.5	0.5		4.0				
1N555	S			R*	600	1.5	0.5	0.005	4.0				
1N560	S	1N4006	1N4001	R*	800	1.75	0.25	0.015	2.0				
1N561	S	1N4007	1N4001	R*	1000	1.75	0.25	0.02	2.0				
1N562	S	MR1128	MR1120	R*	800	1.75	0.4	0.015	3.0				
1N563	S	MR1130	MR1120	R*	1000	1.75	0.4	0.02	3.0				
1N566	G			DS	220	1.0	20M	0.2M					
1N567	G			DS	100	1.0	150M	0.15M	0.3				
1N568	G			DS	7.0	0.32	5.0M	0.1M	0.08				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N569	G			DS	12	0.5	250M	0.05M					
1N570	S			R*	1250	10	37.5	0.1					
1N571	G			DS		1.0	200M	100*	4.0				
1N573	G			R*	380	0.15	0.25						
1N574	G			R*	380	0.15	0.3						
1N575	G			R*	380	0.3	0.35						
1N575A	G			R*	380	0.15	0.35						
1N576A	G			R*	380	0.15	0.4						
1N581	G			R*	380	0.15	0.25						
1N582	G			R*	380	0.15	0.3						
1N583	G			R*	380	0.15	0.35						
1N584	G			R*	380	0.15	0.4						
1N588	S			R*	1500	1.75	0.1	0.1	5.0				
1N589	S	MR991A	MR990A	R*	1500	1.75	0.25	0.1	10				
1N590	S			R*	1500	8.0	0.075	0.1					
1N591	S			R*	1500	8.0	0.075	0.1					
1N596	S	1N4005	1N4001	R*	600	3.0	0.125	0.025	1.0				
1N597	S	1N4006	1N4001	R*	800	3.0	0.125	0.025	1.0				
1N598	S	1N4007	1N4001	R*	1000	3.0	0.125	0.025	1.0				
1N599	S	1N4001	1N4001	R*	50	1.5	0.3	0.025	2.0				
1N599A	S	1N4001	1N4001	R*	50	1.5	0.3	0.001	2.0				
1N600	S	1N4002	1N4001	R*	100	1.5	0.3	0.025	2.0				
1N600A	S	1N4002	1N4001	R*	100	1.5	0.3	0.001	2.0				
1N601	S	1N4003	1N4001	R*	150	1.5	0.3	0.025	2.0				
1N601A	S	1N4003	1N4001	R*	150	1.5	0.3	0.001	2.0				
1N602	S	1N4003	1N4001	R*	200	1.5	0.3	0.025	2.0				
1N602A	S	1N4003	1N4001	R*	200	1.5	0.3	0.001	2.0				
1N603	S	1N4004	1N4001	R*	300	1.5	0.3	0.025	2.0				
1N603A	S	1N4004	1N4001	R*	300	1.5	0.3	0.001	2.0				
1N604	S	1N4004	1N4001	R*	400	1.5	0.3	0.025	2.0				
1N604A	S	1N4004	1N4001	R*	400	1.5	0.3		2.0				
1N605	S	1N4005	1N4001	R*	500	1.5	0.3	0.025	2.0				
1N605A	S	1N4005	1N4001	R*	500	1.5	0.3	0.002	2.0				
1N606	S	1N4005	1N4001	R*	600	1.5	0.3	0.025	2.0				
1N606A	S	1N4005	1N4001	R*	600	1.5	0.3		2.0				
1N607	S			R*	50	1.5	0.8	0.025	3.0				
1N607A	S	MR1120	MR1120	R*	50	1.5	0.8	0.001	3.0				
1N608	S			R*	100	1.5	0.8	0.025	3.0				
1N608A	S	MR1121	MR1120	R*	100	1.5	0.8	0.001	3.0				
1N609	S			R*	150	1.5	0.8	0.025	3.0				
1N609A	S	MR1122	MR1120	R*	150	1.5	0.8	0.001	3.0				
1N610	S			R*	200	1.5	0.8	0.025	3.0				
1N610A	S	MR1122	MR1120	R*	200	1.5	0.8	0.001	3.0				
1N611	S			R*	300	1.5	0.8	0.025	3.0				
1N611A	S	MR1123	MR1120	R*	300	1.5	0.8	0.001	3.0				
1N612	S			R*	400	1.5	0.8	0.025	3.0				
1N612A	S	MR1124	MR1120	R*	400	1.5	0.8	1.5	3.0				
1N613	S			R*	500	1.5	0.8	0.025	3.0				
1N613A	S	MR1125	MR1120	R*	500	1.5	0.8	0.002	3.0				
1N614	S			R*	600	1.5	0.8	0.025	3.0				
1N614A	S	MR1126	MR1120	R*	600	1.5	0.8	2.5	3.0				
1N615	G			R*	300		0.075	1.2	25				
1N616	G			DS	20	1.0	8.0M	0.4M					
1N617	G			DS	115	1.0	3.0M	11*					
1N618	G			DS	115	1.0	5.0M	7.0*					
1N619	S			DS	30	1.0	3.0M	0.08*					
1N622	S			DS	150	1.0	7.0M	0.16*					
1N625	S			DS		1.5	4.0M	1.0*	1.0				
1N626	S			DS		1.5	4.0M	1.0*	1.0				
1N627	S			DS		1.5	4.0M	1.0*	1.0				
1N628	S			DS		1.5	4.0M	1.0*	1.0				
1N629	S			DS		1.5	4.0M	1.0*	1.0				
1N630	S	Microwave L-X-band Detector											
1N631	G			DS	60				0.3				
1N632	G			DS	60	1.0	7.0M		0.3				
1N633	G			DS	80	1.0	125M		0.3				
1N634	G			DS	100	1.0	50M	45*					
1N635	G			DS	150	1.0	50M	175*					
1N636	G			DS	60	1.0	2.5M	10*					
1N643	S			DS	175	1.0	10M	1.0*	0.3				
1N643A	S			DS	175	1.0	100M	1.0*	0.3				
1N645	S	1N4003	1N4001	DS	225	1.0	400M	0.2*					
1N645A	S	1N4003	1N4001	DS	225	1.0	400M	0.05*					
1N646	S	1N4004	1N4001	DS	300	1.0	400M	0.2*					
1N647	S	1N4004	1N4001	DS	400	1.0	400M	0.2*					
1N648	S	1N4005	1N4001	DS	500	1.0	400M	0.2*					
1N649	S	1N4005	1N4001	DS	600	1.0	400M	0.2*					
1N658	S			DS	100	1.0	100M	0.05*	0.3				
1N658A	S			DS	120	1.0	100M	25N	0.3				
1N659	S			DS	50	1.0	6.0M	5.0*	0.3				
1N659A	S			DS	60	1.0	10M	25N	0.3				
1N660	S			DS	100	1.0	6.0M	5.0*	0.3				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N660A	S			DS	120	1.0	10M	25N	0.3				
1N661	S			DS	200	1.0	6.0M	10*	0.3				
1N661A	S			DS	240	1.0	10M	25N	0.3				
1N662	S			DS	80	1.0	10M	1.0*	0.5				
1N662A	S			DS	80	1.0	100M	1.0*	0.3				
1N663	S			DS	80	1.0	100M	5.0*	0.5				
1N663A	S			DS	80	1.0	100M	0.1*	0.3				
1N664	S	1N5237A	1N5221	DZ							8.2*	10	250M
1N665	S	1N5242A	1N5221	DZ						10.8	13.2		0.25W
1N666	S	1N5245B	1N5221	DZ						14.2	15.8		0.25W
1N667	S	1N5248A	1N5221	DZ						16.2	19.8		0.25W
1N668	S	1N5251A	1N5221	DZ						19.8	24.2		0.25W
1N669	S	1N5254A	1N5221	DZ						24.3	29.7		0.25W
1N670	S	1N5266B	1N5221	DZ							68*	5.0	250M
1N671	S	1N5271A	1N5221	DZ						90	110		0.25W
1N672	S	1N5276A	1N5221	DZ						135	165		0.25W
1N673	S		1N5221	DS	350	1.0	250M	1.0*					
1N674	S	1N5230A	1N5221	DZ							4.7*	10	250M
1N675	S	1N5234B	1N5221	DZ							6.2*	5.0	250M
1N676	S	1N4002	1N4001	R*	100	1.0	0.075	0.2	3.0				
1N677	S	1N4002	1N4001	R*	100	1.0	0.15	0.2	5.0				
1N678	S	1N4003	1N4001	R*	200	1.0	0.075	0.2	3.0				
1N679	S	1N4003	1N4001	R*	200	1.0	0.15	0.2	5.0				
1N681	S	1N4004	1N4001	R*	300	1.0	0.075	0.2	3.0				
1N682	S	1N4004	1N4001	R*	300	1.0	0.15	0.2	5.0				
1N683	S	1N4004	1N4001	R*	400	1.0	0.075	0.2	3.0				
1N684	S	1N4004	1N4001	R*	400	1.0	0.15	0.2	5.0				
1N685	S	1N4005	1N4001	R*	500	1.0	0.075	0.2	3.0				
1N686	S	1N4005	1N4001	R*	500	1.0	0.15	0.2	5.0				
1N687	S	1N4005	1N4001	R*	600	1.0	0.075	0.2	3.0				
1N689	S	1N4005	1N4001	R*	600	1.0	0.15	0.2	5.0				
1N690	S			DS	36	1.0	400M	0.25*	0.8				
1N691	S			DS	70	1.0	400M	0.25*	0.8				
1N692	S			DS	100	1.0	400M	0.25*	0.8				
1N693	S			DS	130	1.0	400M	0.25*	0.8				
1N695	G			DS	20	1.0	100M	2.0*	0.3				
1N695A	G			DS	25	0.5	10M	2.0*	0.3				
1N696	S			DS	30	1.0	10M	15N	5.0				
1N697	S			DS		1.0	0.25A	1.0*					
1N698	G			DS	25	0.65	30M	160*	0.5				
1N699	G			DS	80	1.0	100M		0.3				
1N701	S	1N5240B*	1N5221	DZ						9.5	10.5		0.25W
1N702	S	1N5223A*	1N5221	DZ						2.0	3.2		250M
1N702A	S	1N5223B*	1N5221	DZ						2.3	2.9		250M
1N703	S	1N5227A*	1N5221	DZ						3.0	3.9		250M
1N703A	S	1N5227B*	1N5221	DZ						3.23	3.67		250M
1N704	S	1N5229A*	1N5221	DZ						3.7	4.5		250M
1N704A	S	1N5229B*	1N5221	DZ						3.9	4.3		250M
1N705	S	1N5230A*	1N5221	DZ						4.3	5.4		250M
1N705A	S	1N5230B*	1N5221	DZ						4.58	5.12		250M
1N706	S	1N5232A*	1N5221	DZ						5.2	6.4		250M
1N706A	S	1N5232B*	1N5221	DZ						5.5	6.1		250M
1N707	S	1N5236A*	1N5221	DZ						6.2	8.0		250M
1N707A	S	1N5236B*	1N5221	DZ						6.65	7.55		250M
1N708	S	1N5232A*	1N5221	DZ							5.6*	10	250M
1N708A	S	1N5232B*	1N5221	DZ							5.6*	5.0	250M
1N709	S	1N5234A*	1N5221	DZ							6.2*	10	250M
1N709A	S	1N5234B*	1N5221	DZ							6.2*	5.0	250M
1N710	S	1N5235A*	1N5221	DZ							6.8*	10	250M
1N710A	S	1N5235B*	1N5221	DZ							6.8*	5.0	250M
1N711	S	1N5236A*	1N5221	DZ							7.5*	10	250M
1N711A	S	1N5236B*	1N5221	DZ							7.5*	5.0	250M
1N712	S	1N5237A*	1N5221	DZ							8.2*	10	250M
1N712A	S	1N5237B*	1N5221	DZ							8.2*	5.0	250M
1N713	S	1N5239A*	1N5221	DZ							9.1*	10	250M
1N713A	S	1N5239B*	1N5221	DZ							9.1*	5.0	250M
1N714	S	1N5240A*	1N5221	DZ							10*	10	250M
1N714A	S	1N5240B*	1N5221	DZ							10*	5.0	250M
1N715	S	1N5241A*	1N5221	DZ							11*	10	250M
1N715A	S	1N5241B*	1N5221	DZ							11*	5.0	250M
1N716	S	1N5242A*	1N5221	DZ							12*	10	250M
1N716A	S	1N5242B*	1N5221	DZ							12*	5.0	250M
1N717	S	1N5243A*	1N5221	DZ							13*	10	250M
1N717A	S	1N5243B*	1N5221	DZ							13*	5.0	250M
1N718	S	1N5245A*	1N5221	DZ							15*	10	250M
1N718A	S	1N5245B*	1N5221	DZ							15*	5.0	250M
1N719	S	1N5246A*	1N5221	DZ							16*	10	250M
1N719A	S	1N5246B*	1N5221	DZ							16*	5.0	250M
1N720	S	1N5248A*	1N5221	DZ							18*	10	250M
1N720A	S	1N5248B*	1N5221	DZ							18*	5.0	250M
1N721	S	1N5250A*	1N5221	DZ							20*	10	250M
1N721A	S	1N5250B*	1N5221	DZ							20*	5.0	250M

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TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N722	S	1N5251A*	1N5221	DZ							22*	10	250M
1N722A	S	1N5251B*	1N5221	DZ							22*	5.0	250M
1N723	S	1N5252A*	1N5221	DZ							24*	10	250M
1N723A	S	1N5252B*	1N5221	DZ							24*	5.0	250M
1N724	S	1N5254A*	1N5221	DZ							27*	10	250M
1N724A	S	1N5254B*	1N5221	DZ							27*	5.0	250M
1N725	S	1N5256A*	1N5221	DZ							30*	10	250M
1N725A	S	1N5256B*	1N5221	DZ							30*	5.0	250M
1N726	S	1N5257A*	1N5221	DZ							33*	10	250M
1N726A	S	1N5257B*	1N5221	DZ							33*	5.0	250M
1N727	S	1N5258A*	1N5221	DZ							36*	10	250M
1N727A	S	1N5258B*	1N5221	DZ							36*	5.0	250M
1N728	S	1N5259A*	1N5221	DZ							39*	10	250M
1N728A	S	1N5259B*	1N5221	DZ							39*	5.0	250M
1N729	S	1N5260A*	1N5221	DZ							43*	10	250M
1N729A	S	1N5260B*	1N5221	DZ							43*	5.0	250M
1N730	S	1N5261A*	1N5221	DZ							47*	10	250M
1N730A	S	1N5261B*	1N5221	DZ							47*	5.0	250M
1N731	S	1N5262A*	1N5221	DZ							51*	10	250M
1N731A	S	1N5262B*	1N5221	DZ							51*	5.0	250M
1N732	S	1N5263A*	1N5221	DZ							56*	10	250M
1N732A	S	1N5263B*	1N5221	DZ							56*	5.0	250M
1N733	S	1N5265A*	1N5221	DZ							62*	10	250M
1N733A	S	1N5265B*	1N5221	DZ							62*	5.0	250M
1N734	S	1N5266A*	1N5221	DZ							68*	10	250M
1N734A	S	1N5266B*	1N5221	DZ							68*	5.0	250M
1N735	S	1N5267A*	1N5221	DZ							75*	10	250M
1N735A	S	1N5267B*	1N5221	DZ							75*	5.0	250M
1N736	S	1N5268A*	1N5221	DZ							82*	10	250M
1N736A	S	1N5268B*	1N5221	DZ							82*	5.0	250M
1N737	S	1N5270A*	1N5221	DZ							91*	10	250M
1N737A	S	1N5270B*	1N5221	DZ							91*	5.0	250M
1N738	S	1N5271A*	1N5221	DZ							100*	10	250M
1N738A	S	1N5271B*	1N5221	DZ							100*	5.0	250M
1N739	S	1N5272A*	1N5221	DZ							110*	10	250M
1N739A	S	1N5272B*	1N5221	DZ							110*	5.0	250M
1N740	S	1N5273A*	1N5221	DZ							120*	10	250M
1N740A	S	1N5273B*	1N5221	DZ							120*	5.0	250M
1N741	S	1N5274A*	1N5221	DZ							130*	10	250M
1N741A	S	1N5274B*	1N5221	DZ							130*	5.0	250M
1N742	S	1N5276A*	1N5221	DZ							150*	10	250M
1N742A	S	1N5276B*	1N5221	DZ							150*	5.0	250M
1N743	S	1N5277A*	1N5221	DZ							160*	10	250M
1N743A	S	1N5277B*	1N5221	DZ							160*	5.0	250M
1N744	S	1N5279A*	1N5221	DZ							180*	10	250M
1N744A	S	1N5279B*	1N5221	DZ							180*	5.0	250M
1N745	S	1N5281A*	1N5221	DZ							200*	0	250M
1N745A	S	1N5281B*	1N5221	DZ							200*	5.0	250M
1N746	S		1N702	DZ							3.3*	10	400M
1N746A	S		1N702	DZ							3.3*	5.0	400M
1N747	S		1N702	DZ							3.6*	10	400M
1N747A	S		1N702	DZ							3.6*	5.0	400M
1N748	S		1N702	DZ							3.9*	10	400M
1N748A	S		1N702	DZ							3.9*	5.0	400M
1N749	S		1N702	DZ							4.3*	10	400M
1N749A	S		1N702	DZ							4.3*	5.0	400M
1N750	S		1N702	DZ							4.7*	10	400M
1N750A	S		1N702	DZ							4.7*	5.0	400M
1N751	S		1N702	DZ							5.1*	10	400M
1N751A	S		1N702	DZ							5.1*	5.0	400M
1N752	S		1N702	DZ							5.6*	10	400M
1N752A	S		1N702	DZ							5.6*	5.0	400M
1N753	S		1N702	DZ							6.2*	10	400M
1N753A	S		1N702	DZ							6.2*	5.0	400M
1N754	S		1N702	DZ							6.8*	10	400M
1N754A	S		1N702	DZ							6.8*	5.0	400M
1N755	S		1N702	DZ							7.5*	10	400M
1N755A	S		1N702	DZ							7.5*	5.0	400M
1N756	S		1N702	DZ							8.2*	10	400M
1N756A	S		1N702	DZ							8.2*	5.0	400M
1N757	S		1N702	DZ							9.1*	10	400M
1N757A	S		1N702	DZ							9.1*	5.0	400M
1N758	S		1N702	DZ							10.0*	10	400M
1N758A	S		1N702	DZ							10.0*	5.0	400M
1N759	S		1N702	DZ							12.0*	10	400M
1N759A	S		1N702	DZ							12.0*	5.0	400M
1N761	S	1N5230A *	1N5221	DZ						4.3	5.4		250M
1N762	S	1N5232B *	1N5221	DZ						5.2	6.4		250M
1N763	S	1N5238B *	1N5221	DZ						6.2	8.0		250M
1N764	S	1N5238A *	1N5221	DZ						7.5	10.0		250M
1N765	S	1N5240A *	1N5221	DZ						9.0	12.0		250M
1N766	S	1N5243A *	1N5221	DZ						11.0	14.5		250M

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TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N767	S	1N5246A *	1N5221	DZ						13.5	18.0		250M
1N768	S	1N5249A *	1N5221	DZ						17.0	21.0		250M
1N769	S	1N5252A *	1N5221	DZ						20.0	27.0		250M
1N770	G			DS	20	0.42	5.0M	40*	0.35				
1N771	G			DS	80	1.0	100M	25*					
1N771A	G			DS	80	1.0	200M	25*					
1N771B	G			DS	80	1.0	400M	25*					
1N772	G			DS	70	1.0	100M	50*					
1N772A	G			DS	70	1.0	200M	50*					
1N773	G			DS	65	1.0	100M	10*					
1N773A	G			DS	65	1.0	200M	10*					
1N774	G			DS	60	1.0	100M	15*					
1N774A	G			DS	60	1.0	200M	15*					
1N775	G			DS	60	1.0	100M	20*					
1N776	G			DS	20	1.0	50M	200*					
1N777	G			DS	60	1.0	100M	25*	3.5				
1N778	S			DS	100	1.0	10M	0.5*	0.3				
1N779	S			DS	175	1.0	10M	0.5*	0.3				
1N781	G			DS	40	0.45	10M	5.0*	0.5				
1N781A	G			DS	40	0.45	10M	5.0*	0.5				
1N789	S			DS		1.0	10M	1.0*	0.5				
1N790	S			DS		1.0	10M	5.0*	0.25				
1N791	S			DS		1.0	50M	5.0*	0.5				
1N792	S			DS		1.0	100M	5.0*	0.5				
1N793	S			DS		1.0	10M	1.0*	0.5				
1N794	S			DS		1.0	10M	5.0*	0.25				
1N795	S			DS		1.0	50M	5.0*	0.5				
1N796	S			DS		1.0	100M	5.0*	0.5				
1N797	S			DS		1.0	10M	1.0*	0.5				
1N798	S			DS		1.0	10M	5.0*	0.25				
1N799	S			DS		1.0	50M	5.0*	0.5				
1N800	S			DS		1.0	100M	5.0*	0.5				
1N801	S			DS		1.0	10M	1.0*	0.5				
1N802	S			DS		1.0	50M	5.0*	0.5				
1N803	S			DS		1.0	10M	5.0*	0.5				
1N804	S			DS		1.0	50M	10*	0.5				
1N805	G			DS	40	1.0	3.0M	100*					
1N806	S			DS	100	1.0	4.0M	0.5*	0.3				
1N807	S			DS	180	1.0	4.0M	0.5*	0.3				
1N808	S			DS	100	1.0	100M	1.0*	0.3				
1N809	S			DS	200	1.0	100M	1.0*	0.3				
1N810	S			DS	50	1.0	10M	1.0*	50				
1N811	S			DS	20	1.0	1.0M	1.0*	0.25				
1N812	S			DS	30	1.0	1.0M	0.1*	0.25				
1N813	S			DS	15	1.0	5.0M	0.5*	0.25				
1N814	S			DS	40	1.0	2.0M	0.1*	0.25				
1N815	S			DS	15	1.5	100M	0.5*	0.25				
1N816	S			DS	6.0	1.0	100M	0.1*					
1N817	S			DS	200	1.5	6.0M	20*	1.0				
1N818	S			DS	80	1.5	30M	0.25*	0.5				
1N819	S			DS	80	1.0	200M	25N					
1N821	S		1N821	DR						0.01	6.2	-55	100
1N821A	S		1N821	DR						0.01	6.2	-55	100
1N822	S			DR						0.01	6.2	-55	100
1N823	S		1N821	DR						0.005	6.2	-55	100
1N823A	S		1N821	DR						0.005	6.2	-55	100
1N824	S			DR						0.005	6.2	-55	100
1N825	S		1N821	DR						0.002	6.2	-55	100
1N825A	S		1N821	DR						0.002	6.2	-55	100
1N826	S	1N825	1N821	DR						0.002	6.5	-50	100
1N827	S		1N821	DR						0.001	6.2	-55	100
1N827A	S		1N821	DR						0.001	6.2	-55	100
1N828	S	1N827	1N821	DR						0.001	6.5	-50	100
1N829	S		1N821	DR						0.0005	6.2	-50	100
1N830	S	Micro-min. UHF Detector											
1N830A	S	Micro-min. UHF Detector											
1N831	S	Microwave S-band Mixer; NF = 8.3 to 6.5 dB											
1N831A	S	Microwave S-band Mixer; NF = 8.3 to 6.5 dB											
1N831B	S	Microwave S-band Mixer; NF = 8.3 to 6.5 dB											
1N832	S	Microwave X-band Mixer; NF = 9.5 to 7.0 dB											
1N832A	S	Microwave X-band Mixer; NF = 9.5 to 7.0 dB											
1N832B	S	Microwave X-band Mixer; NF = 9.5 to 7.0 dB											
1N833	S	Microwave X-band Detector											
1N833A	S	Microwave X-band Detector											
1N835	G			DS	30	0.5	5.0M	20*	0.5				
1N836	G			DS	5.0								
1N837	S			DS		1.0	150M	0.1*	0.5				
1N837A	S			DS		1.0	150M	0.1*	0.3				
1N838	S			DS		1.0	150M	0.1*	0.5				
1N839	S			DS		1.0	150M	0.1*	0.5				
1N840	S			DS		1.0	150M	0.1*	0.3				
1N841	S			DS		1.0	150M	0.1*	0.3				

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TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N842	S			DS		1.0	150M	0.1*	0.3				
1N843	S			DS		1.0	150M	0.1*	0.3				
1N844	S			DS		1.0	200M	0.1*	0.5				
1N845	S			DS		1.0	200M	0.1*	0.5				
1N846	S	1N4001	1N4001	R*	50	0.6	200M	20*					
1N847	S	1N4002	1N4001	R*	100	0.6	200M	20*					
1N848	S	1N4003	1N4001	R*	200	0.6	200M	20*					
1N849	S	1N4004	1N4001	R*	300	0.6	200M	20*					
1N850	S	1N4004	1N4001	R*	400	0.6	200M	20*					
1N851	S	1N4005	1N4001	R*	500	0.6	200M	20*					
1N852	S	1N4005	1N4001	R*	600	0.6	200M	20*					
1N853	S	1N4006	1N4001	R*	700	0.6	200M	20*					
1N854	S	1N4006	1N4001	R*	800	0.6	200M	20*					
1N855	S	1N4007	1N4001	R*	900	0.6	200M	20*					
1N856	S	1N4007	1N4001	R*	1.0K	0.6	200M	20*					
1N857	S	1N4001	1N4001	R*	50	0.6	150M	20*					
1N858	S	1N4002	1N4001	R*	100	0.6	150M	20*					
1N859	S	1N4003	1N4001	R*	200	0.6	150M	20*					
1N860	S	1N4004	1N4001	R*	300	0.6	150M	20*					
1N861	S	1N4004	1N4001	R*	400	0.6	150M	20*					
1N862	S	1N4005	1N4001	R*	500	0.6	150M	20*					
1N863	S	1N4005	1N4001	R*	600	0.6	150M	20*					
1N864	S	1N4006	1N4001	R*	700	0.6	150M	20*					
1N865	S	1N4006	1N4001	R*	800	0.6	150M	20*					
1N866	S	1N4007	1N4001	R*	900	0.6	150M	20*					
1N867	S	1N4007	1N4001	R*	1.0K	0.6	150M	20*					
1N868	S	1N4001	1N4001	R*	50	0.6	100M	20*					
1N869	S	1N4002	1N4001	R*	100	0.6	100M	20*					
1N870	S	1N4003	1N4001	R*	200	0.6	100M	20*					
1N871	S	1N4004	1N4001	R*	300	0.6	100M	20*					
1N872	S	1N4004	1N4001	R*	400	0.6	100M	20*					
1N873	S	1N4005	1N4001	R*	500	0.6	100M	20*					
1N874	S	1N4005	1N4001	R*	600	0.6	100M	20*					
1N875	S	1N4006	1N4001	R*	700	0.6	100M	20*					
1N876	S	1N4006	1N4001	R*	800	0.6	100M	20*					
1N877	S	1N4007	1N4001	R*	900	0.6	100M	20*					
1N878	S	1N4007	1N4001	R*	1.0K	0.6	100M	20*					
1N879	S	1N4001	1N4001	R*	50	0.6	50M	20*					
1N880	S	1N4002	1N4001	R*	100	0.6	50M	20*					
1N881	S	1N4003	1N4001	R*	200	0.6	50M	20*					
1N882	S	1N4004	1N4001	R*	300	0.6	50M	20*					
1N883	S	1N4004	1N4001	R*	400	0.6	50M	20*					
1N884	S	1N4005	1N4001	R*	500	0.6	50M	20*					
1N885	S	1N4005	1N4001	R*	600	0.6	50M	20*					
1N886	S	1N4006	1N4001	R*	700	0.6	50M	20*					
1N887	S	1N4006	1N4001	R*	800	0.6	50M	20*					
1N888	S	1N4007	1N4001	R*	900	0.6	50M	20*					
1N889	S	1N4007	1N4001	R*	1.0K	0.6	50M	20*					
1N890	S			DS	60	1.0	20M	25N					
1N891	S			DS		1.0	50M	0.1*	0.3				
1N892	S			DS		1.0	50M	0.1*	0.3				
1N893	S			DS		1.0	50M	0.1*	0.3				
1N894	G			DS	5.0								
1N895	G			DS	5.0								
1N896	G			DS	5.0								
1N897	S			DS	2.5	4.0	5.0M	0.1*	1.0				
1N898	S			DS	2.5	1.0	100M	5.0*	0.3				
1N899	S			DS	85	1.0	5.0M	0.1*	0.3				
1N900	S			DS	85	1.0	50M	0.1*	0.3				
1N901	S			DS	85	1.0	100M	0.5*	0.3				
1N902	S			DS	170	1.0	10M	1.0*	0.3				
1N903	S			DS	40	1.0	10M	0.1*	4.0				
1N903A	S			DS	40	1.0	20M	0.1*	4.0				
1N904	S			DS	30	1.0	10M	0.1*	4.0				
1N904A	S			DS	30	1.0	20M	0.1*	4.0				
1N905	S			DS	20	1.0	10M	0.1*	4.0				
1N905A	S			DS	20	1.0	20M	0.1*	4.0				
1N906	S			DS	20	1.0	10M	0.1*	4.0				
1N906A	S			DS	20	1.0	20M	0.1*	4.0				
1N907	S			DS	30	1.0	10M	0.1*	4.0				
1N907A	S			DS	30	1.0	20M	0.1*	4.0				
1N908	S			DS	40	1.0	10M	0.1*	4.0				
1N908A	S			DS	40	1.0	20M	0.1*	4.0				
1N909	G			DS	50	1.0	100M	10*					
1N910	G			DS	30	1.0	100M	10*					
1N911	G			DS	20	1.0	100M	10*					
1N912	S			DS	10	0.62	1.0M	1.0*					
1N912A	S			DS	10	0.62	1.0M	1.0*					
1N913	S			DS	10	0.62	1.0M	5.0*					
1N913A	S			DS	10	0.62	1.0M	1.0*					
1N914	S			DS	75	1.0	10M	5.0*	4.0				
1N914A	S			DS	75	1.0	20M	5.0*	4.0				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS: V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	ZENER DIODES: V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES: PRV (volts)	V_F @ I_F (volts)	I_F	I_R	t_{rr} (μS)	REFERENCE DIODES: TC %/°C	V_Z	T (min) °C	T (max) °C
1N914B	S			DS	75	1.0	100M	5.0*	4.0				
1N915	S			DS	50	1.0	50M	5.0*	10				
1N916	S			DS	75	1.0	10M	5.0*	4.0				
1N916A	S			DS	75	1.0	20M	5.0*	4.0				
1N916B	S			DS	75	1.0	30M	5.0*	4.0				
1N917	S			DS	30	1.0	10M	0.05*	3.0				
1N918	S	Microwave Ku-band Mixer											
1N919	S			DS	150	1.0	100M	0.5*	0.3				
1N920	S			DS	36	1.0	500M	0.25*	0.3				
1N921	S			DS	70	1.0	500M	0.25*	0.3				
1N922	S			DS	100	1.0	500M	0.25*	0.3				
1N923	S			DS	130	1.0	500M	0.25*	0.3				
1N925	S			DS	32	1.0	5.0M	1.0*	0.15				
1N926	S			DS	32	1.0	5.0M	0.1*	0.15				
1N927	S			DS	52	1.0	10M	0.1*	0.15				
1N928	S			DS	96	1.0	10M	0.1*	0.15				
1N929	S			DS	20	1.0	20M	0.1*					
1N930	S			DS	50	1.0	20M	0.1*					
1N931	S			DS	100	1.0	20M	0.1*					
1N932	S			DS	200	1.0	20M	0.1*					
1N933	G			DS	100	1.0	14M	10*	0.4				
1N934	S			DS	60	1.0	30M	25N	1.0				
1N935	S		1N935	DR						0.01	9.45	0	75
1N935A	S		1N935	DR						0.01	9.45	-55	100
1N935B	S		1N935	DR						0.01	9.45	-55	150
1N936	S		1N935	DR						0.005	9.45	0	75
1N936A	S		1N935	DR						0.005	9.45	-55	100
1N936B	S		1N935	DR						0.005	9.45	-55	150
1N937	S		1N935	DR						0.002	9.45	0	75
1N937A	S		1N935	DR						0.002	9.45	-55	100
1N937B	S		1N935	DR						0.002	9.45	-55	150
1N938	S		1N935	DR						0.001	9.45	0	75
1N938A	S		1N935	DR						0.001	9.45	-55	100
1N938B	S		1N935	DR						0.001	9.45	-55	150
1N939	S		1N935	DR						0.0005	9.45	0	75
1N939A	S		1N935	DR						0.0005	9.45	-55	100
1N939B	S		1N935	DR						0.0005	9.45	-55	150
1N940	S			DR						0.0002	9.0	0	75
1N940A	S			DR						0.0002	9.0	-55	100
1N940B	S			DR						0.0002	9.0	-55	150
1N941	S		1N941	DR						0.01	12.28	0	75
1N941A	S		1N941	DR						0.01	12.28	-55	100
1N941B	S		1N941	DR						0.01	12.28	-55	150
1N942	S		1N941	DR						0.005	12.28	0	75
1N942A	S		1N941	DR						0.005	12.28	-55	100
1N942B	S		1N941	DR						0.005	12.28	-55	150
1N943	S		1N941	DR						0.002	12.28	0	75
1N943A	S		1N941	DR						0.002	12.28	-55	100
1N943B	S		1N941	DR						0.002	12.28	-55	150
1N944	S		1N941	DR						0.001	12.28	0	75
1N944A	S		1N941	DR						0.001	12.28	-55	100
1N944B	S		1N941	DR						0.001	12.28	-55	150
1N945	S		1N941	DR						0.0005	12.28	0	75
1N945A	S		1N941	DR						0.0005	12.28	-55	100
1N945B	S		1N941	DR						0.0005	12.28	-55	150
1N946	S			DR						0.0002	11.7	0	75
1N946A	S			DR						0.0002	11.7	-55	100
1N946B	S			DR						0.0002	11.7	-55	150
1N947	S			DS		1.0	400M	2.0*					
1N948	S			DS	36	1.5	100M	0.25*	1.0				
1N949	G			DS	50	0.39	10M	10*					
1N950 thru 1N956	S	Varactor Diodes, see Table on Page 1-94											
1N957	S		1N957	DZ							6.8*	20	400M
1N957A	S		1N957	DZ							6.8*	10	400M
1N957B	S		1N957	DZ							6.8*	5.0	400M
1N958	S		1N957	DZ							7.5*	20	400M
1N958A	S		1N957	DZ							7.5*	10	400M
1N958B	S		1N957	DZ							7.5*	5.0	400M
1N959	S		1N957	DZ							8.2*	20	400M
1N959A	S		1N957	DZ							8.2*	10	400M
1N959B	S		1N957	DZ							8.2*	5.0	400M
1N960	S		1N957	DZ							9.1*	20	400M
1N960A	S		1N957	DZ							9.1*	10	400M
1N960B	S		1N957	DZ							9.1*	5.0	400M
1N961	S		1N957	DZ							10*	20	400M
1N961A	S		1N957	DZ							10*	10	400M
1N961B	S		1N957	DZ							10*	5.0	400M
1N962	S		1N957	DZ							11*	20	400M
1N962A	S		1N957	DZ							11*	10	400M
1N962B	S		1N957	DZ							11*	5.0	400M

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N963	S		1N957	DZ							12*	20	400M
1N963A	S		1N957	DZ							12*	10	400M
1N963B	S		1N957	DZ							12*	5.0	400M
1N964	S		1N957	DZ							13*	20	400M
1N964A	S		1N957	DZ							13*	10	400M
1N964B	S		1N957	DZ							13*	5.0	400M
1N965	S		1N957	DZ							15*	20	400M
1N965A	S		1N957	DZ							15*	10	400M
1N965B	S		1N957	DZ							15*	5.0	400M
1N966	S		1N957	DZ							16*	20	400M
1N966A	S		1N957	DZ							16*	10	400M
1N966B	S		1N957	DZ							16*	5.0	400M
1N967	S		1N957	DZ							18*	20	400M
1N967A	S		1N957	DZ							18*	10	400M
1N967B	S		1N957	DZ							18*	5.0	400M
1N968	S		1N957	DZ							20*	20	400M
1N968A	S		1N957	DZ							20*	10	400M
1N968B	S		1N957	DZ							20*	5.0	400M
1N969	S		1N957	DZ							22*	20	400M
1N969A	S		1N957	DZ							22*	10	400M
1N969B	S		1N957	DZ							22*	5.0	400M
1N970	S		1N957	DZ							24*	20	400M
1N970A	S		1N957	DZ							24*	10	400M
1N970B	S		1N957	DZ							24*	5.0	400M
1N971	S		1N957	DZ							27*	20	400M
1N971A	S		1N957	DZ							27*	10	400M
1N971B	S		1N957	DZ							27*	5.0	400M
1N972	S		1N957	DZ							30*	20	400M
1N972A	S		1N957	DZ							30*	10	400M
1N972B	S		1N957	DZ							30*	5.0	400M
1N973	S		1N957	DZ							33*	20	400M
1N973A	S		1N957	DZ							33*	10	400M
1N973B	S		1N957	DZ							33*	5.0	400M
1N974	S		1N957	DZ							36*	20	400M
1N974A	S		1N957	DZ							36*	10	400M
1N974B	S		1N957	DZ							36*	5.0	400M
1N975	S		1N957	DZ							39*	20	400M
1N975A	S		1N957	DZ							39*	10	400M
1N975B	S		1N957	DZ							39*	5.0	400M
1N976	S		1N957	DZ							43*	20	400M
1N976A	S		1N957	DZ							43*	10	400M
1N976B	S		1N957	DZ							43*	5.0	400M
1N977	S		1N957	DZ							47*	20	400M
1N977A	S		1N957	DZ							47*	10	400M
1N977B	S		1N957	DZ							47*	5.0	400M
1N978	S		1N957	DZ							51*	20	400M
1N978A	S		1N957	DZ							51*	10	400M
1N978B	S		1N957	DZ							51*	5.0	400M
1N979	S		1N957	DZ							56*	20	400M
1N979A	S		1N957	DZ							56*	10	400M
1N979B	S		1N957	DZ							56*	5.0	400M
1N980	S		1N957	DZ							62*	20	400M
1N980A	S		1N957	DZ							62*	10	400M
1N980B	S		1N957	DZ							62*	5.0	400M
1N981	S		1N957	DZ							68*	20	400M
1N981A	S		1N957	DZ							68*	10	400M
1N981B	S		1N957	DZ							68*	5.0	400M
1N982	S		1N957	DZ							75*	20	400M
1N982A	S		1N957	DZ							75*	10	400M
1N982B	S		1N957	DZ							75*	5.0	400M
1N983	S		1N957	DZ							82*	20	400M
1N983A	S		1N957	DZ							82*	10	400M
1N983B	S		1N957	DZ							82*	5.0	400M
1N984	S		1N957	DZ							91*	20	400M
1N984A	S		1N957	DZ							91*	10	400M
1N984B	S		1N957	DZ							91*	5.0	400M
1N985	S		1N957	DZ							100*	20	400M
1N985A	S		1N957	DZ							100*	10	400M
1N985B	S		1N957	DZ							100*	5.0	400M
1N986	S		1N957	DZ							110*	20	400M
1N986A	S		1N957	DZ							110*	10	400M
1N986B	S		1N957	DZ							110*	5.0	400M
1N987	S		1N957	DZ							120*	20	400M
1N987A	S		1N957	DZ							120*	10	400M
1N987B	S		1N957	DZ							120*	5.0	400M
1N988	S		1N957	DZ							130*	20	400M
1N988A	S		1N957	DZ							130*	10	400M
1N988B	S		1N957	DZ							130*	5.0	400M
1N989	S		1N957	DZ							150*	20	400M
1N989A	S		1N957	DZ							150*	10	400M
1N989B	S		1N957	DZ							150*	5.0	400M
1N990	S		1N957	DZ							160*	20	400M

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N990A	S		1N957	DZ							160*	10	400M
1N990B	S		1N957	DZ							160*	5.0	400M
1N991	S		1N957	DZ							180*	20	400M
1N991A	S		1N957	DZ							180*	10	400M
1N991B	S		1N957	DZ							180*	5.0	400M
1N992	S		1N957	DZ							200*	20	400M
1N992A	S		1N957	DZ							200*	10	400M
1N992B	S		1N957	DZ							200*	5.0	400M
1N993	S			DS	20	1.2	10M	1.0*	4.0				
1N994	G			DS	6.5	1.0	10M	30*	2.0				
1N995	G			DS	15	0.5	10M	10*	6.0				
1N996	G			DS	20	0.8	40M	15*	0.3				
1N997	S			DS	35	1.0	10M	25N	0.15				
1N998	S			DS	150	1.0	200M	1.0N					
1N999	S			DS	100	1.0	50M	1.0N	4.0				
1N1005	G			R*	380	0.15	0.25						
1N1007	G			R*	380	0.3	0.35						
1N1008	S			R*	380	0.3	0.4						
1N1013	G			R*	380	0.15	0.25						
1N1016	G			R*	380	0.15	0.4						
1N1021	G			R*	380	0.15	0.25						
1N1022	G			R*	380	0.15	0.3						
1N1023	G			R*	380	0.15	0.35						
1N1024	G			R*	380	0.15	0.4						
1N1028	S			R*	50	1.5	0.25		15				
1N1029	S			R*	100	1.5	0.25		15				
1N1030	S			R*	150	1.5	0.25		15				
1N1031	S			R*	200	1.5	0.25		15				
1N1032	S			R*	300	1.5	0.25		15				
1N1033	S			R*	400	1.5	0.25		15				
1N1034	S			R*	50	1.5	0.5		15				
1N1035	S			R*	100	1.5	0.5		15				
1N1036	S			R*	150	1.5	0.5		15				
1N1037	S			R*	200	1.5	0.5		15				
1N1038	S			R*	300	1.5	0.5		15				
1N1039	S			R*	400	1.5	0.5		15				
1N1040	S			R*	50	1.5	0.5		15				
1N1041	S			R*	100	1.5	0.5		15				
1N1042	S			R*	150	1.5	0.5		15				
1N1043	S			R*	200	1.5	0.5		15				
1N1044	S			R*	300	1.5	0.5		15				
1N1045	S			R*	400	1.5	0.5		15				
1N1046	S			R*	50	1.5	0.5		15				
1N1047	S			R*	100	1.5	0.5		15				
1N1048	S			R*	150	1.5	0.5		15				
1N1049	S			R*	200	1.5	0.5		15				
1N1050	S			R*	300	1.5	0.5		15				
1N1051	S			R*	400	1.5	0.5		15				
1N1052	S			R*	50	1.5	0.5		20				
1N1053	S			R*	100	1.5	0.5		20				
1N1054	S			R*	150	1.5	0.5		20				
1N1055	S			R*	200	1.5	0.5		20				
1N1056	S			R*	300	1.5	0.5		20				
1N1057	S			R*	400	1.5	0.5		20				
1N1058	S			R*	50	1.5	1.5		20				
1N1059	S			R*	100	1.5	1.5		20				
1N1060	S			R*	150	1.5	1.5		20				
1N1061	S			R*	200	1.5	1.5		20				
1N1062	S			R*	300	1.5	1.5		20				
1N1063	S			R*	400	1.5	1.5		20				
1N1064	S			R*	50	1.5	1.5		20				
1N1065	S			R*	100	1.5	1.5		20				
1N1066	S			R*	150	1.5	1.5		20				
1N1067	S			R*	200	1.5	1.5		20				
1N1068	S			R*	300	1.5	1.5		20				
1N1069	S			R*	400	1.5	1.5		20				
1N1070	S			R*	50	1.5	1.5		20				
1N1071	S			R*	100	1.5	1.5		20				
1N1072	S			R*	150	1.5	1.5		20				
1N1073	S			R*	200	1.5	1.5		20				
1N1074	S			R*	300	1.5	1.5		20				
1N1075	S			R*	400	1.5	1.5		20				
1N1076	S			R*	50	1.5	5.0		50				
1N1077	S			R*	100	1.5	5.0		50				
1N1078	S			R*	150	1.5	5.0		50				
1N1079	S			R*	200	1.5	5.0		50				
1N1080	S			R*	300	1.5	5.0		50				
1N1081	S	1N4002	1N4001	R*	100	1.5	0.25		15				
1N1082	S	1N4003	1N4001	R*	200	1.5	0.25		15				
1N1083	S	1N4004	1N4001	R*	300	1.5	0.25		15				
1N1084	S	1N4004	1N4001	R*	400	1.5	0.25		15				
1N1085	S			R*	100	1.5	0.6		24				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1086	S			R*	200	1.5	0.6		24				
1N1087	S			R*	300	1.5	0.6		24				
1N1088	S			R*	400	1.5	0.6		24				
1N1089	S			R*	100	1.5	2.0		24				
1N1090	S			R*	200	1.5	2.0		24				
1N1091	S			R*	300	1.5	2.0		24				
1N1092	S			R*	400	1.5	2.0		24				
1N1093	G			DS	15	0.4	5.0M	25*	0.5				
1N1095	S	1N4005	1N4001	R*	500	0.5	0.425	0.3	15				
1N1096	S	1N4005	1N4001	R*	600	0.5	0.4	0.3	15				
1N1100	S	1N4002	1N4001	R*	100	1.2	0.25	0.2	15				
1N1101	S	1N4003	1N4001	R*	200	1.2	0.25	0.2	15				
1N1102	S	1N4004	1N4001	R*	300	1.2	0.25	0.2	15				
1N1103	S	1N4004	1N4001	R*	400	1.2	0.25	0.2	15				
1N1104	S	1N4005	1N4001	R*	500	1.2	0.25	0.2	15				
1N1105	S	1N4005	1N4001	R*	600	1.2	0.25	0.2	15				
1N1108	S			R*	800	3.0	0.225		13.5				
1N1109	S			R*	1200	4.5	0.212		12.7				
1N1110	S			R*	1600	6.0	0.2		12				
1N1111	S			R*	2000	7.5	0.187		11.2				
1N1112	S			R*	2400	9.0	0.175		10.5				
1N1113	S			R*	2800	10.5	0.162		9.7				
1N1115	S	MR1121 *	MR1120	R*	100	0.65	0.6	0.4	15				
1N1116	S	MR1122 *	MR1120	R*	200	0.65	0.6	0.3	15				
1N1117	S	MR1123 *	MR1120	R*	300	0.65	0.6	0.3	15				
1N1118	S	MR1124 *	MR1120	R*	400	0.65	0.6	0.3	15				
1N1119	S	MR1125 *	MR1120	R*	500	0.65	0.6	0.3	15				
1N1120	S	MR1126 *	MR1120	R*	600	0.65	0.6	0.3	15				
1N1124	S	*		R*	200	1.1		0.3	25				
1N1124A	S	1N1124 *		R*	200		3.3	0.3	25				
1N1125	S	*		R*	300	1.1		0.3	25				
1N1125A	S	1N1125 *		R*	300		3.3	0.3	25				
1N1126	S	*		R*	400	1.1	1.0	0.3	25				
1N1126A	S	1N1126 *		R*	400		3.3	0.3	25				
1N1127	S	*		R*	500	1.1	1.0	0.3	25				
1N1127A	S	1N1126 *		R*	500		3.3	0.3	25				
1N1128	S	*		R*	600	1.1	1.0	0.3	25				
1N1128A	S	1N1126 *		R*	600		3.3	0.3	25				
1N1130	S			R*	1500	15	0.3	0.05					
1N1131	S			R*	1500	15	0.3	0.05					
1N1132	S	Microwave S-X-band Mixer; NF = 9.5 dB											
1N1133	S			R*	1500	15	0.085	0.025	3.5				
1N1134	S			R*	1500	7.5	0.115	0.025	3.5				
1N1135	S			R*	1800	18	0.075	0.025	3.5				
1N1136	S			R*	1800	9.0	0.095	0.025	3.5				
1N1137	S			R*	2400	24	0.057	0.025	3.5				
1N1138	S			R*	2400	12	0.070	0.025	3.5				
1N1139	S			R*	3600	27	0.075	0.025	3.5				
1N1140	S			R*	3600	18	0.075	0.025	3.5				
1N1141	S			R*	4800	36	0.070	0.025	3.5				
1N1142	S			R*	4800	24	0.057	0.025	3.5				
1N1143	S			R*	6000	45	0.057	0.025	3.5				
1N1143A	S			R*	6000	30	0.075	0.025	3.5				
1N1144	S			R*	7200	54	0.057	0.025	3.5				
1N1145	S			R*	7200	36	0.070	0.025	3.5				
1N1146	S			R*	8000	60	0.050	0.025	3.5				
1N1147	S			R*	12K	60	0.050	0.025	3.5				
1N1148	S			R*	14K	52	0.057	0.025	3.5				
1N1149	S			R*	16K	60	0.050	0.025	3.5				
1N1150	S			R*	1600		0.75		8.0				
1N1150A	S			R*	1600	6.5	0.375	1.0	10				
1N1157	S			R*	50		20		200				
1N1158	S			R*	100		20						
1N1159	S			R*	200		20						
1N1160	S			R*	300		20						
1N1161	S			R*	50		35		350				
1N1162	S			R*	100		35		350				
1N1163	S			R*	200		35		350				
1N1164	S			R*	300		35		350				
1N1165	S			R*	50		100		1000				
1N1166	S			R*	100		100		1000				
1N1167	S			R*	200		100		1000				
1N1168	S			R*	300		100		1000				
1N1169	S	1N4004	1N4001	R*			0.5						
1N1169A	S	1N4004	1N4001	R*	400		0.5	3.5					
1N1170	G			DS	50	1.0	4.0M	5.0*					
1N1171	S			R*	50		20						
1N1172	S			R*	100		20						
1N1173	S			R*	200		20						
1N1174	S			R*	300		20						
1N1175	S			R*	50		35		350				
1N1176	S			R*	100		35		350				

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TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1177	S			R*	200		35		350				
1N1178	S			R*	300		35		350				
1N1179	S			R*	50		100		1000				
1N1180	S			R*	100		100		1000				
1N1181	S			R*	200		100		1000				
1N1182	S			R*	300		100		1000				
1N1183	S		1N1183	R*	50	1.7	35	10	500				
1N1184	S		1N1183	R*	100	1.7	35	10	500				
1N1185	S		1N1183	R*	150	1.7	35	10	500				
1N1186	S		1N1183	R*	200	1.7	35	10	500				
1N1187	S		1N1183	R*	300	1.7	35	10	500				
1N1188	S		1N1183	R*	400	1.7	35	10	500				
1N1189	S		1N1183	R*	500	1.7	35	10	500				
1N1189A	S			R*	500	1.2	40	2.0	800				
1N1190	S		1N1183	R*	600	1.7	35	10	500				
1N1190A	S			R*	600	1.2	40	1.8	800				
1N1191	S			R*	50	2.35	18	5.0	220				
1N1191A	S			R*	50	2.0	22	2.5	500				
1N1192	S			R*	100	2.35	18	5.0	220				
1N1192A	S			R*	100	2.0	22	2.5	500				
1N1193	S			R*	150	2.35	18	5.0	220				
1N1193A	S			R*	150	2.0	22	2.5	500				
1N1194	S			R*	200	2.35	18	5.0	220				
1N1194A	S			R*	200	2.0	22	2.5	500				
1N1195	S			R*	300	2.35	18	5.0	220				
1N1195A	S			R*	300	0.6	20	3.2	350				
1N1196	S			R*	400	2.35	18	5.0	220				
1N1196A	S			R*	400	0.6	20	2.5	350				
1N1197	S			R*	500	2.35	18	5.0	220				
1N1197A	S			R*	500	0.6	20	2.2	350				
1N1198	S			R*	600	2.35	18	5.0	220				
1N1198A	S			R*	600	0.6	20	1.5	350				
1N1199	S	*		R*	50		12	10					
1N1199A	S	1N1199 *		R*	50	1.35	12	3.0	240				
1N1199B	S			R*	50	1.2	12	0.9	250				
1N1200	S	*		R*	100		12	10					
1N1200A	S	1N1200 *		R*	100	1.35	50	2.5	12				
1N1200B	S			R*	100	1.2	12	0.9	250				
1N1201	S	*		R*	150		12	10					
1N1201A	S	1N1201 *		R*	150	1.35	50	2.25	12				
1N1201B	S			R*	150	1.2	12	0.9	250				
1N1202	S	*		R*	200		12	10					
1N1202A	S	1N1202 *		R*	200	1.35	50	2.0	12				
1N1202B	S			R*	200	1.2	12	0.9	250				
1N1203	S	*		R*	300		12	10					
1N1203A	S	1N1203 *		R*	300	1.35	50	1.75	12				
1N1203B	S			R*	300	1.2	12	0.9	250				
1N1204	S	*		R*	400		12	10					
1N1204A	S	1N1204 *		R*	400	1.35	50	1.5	12				
1N1204B	S			R*	400	1.2	12	0.9	250				
1N1205	S	*		R*	500		12	10					
1N1205A	S	1N1205 *		R*	500	1.35	50	1.25	12				
1N1205B	S			R*	500	1.2	12	0.9	250				
1N1206	S	*		R*	600		12	10					
1N1206A	S	1N1206 *		R*	600	1.35	50	1.0	12				
1N1206B	S			R*	600	1.2	12	0.9	250				
1N1217	S	1N4001	1N4001	R*	50	1.0	1.6	1.5	20				
1N1217A	S	1N4001	1N4001	R*	50	1.5	1.6	0.05					
1N1217B	S			R*	50	1.7	1.35	0.3	25				
1N1218	S	1N4002	1N4001	R*	100	1.0	1.6	1.5	20				
1N1218A	S	1N4002	1N4001	R*	100	1.5	1.6	0.05					
1N1218B	S			R*	100	1.7	1.35	0.3	25				
1N1219	S	1N4003	1N4001	R*	150	1.0	1.6	1.5	20				
1N1219A	S	1N4003	1N4001	R*	150	1.5	1.6	0.05					
1N1219B	S			R*	150	1.7	1.35	0.3	25				
1N1220	S	1N4003	1N4001	R*	200	1.0	1.6	1.5	20				
1N1220A	S	1N4003	1N4001	R*	200	1.5	1.6	0.05					
1N1220B	S			R*	200	1.7	1.35	0.3	25				
1N1221	S	1N4004	1N4001	R*	300	1.0	1.6	1.5	20				
1N1221A	S	1N4004	1N4001	R*	300	1.5	1.6	0.05					
1N1221B	S			R*	300	1.7	1.35	0.3	25				
1N1222	S	1N4004	1N4001	R*	400	1.0	1.6	1.5	20				
1N1222A	S	1N4004	1N4001	R*	400	1.5	1.6	0.05					
1N1222B	S			R*	400	1.7	1.35	0.3	25				
1N1223	S	1N4005	1N4001	R*	500	1.0	1.6	1.5	20				
1N1223A	S	1N4005	1N4001	R*	500	1.5	1.6	0.05					

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TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1223B	S			R*	500	1.7	1.35	0.3	25				
1N1224	S	1N4005	1N4001	R*	600	1.0	1.6	1.5	20				
1N1224A	S	1N4005	1N4001	R*	600	1.5	1.6	0.05					
1N1224B	S			R*	600	1.62	1.25	0.3	25				
1N1225	S	1N4006	1N4001	R*	700	1.0	1.6	1.5	20				
1N1225A	S	1N4006	1N4001	R*	700	1.55	1.1	0.5	25				
1N1225B	S			R*	700	1.62	1.25	0.3	25				
1N1226	S	1N4006	1N4001	R*	800	1.0	1.6	1.5	20				
1N1226A	S	1N4006	1N4001	R*	800	1.50	1.1	0.5	25				
1N1226B	S			R*	800	1.58	1.15	0.3	25				
1N1227	S			R*	50	1.0	1.6	1.5	20				
1N1227A	S	MR1120	MR1120	R*	50	1.5	1.6	0.05					
1N1228	S			R*	100	1.0	1.6	1.5	20				
1N1228A	S	MR1121	MR1120	R*	100	1.5	1.6	0.05					
1N1229	S			R*	150	1.0	1.6	1.5	20				
1N1229A	S	MR1122	MR1120	R*	150	1.5	1.6	0.05					
1N1230	S			R*	200	1.0	1.6	1.5	20				
1N1230A	S	MR1122	MR1120	R*	200	1.5	1.6	0.05					
1N1231	S			R*	300	1.0	1.6	1.5	20				
1N1231A	S	MR1123	MR1120	R*	300	1.5	1.6	0.05					
1N1232	S			R*	400	1.0	1.6	1.5	20				
1N1232A	S	MR1124	MR1120	R*	400	1.5	1.6	0.05					
1N1233	S			R*	500	1.0	1.6	1.5	20				
1N1233A	S	MR1125	MR1120	R*	500	1.5	1.6	0.05					
1N1234	S			R*	600	1.0	1.6	1.5	20				
1N1234A	S	MR1126	MR1120	R*	600	1.5	1.6	0.05					
1N1235	S			R*	700	1.0	1.6	1.5	20				
1N1236	S			R*	800	1.0	1.6	1.5	20				
1N1237	S			R*	1600		0.75		8.0				
1N1238	S			R*	1600		0.75		8.0				
1N1239	S			R*	2800		0.5		5.0				
1N1240	S			R*	50	1.0	0.25	0.5	5.0				
1N1241	S			R*	100	1.0	0.25	0.5	5.0				
1N1242	S			R*	200	1.0	0.25	0.5	5.0				
1N1243	S			R*	300	1.0	0.2	0.5	5.0				
1N1244	S			R*	400	1.0	0.15	0.5					
1N1244A	S			R*	400	1.0	0.2	0.5	5.0				
1N1245	S			R*	500	1.0	0.13	0.4					
1N1246	S			R*	600	1.0	0.115	0.3					
1N1247	S			R*	700	1.0	0.1	0.2					
1N1248	S			R*	800	1.0	0.08	0.1					
1N1249	S			R*	900	1.0	0.065	0.1					
1N1250	S			R*	1000	1.0	0.05	0.1					
1N1251	S	1N4001	1N4001	R*	50	1.0	0.25	0.5	5.0				
1N1252	S	1N4002	1N4001	R*	100	1.0	0.25	0.5	5.0				
1N1253	S	1N4003	1N4001	R*	200	1.0	0.25	0.5	5.0				
1N1254	S	1N4004	1N4001	R*	300	1.0	0.2	0.5	5.0				
1N1255	S	1N4004	1N4001	R*	400	1.0	0.15	0.5					
1N1255A	S			R*	400	1.0	0.2	0.5	5.0				
1N1256	S			R*	500	1.0	0.13	0.4					
1N1257	S			R*	600	1.0	0.115	0.3					
1N1258	S			R*	700	1.0	0.1	0.2					
1N1259	S			R*	800	1.0	0.08	0.1					
1N1260	S			R*	900	1.0	0.065	0.1					
1N1261	S			R*	1000	1.0	0.05	0.1					
1N1262	S			R*	4500		0.25		2.5				
1N1263	S			R*	50		150		1500				
1N1263A	S			R*	50		200		2000				
1N1264	S			R*	100		150		1500				
1N1264A	S			R*	100		200		2000				
1N1265	S			R*	200		150		1500				
1N1265A	S			R*	200		200		2000				
1N1266	S			R*	300		150		1500				
1N1266A	S			R*	300		200		2000				
1N1267	S			R*	50		150		1500				
1N1267A	S			R*	50		200		2000				
1N1268	S			R*	100		150		1500				
1N1268A	S			R*	100		200		2000				
1N1269	S			R*	200		150		1500				
1N1269A	S			R*	200		200		2000				
1N1270	S			R*	300		150		1500				
1N1270A	S			R*	300		200		2000				
1N1271	S			R*	50		160	40					
1N1272	S			R*	100		160	40					
1N1273	S			R*	150		160	40					
1N1274	S			R*	200		160	40					
1N1275	S			R*	300		160	40					
1N1276	S			R*	400		160	40					
1N1277	S			R*	500		160	40					
1N1281	S			R*	50		160	40					
1N1282	S			R*	100		160	40					
1N1283	S			R*	150		160	40					
1N1284	S			R*	200		160	40					

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1285	S			R*	300		160	40					
1N1286	S			R*	400		160	40					
1N1287	S			R*	500		160	40					
1N1291	S			R*	50		160	40					
1N1292	S			R*	100		160	40					
1N1293	S			R*	150		160	40					
1N1294	S			R*	200		160	40					
1N1295	S			R*	300		160	40					
1N1296	S			R*	400		160	40					
1N1297	S			R*	500		160	40					
1N1301	S			R*	50	0.63	17.5	15	300				
1N1302	S			R*	100	0.63	17.5	5.0	300				
1N1304	S			R*	200	0.63	17.5	5.0	300				
1N1306	S			R*	300	0.63	17.5	5.0	300				
1N1313	S	MZ92-8.8A	MZ92-2.4,A,B								8*	5.0	150M
1N1313A	S	MZ92-8.8B	MZ92-2.4,A,B								9.1*	5.0	150M
1N1314	S	MZ92-10.5A	MZ92-2.4,A,B								10*	5.0	150M
1N1314A	S	MZ92-10.5B	MZ92-2.4,A,B								10*	5.0	150M
1N1315	S	MZ92-12.8A	MZ92-2.4,A,B								12*	5.0	150M
1N1315A	S	MZ92-12.8B	MZ92-2.4,A,B								12*	5.0	150M
1N1316	S	MZ92-15.8A	MZ92-2.4,A,B								15*	5.0	150M
1N1316A	S	MZ92-15.8B	MZ92-2.4,A,B								15*	5.0	150M
1N1317	S	MZ92-19A	MZ92-2.4,A,B								20*	5.0	150M
1N1317A	S	MZ92-19B	MZ92-2.4,A,B								18*	5.0	150M
1N1318	S	MZ92-23.5A	MZ92-2.4,A,B								25*	5.0	150M
1N1318A	S	MZ92-23.5B	MZ92-2.4,A,B								22*	5.0	150M
1N1319	S	MZ92-28.5A	MZ92-2.4,A,B								30*	5.0	150M
1N1319A	S	MZ92-28.5B	MZ92-2.4,A,B								27*	5.0	150M
1N1320	S	MZ92-34.5A	MZ92-2.4,A,B								35*	5.0	150M
1N1320A	S	MZ92-34.5B	MZ92-2.4,A,B								33*	5.0	150M
1N1321	S	MZ92-41A	MZ92-2.4,A,B								40*	5.0	150M
1N1321A	S	MZ92-41B	MZ92-2.4,A,B								39*	5.0	150M
1N1322	S	MZ92-48.5A	MZ92-2.4,A,B								50*	5.0	150M
1N1322A	S	MZ92-48.5B	MZ92-2.4,A,B								47*	5.0	150M
1N1323	S	MZ92-58A	NZ92-2.4,A,B								60*	5.0	150M
1N1323A	S	MZ92-58B	MZ92-2.4,A,B								56*	5.0	150M
1N1324	S	MZ92-71A	MZ92-2.4,A,B								70*	5.0	150M
1N1325	S	MZ92-87.5A	MZ92-2.4,A,B								90*	5.0	150M
1N1326	S	MZ92-105A	MZ92-2.4,A,B								105*	5.0	150M
1N1327	S	MZ92-127.5A	MZ92-2.4,A,B								125*	5.0	150M
1N1329	S			R*	1500	1.3	0.1	0.02	2.0				
1N1330	S			R*	50		240	50					
1N1331	S			R*	100		240	50					
1N1332	S			R*	150		240	50					
1N1333	S			R*	200		240	50					
1N1334	S			R*	300		240	50					
1N1335	S			R*	400		240	50					
1N1336	S			R*	500		240	50					
1N1341	S	*		R*	50	1.6	6.0	4.0	150				
1N1341A	S	MR1120*	MR1120	R*	50	1.4	6.0	3.0	150				
1N1341B	S			R*	50	1.2	6.0	0.45	160				
1N1342	S	*		R*	100	1.6	6.0	4.0	150				
1N1342A	S	MR1121*	MR1120	R*	100	1.4	6.0	2.5	150				
1N1342B	S			R*	100	1.2	6.0	0.45	160				
1N1343	S	*		R*	150	1.6	6.0	4.0	150				
1N1343A	S	MR1122*	MR1120	R*	150	1.4	6.0	2.25	150				
1N1343B	S			R*	150	1.2	6.0	0.45	160				
1N1344	S	*		R*	200	1.6	6.0	4.0	150				
1N1344A	S	MR1122*	MR1120	R*	200	1.4	6.0	2.0	150				
1N1344B	S			R*	200	1.2	6.0	0.45	160				
1N1345	S	*		R*	300	1.6	6.0	4.0	150				
1N1345A	S	MR1123*	MR1120	R*	300	1.4	6.0	1.75	150				
1N1345B	S			R*	300	1.2	6.0	0.45	160				
1N1346	S	*		R*	400	1.6	6.0	4.0	150				
1N1346A	S	MR1124*	MR1120	R*	400	1.4	6.0	1.5	150				
1N1346B	S			R*	400	1.2	6.0	0.45	160				
1N1347	S	*		R*	500	1.6	6.0	4.0	150				
1N1347A	S	MR1125*	MR1120	R*	500	1.4	6.0	1.25	150				
1N1347B	S			R*	500	1.2	6.0	0.45	160				
1N1348	S	*		R*	600	1.6	6.0	4.0	150				
1N1348A	S	MR1126*	MR1120	R*	600	1.4	6.0	1.0	150				
1N1348B	S			R*	600	1.2	6.0	0.45	160				
1N1351	S	1N2974A *	1N2970	DZ							10*	10	10W
1N1351A	S	1N2974B *	1N2970	DZ							10*	5.0	10W
1N1352	S	1N2975A *	1N2970	DZ							11*	10	10W
1N1352A	S	1N2975B *	1N2970	DZ							11*	5.0	10W
1N1353	S	1N2976A *	1N2970	DZ							12*	10	10W
1N1353A	S	1N2976B *	1N2970	DZ							12*	5.0	10W
1N1354	S	1N2977A *	1N2970	DZ							13*	10	10W
1N1354A	S	1N2977B *	1N2970	DZ							13*	5.0	10W
1N1355	S	1N2979A *	1N2970	DZ							15*	10	10W
1N1355A	S	1N2979B *	1N2970	DZ							15*	5.0	10W

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F (volts) @ I_F		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1356	S	1N2980A*	1N2970	DZ							16*	10	10W
1N1356A	S	1N2980B*	1N2970	DZ							16*	5.0	10W
1N1357	S	1N2982A*	1N2970	DZ							18*	10	10W
1N1357A	S	1N2982B*	1N2970	DZ							18*	5.0	10W
1N1358	S	1N2984A*	1N2970	DZ							20*	10	10W
1N1358A	S	1N2984B*	1N2970	DZ							20*	5.0	10W
1N1359	S	1N2985A*	1N2970	DZ							22*	10	10W
1N1359A	S	1N2985B*	1N2970	DZ							22*	5.0	10W
1N1360	S	1N2986A*	1N2970	DZ							24*	10	10W
1N1360A	S	1N2986B*	1N2970	DZ							24*	5.0	10W
1N1361	S	1N2988A*	1N2970	DZ							27*	10	10W
1N1361A	S	1N2988B*	1N2970	DZ							27*	5.0	10W
1N1362	S	1N2989A*	1N2970	DZ							30*	10	10W
1N1362A	S	1N2989B*	1N2970	DZ							30*	5.0	10W
1N1363	S	1N2990A*	1N2970	DZ							33*	10	10W
1N1363A	S	1N2990B*	1N2970	DZ							33*	5.0	10W
1N1364	S	1N2991A*	1N2970	DZ							36*	10	10W
1N1364A	S	1N2991B*	1N2970	DZ							36*	5.0	10W
1N1365	S	1N2992A*	1N2970	DZ							39*	10	10W
1N1365A	S	1N2992B*	1N2970	DZ							39*	5.0	10W
1N1366	S	1N2993A*	1N2970	DZ							43*	10	10W
1N1366A	S	1N2993B*	1N2970	DZ							43*	5.0	10W
1N1367	S	1N2995A*	1N2970	DZ							47*	10	10W
1N1367A	S	1N2995B*	1N2970	DZ							47*	5.0	10W
1N1368	S	1N2997A*	1N2970	DZ							51*	10	10W
1N1368A	S	1N2997B*	1N2970	DZ							51*	5.0	10W
1N1369	S	1N2999A*	1N2970	DZ							56*	10	10W
1N1369A	S	1N2999B*	1N2970	DZ							56*	5.0	10W
1N1370	S	1N3000A*	1N2970	DZ							62*	10	10W
1N1370A	S	1N3000B*	1N2970	DZ							62*	5.0	10W
1N1371	S	1N3001A*	1N2970	DZ							68*	10	10W
1N1371A	S	1N3001B*	1N2970	DZ							68*	5.0	10W
1N1372	S	1N3002A*	1N9270	DZ							75*	10	10W
1N1372A	S	1N3002B*	1N9270	DZ							75*	5.0	10W
1N1373	S	1N3003A*	1N2970	DZ							82*	10	10W
1N1373A	S	1N3003B*	1N2970	DZ							82*	5.0	10W
1N1374	S	1N3004A*	1N2970	DZ							91*	10	10W
1N1374A	S	1N3004B*	1N2970	DZ							91*	5.0	10W
1N1375	S	1N3005A*	1N2970	DZ							100*	10	10W
1N1375A	S	1N3005B*	1N2970	DZ							100*	5.0	10W
1N1376	S			R*	50		240	50					
1N1377	S			R*	100		240	50					
1N1378	S			R*	150		240	50					
1N1379	S			R*	200		240	50					
1N1380	S			R*	300		240	50					
1N1381	S			R*	400		240	50					
1N1382	S			R*	500		240	50					
1N1396	S	MR1810SB		R*	50	1.55	70	15	1200				
1N1397	S	MR1811SB		R*	100	1.55	70	15	1200				
1N1398	S	MR1812SB		R*	150	1.55	70	15	1200				
1N1399	S	MR1813SB		R*	200	1.55	70	15	1200				
1N1400	S	MR1815SB		R*	300	1.55	70	15	1200				
1N1401	S	MR1817SB		R*	400	1.55	70	15	1200				
1N1402	S	MR1818SB		R*	500	1.55	70	15	1200				
1N1403	S	MR1819SB		R*	600	1.55	70	15	1200				
1N1406	S	1N4005	1N4001	R*	600	5.0	0.1	0.1	3.5				
1N1407	S	1N4006	1N4001	R*	800	5.0	1.0	0.1	3.5				
1N1408	S	1N4007	1N4001	R*	1000	5.0	1.0	0.1	3.5				
1N1409	S	MR991A	MR990A	R*	1200	5.0	0.1	0.1	3.5				
1N1410	S	MR991A	MR990A	R*	1500	6.25	0.1	0.1	3.5				
1N1411	S	MR992A	MR990A	R*	1800	7.5	0.1	0.1	3.5				
1N1412	S	MR992A	MR990A	R*	2000	6.25	0.1	0.1	3.5				
1N1413	S	MR993A	MR990A	R*	2400	7.5	0.1	0.1	3.5				
1N1414	S			R*	400	1.25	10	1.0	100				
1N1415	S			DS	1.1		1.0	1.0*					
1N1416	S	1N2972B	1N2970	DZ							8.2*	5.0	10W
1N1417	S	1N2976B	1N2970	DZ							12*	5.0	10W
1N1418	S	1N2979B	1N2970	DZ							15*	5.0	10W
1N1419	S	1N2982B	1N2970	DZ							18*	5.0	10W
1N1420	S	1N2985B	1N2970	DZ							22*	5.0	10W
1N1421	S	1N2988B	1N2970	DZ							27*	5.0	10W
1N1422	S	1N3001B	1N2970	DZ							68*	5.0	10W
1N1423	S	1N3005B	1N2970	DZ							100*	5.0	10W
1N1424	S	1N3011B	1N2970	DZ							150*	5.0	10W
1N1425	S	1N4738A	1N2970	DZ							8.2*	5.0	1.0W
1N1426	S	1N4742A	1N2970	DZ							12*	5.0	1.0W
1N1427	S	1N4744A	1N2970	DZ							15*	5.0	1.0W
1N1428	S	1N4746A	1N2970	DZ							18*	5.0	1.0W
1N1429	S	1N4748A	1N2970	DZ							22*	5.0	1.0W
1N1430	S	1N4750A	1N2070	DZ							27*	5.0	1.0W
1N1431	S	1N4760A	1N2070	DZ							68*	5.0	1.0W
1N1432	S	1N4764A	1N2070	DZ							100*	5.0	1.0W

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1433	S	1M150ZS5		DZ							150*	5.0	10W
1N1434	S	1N1183	1N1183	R*	50	1.2	30	5.0					
1N1435	S	1N1184	1N1183	R*	100	1.2	30	5.0					
1N1436	S	1N1186	1N1183	R*	200	1.2	30	5.0					
1N1437	S	1N1188	1N1183	R*	400	1.2	30	5.0					
1N1438	S	1N1190	1N1183	R*	600	1.2	30	5.0					
1N1440	S			R*	200	1.2	0.75	0.5	30				
1N1441	S			R*	300	1.2	0.75	0.5	30				
1N1442	S			R*	400	1.2	0.75	0.5	30				
1N1443	S	1N4007	1N4001	R*	1000	1.0	1.6	1.5	20				
1N1443A	S			R*	1000	1.45	1.1	0.5	25				
1N1443B	S			R*	1000	1.55	1.1	0.3	25				
1N1444	S	MR1130	MR1120	R*	1000	1.0	1.6	1.5	20				
1N1445	S			R*	360	2.0	0.2	4.0					
1N1446	S			R*	100	2.0		2.0					
1N1447	S			R*	200	2.0		2.0					
1N1448	S			R*	300	1.4		2.0					
1N1449	S			R*	400	2.0		2.0					
1N1450	S			R*	100	1.4		5.0					
1N1451	S			R*	200	1.4		5.0					
1N1452	S			R*	300	1.4		5.0					
1N1453	S			R*	400	1.4		5.0					
1N1454	S			R*	100	1.5	25	25					
1N1455	S			R*	200	1.5	25	25					
1N1456	S			R*	300	1.5	25	25					
1N1457	S			R*	400	1.5	25	25					
1N1458	S			R*	100	1.5	35	25					
1N1459	S			R*	200	1.5	35	25					
1N1460	S			R*	300	1.5	35	25					
1N1461	S			R*	400	1.5	35	25					
1N1462	S			R*	100	1.5	50	50					
1N1463	S			R*	200	1.5	50	50					
1N1464	S			R*	300	1.5	50	50					
1N1465	S			R*	400	1.5	50	50					
1N1466	S	MR1221FB		R*	100	1.5	75	50					
1N1467	S	MR1223FB		R*	200	1.5	75	50					
1N1468	S	MR1225FB		R*	300	1.5	75	50					
1N1469	S	MR1227FB		R*	400	1.5	75	50					
1N1470	S			R*	100	1.5	100	100					
1N1471	S			R*	200	1.5	100	100					
1N1472	S			R*	300	1.5	100	100					
1N1473	S			R*	400	1.5	100	100					
1N1474	S			R*	100	1.5	150	100					
1N1475	S			R*	200	1.5	150	100					
1N1476	S			R*	300	1.5	150	100					
1N1477	S			R*	400	1.5	150	100					
1N1478	S	MR1241FB	MR1240	R*	100	1.5	200	100					
1N1479	S	MR1243FB	MR1240	R*	200	1.5	200	100					
1N1480	S	MR1245FB	MR1240	R*	300	1.5	200	100					
1N1481	S	MR1247FB	MR1240	R*	400	1.5	200	100					
1N1482	S	1N3995A	1N3993	DZ						4.47	4.93		10W
1N1483	S	1N3998A	1N3993	DZ						5.90	6.50		10W
1N1484	S	1N4732A	1N4728	DZ						4.47	4.93		1.0W
1N1485	S	1N4735A	1N4728	DZ							6.2*	5.0	1.0W
1N1486	S	1N4005	1N4001	R*	500		0.5	3.5					
1N1487	S	1N4002	1N4001	R*	100	0.55	0.25	0.4	15				
1N1488	S	1N4003	1N4001	R*	200	0.55	0.25	0.3	15				
1N1489	S	1N4004	1N4001	R*	300	0.55	0.25	0.3	15				
1N1490	S	1N4004	1N4001	R*	400	0.55	0.25	0.3	15				
1N1491	S	1N4005	1N4001	R*	500	0.55		0.3	15				
1N1492	S	1N4005	1N4001	R*	600	0.55		0.3	15				
1N1507	S	1N4730 *	1N4728	DZ							3.9*	10	750M
1N1507A	S	1N4730A *	1N4728	DZ							3.9*	5.0	750M
1N1508	S	1N4732 *	1N4728	DZ							4.7*	10	750M
1N1508A	S	1N4732A *	1N4728	DZ							4.7*	5.0	750M
1N1509	S	1N4734 *	1N4728	DZ							5.6*	10	750M
1N1509A	S	1N4734A *	1N4728	DZ							5.6*	5.0	750M
1N1510	S	1N4736 *	1N4728	DZ							6.8*	10	750M
1N1510A	S	1N4736A *	1N4728	DZ							6.8*	5.0	750M
1N1511	S	1N4738 *	1N4728	DZ							8.2*	10	750M
1N1511A	S	1N4738A *	1N4728	DZ							8.2*	5.0	750M
1N1512	S	1N4740 *	1N4728	DZ							10*	10	750M
1N1512A	S	1N4740A *	1N4728	DZ							10*	5.0	750M
1N1513	S	1N4742 *	1N4728	DZ							12*	10	750M
1N1513A	S	1N4742A *	1N4728	DZ							12*	5.0	750M
1N1514	S	1N4744 *	1N4728	DZ							15*	10	750M
1N1514A	S	1N4744A *	1N4728	DZ							15*	5.0	750M
1N1515	S	1N4746 *	1N4728	DZ							18*	10	750M
1N1515A	S	1N4746A *	1N4728	DZ							18*	5.0	750M
1N1516	S	1N4748 *	1N4728	DZ							22*	10	750M
1N1516A	S	1N4748A *	1N4728	DZ							22*	5.0	750M
1N1517	S	1N4750 *	1N4728	DZ							27*	10	750M

Replacement * denotes exact device type replacement available on request.

1N1517A–1N1590A

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1517A	S	1N4750A *	1N4728	DZ							27*	5.0	750M
1N1518	S	1N4730 *	1N4728	DZ							3.9*	10	1.0W
1N1518A	S	1N4730A *	1N4728	DZ							3.9*	5.0	1.0W
1N1519	S	1N4732 *	1N4728	DZ							4.7*	10	1.0W
1N1519A	S	1N4732A *	1N4728	DZ							4.7*	5.0	1.0W
1N1520	S	1N4734 *	1N4728	DZ							5.6*	10	1.0W
1N1520A	S	1N4734A *	1N4728	DZ							5.6*	5.0	1.0W
1N1521	S	1N4736 *	1N4728	DZ							6.8*	10	1.0W
1N1521A	S	1N4736A *	1N4728	DZ							6.8*	5.0	1.0W
1N1522	S	1N4738 *	1N4728	DZ							8.2*	10	1.0W
1N1522A	S	1N4738A *	1N4728	DZ							8.2*	5.0	1.0W
1N1523	S	1N4740 *	1N4728	DZ							10*	10	1.0W
1N1523A	S	1N4740A *	1N4728	DZ							10*	5.0	1.0W
1N1524	S	1N4742 *	1N4728	DZ							12*	10	1.0W
1N1524A	S	1N4742A *	1N4728	DZ							12*	5.0	1.0W
1N1525	S	1N4744 *	1N4728	DZ							15*	10	1.0W
1N1525A	S	1N4744A *	1N4728	DZ							15*	5.0	1.0W
1N1526	S	1N4746 *	1N4728	DZ							18*	10	1.0W
1N1526A	S	1N4746A *	1N4728	DZ							18*	5.0	1.0W
1N1527	S	1N4748 *	1N4728	DZ							22*	10	1.0W
1N1527A	S	1N4748A *	1N4728	DZ							22*	5.0	1.0W
1N1528	S	1N4750 *	1N4728	DZ							27*	10	1.0W
1N1528A	S	1N4750A *	1N4728	DZ							27*	5.0	1.0W
1N1530	S	1N3156 *	1N3154	DR							8.4	-55	100
1N1530A	S	1N3157 *	1N3154	DR							8.4	-55	100
1N1537	S	MR1120 *		R*	50	1.5	1.6	0.05					
1N1538	S	MR1121 *		R*	100	1.5	1.6	0.05					
1N1539	S	MR1122 *		R*	150	1.5	1.6	0.05					
1N1540	S	MR1122 *		R*	200	1.5	1.6	0.05					
1N1541	S	MR1123 *		R*	300	1.5	1.6	0.05					
1N1542	S	MR1124 *		R*	400	1.5	1.6	0.05					
1N1543	S	MR1125 *		R*	500	1.5	1.6	0.05					
1N1544	S	MR1126 *		R*	600	1.5	1.6	0.05					
1N1551	S	MR1121		R*	100	1.4		1.0					
1N1552	S	MR1122		R*	200	1.4		1.0					
1N1553	S	MR1123		R*	300	1.4		1.0					
1N1554	S	MR1124		R*	400	1.4		1.0					
1N1555	S	MR1125		R*	500	1.4		1.0					
1N1556	S			R*	100	1.4		1.0					
1N1557	S			R*	200	1.4		1.0					
1N1558	S			R*	300	1.4		1.0					
1N1559	S			R*	400	1.4		1.0					
1N1560	S			R*	500	1.4		1.0					
1N1561	G			DS	25	0.4	12M	25*					
1N1562	G			DS	25	0.4	8.0M	25*					
1N1563	S			R*	100	1.5	1.0	0.003	70				
1N1563A	S			R*	100	1.5	1.5	0.003	70				
1N1564	S			R*	200	1.5	1.0	0.003	70				
1N1564A	S			R*	200	1.5	1.5	0.003	70				
1N1565	S			R*	300	1.5	1.0	0.003	70				
1N1565A	S			R*	300	1.5	1.5	0.003	70				
1N1566	S			R*	400	1.5	1.0	0.003	70				
1N1566A	S			R*	400	1.5	1.5	0.003	70				
1N1567	S			R*	500	1.2	1.0	0.005	70				
1N1567A	S			R*	500	1.5	1.5	0.003	70				
1N1568	S			R*	600	1.2	1.0	0.005	70				
1N1568A	S			R*	600	1.5	1.5	0.003	70				
1N1569	S			R*	100	1.5	1.0	0.005	70				
1N1570	S			R*	200	1.5	1.0	0.005	70				
1N1571	S			R*	300	1.5	1.0	0.005	70				
1N1572	S			R*	400	1.5	1.0	0.005	70				
1N1573	S			R*	500	1.5	1.0	0.005	70				
1N1574	S			R*	600	1.5	1.0	0.005	70				
1N1575	S			R*	100	1.5	3.5	0.005	70				
1N1576	S			R*	200	1.5	3.5	0.005	70				
1N1577	S			R*	300	1.5	3.5	0.005	70				
1N1578	S			R*	400	1.5	3.5	0.005	70				
1N1579	S			R*	500	1.5	3.5	0.005	70				
1N1580	S			R*	600	1.5	3.5	0.005	70				
1N1581	S	MR1120	MR1120	R*	50	1.5	3.0	5.0	40				
1N1582	S	MR1121	MR1120	R*	100	1.5	3.0	5.0	40				
1N1583	S	MR1122	MR1120	R*	200	1.5	3.0	5.0	40				
1N1584	S	MR1123	MR1120	R*	300	1.5	3.0	5.0	40				
1N1585	S	MR1124	MR1120	R*	400	1.5	3.0	5.0	40				
1N1586	S	MR1125	MR1120	R*	500	1.5	3.0	5.0	40				
1N1587	S	MR1126	MR1120	R*	600	1.5	3.0	5.0	40				
1N1588	S	1N3993 *	1N3993	DZ							3.9*	10	3.5W
1N1588A	S	1N3993A *	1N3993	DZ							3.9*	5.0	3.5W
1N1589	S	1N3995 *	1N3993	DZ							4.7*	10	3.5W
1N1589A	S	1N3995A *	1N3993	DZ							4.7*	5.0	3.5W
1N1590	S	1N3997 *	1N3993	DZ							5.6*	10	3.5W
1N1590A	S	1N3997A *	1N3993	DZ							5.6*	5.0	3.5W

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TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1591	S	1N2970RA *	1N2970	DZ							6.8*	10	3.5W
1N1591A	S	1N2970RB *	1N2970	DZ							6.8*	5.0	3.5W
1N1592	S	1N2972RA *	1N2970	DZ							8.2*	10	3.5W
1N1592A	S	1N2972RB *	1N2970	DZ							8.2*	5.0	3.5W
1N1593	S	1N2974RA *	1N2970	DZ							10*	10	3.5W
1N1593A	S	1N2974RB *	1N2970	DZ							10*	5.0	3.5W
1N1594	S	1N2976RA *	1N2970	DZ							12*	10	3.5W
1N1594A	S	1N2976RB *	1N2970	DZ							12*	5.0	3.5W
1N1595	S	1N2979RA *	1N2970	DZ							15*	10	3.5W
1N1595A	S	1N2979RB *	1N2970	DZ							15*	5.0	3.5W
1N1596	S	1N2982RA *	1N2970	DZ							18*	10	3.5W
1N1596A	S	1N2982RB *	1N2970	DZ							18*	5.0	3.5W
1N1597	S	1N2985RA *	1N2970	DZ							22*	10	3.5W
1N1597A	S	1N2985RB *	1N2970	DZ							22*	5.0	3.5W
1N1598	S	1N2988RA *	1N2970	DZ							27*	10	3.5W
1N1598A	S	1N2988RB *	1N2970	DZ							27*	5.0	3.5W
1N1599	S	1N3993 *	1N3993	DZ							3.9*	10	10W
1N1599A	S	1N3993A *	1N3993	DZ							3.9*	5.0	10W
1N1600	S	1N3995 *	1N3993	DZ							4.7*	10	10W
1N1600A	S	1N3995A *	1N3993	DZ							4.7*	5.0	10W
1N1601	S	1N3997 *	1N3993	DZ							5.6*	10	10W
1N1601A	S	1N3997A *	1N3993	DZ							5.6*	5.0	10W
1N1602	S	1N2970RA *	1N2970	DZ							6.8*	10	10W
1N1602A	S	1N2970RB *	1N2970	DZ							6.8*	5.0	10W
1N1603	S	1N2972RA *	1N2970	DZ							8.2*	10	10W
1N1603A	S	1N2972RB *	1N2970	DZ							8.2*	5.0	10W
1N1604	S	1N2974RA *	1N2970	DZ							10*	10	10W
1N1604A	S	1N2974RB *	1N2970	DZ							10*	5.0	10W
1N1605	S	1N2976RA *	1N2970	DZ							12*	10	10W
1N1605A	S	1N2976RB *	1N2970	DZ							12*	5.0	10W
1N1606	S	1N2979RA *	1N2970	DZ							15*	10	10W
1N1606A	S	1N2979RB *	1N2970	DZ							15*	5.0	10W
1N1607	S	1N2982RA *	1N2970	DZ							18*	10	10W
1N1607A	S	1N2982RB *	1N2970	DZ							18*	5.0	10W
1N1608	S	1N2985RA *	1N2970	DZ							22*	10	10W
1N1608A	S	1N2985RB *	1N2970	DZ							22*	5.0	10W
1N1609	S	1N2988RA *	1N2970	DZ							27*	10	10W
1N1609A	S	1N2988RB *	1N2970	DZ							27*	5.0	10W
1N1610	S	Microwave S-X-band Detector											
1N1611	S	Microwave C-X-band Detector											
1N1611A	S	Microwave C-X-band Detector											
1N1611B	S	Microwave C-X-band Detector											
1N1612	S	MR1120*	MR1120	R*	50	1.5	5.0	1.0					
1N1613	S	MR1121*	MR1120	R*	100	1.5	5.0	1.0					
1N1614	S	MR1122*	MR1120	R*	200	1.5	5.0	1.0					
1N1615	S	MR1124*	MR1120	R*	400	1.5	5.0	1.0					
1N1616	S	MR1126*	MR1120	R*	600	1.5	5.0	1.0					
1N1617	S	1N4002	1N4001	R*	100	1.2	1.5		60				
1N1618	S	1N4003	1N4001	R*	200	1.2	1.5		60				
1N1619	S	1N4004	1N4001	R*	300	1.2	1.5		60				
1N1620	S	1N4004	1N4001	R*	400	1.2	1.5		60				
1N1621	S			R*	100	1.2	10		80				
1N1622	S			R*	200	1.2	10		80				
1N1623	S			R*	300	1.2	10		80				
1N1624	S			R*	400	1.2	10		80				
1N1625	Se			R*	48	1.0		0.015	0.005				
1N1625A	Se			R*	48	1.0		0.015	0.01				
1N1626	Se			R*	96	2.0		0.015	0.005				
1N1626A	Se			R*	96	2.0		0.015	0.01				
1N1627	Se			R*	48	1.0		0.027	0.08				
1N1628	Se			R*	96	2.0		0.027	0.08				
1N1629	Se			R*	144	3.0		0.027	0.08				
1N1630	Se			R*	192	4.0		0.027	0.08				
1N1631	Se			R*	240	5.0		0.027	0.08				
1N1632	Se			R*	288	6.0		0.027	0.08				
1N1633	Se			R*	336	7.0		0.027	0.08				
1N1634	Se			R*	384	8.0		0.027	0.08				
1N1635	Se			R*	48	1.0		0.108	0.25				
1N1636	Se			R*	96	2.0		0.108	0.25				
1N1637	Se			R*	144	3.0		0.108	0.25				
1N1638	Se			R*	192	4.0		0.108	0.25				
1N1639	Se			R*	240	5.0		0.108	0.25				
1N1640	Se			R*	48	1.0	0.028	0.240	0.55				
1N1641	Se			R*	96	2.0	0.028	0.240	0.55				
1N1642	Se			R*	144	3.0	0.028	0.240	0.55				
1N1644	S			R*	50	0.5	0.25	0.4	15				
1N1645	S			R*	100	0.5	0.25	0.4	15				
1N1646	S			R*	150	0.5	0.25	0.3	15				
1N1647	S			R*	200	0.5	0.25	0.3	15				
1N1648	S			R*	250	0.5	0.25	0.3	15				
1N1649	S			R*	300	0.5	0.25	0.3	15				
1N1650	S			R*	350	0.5	0.25	0.3	15				

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TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1651	S			R*	400	0.5	0.25	0.3	15				
1N1652	S			R*	500	0.5	0.25	0.3	15				
1N1653	S			R*	600	0.5	0.25	0.3	15				
1N1660	S			R*	50		160	40					
1N1661	S	MR1221SB	MR1220	R*	100		160	40					
1N1662	S	MR1222SB	MR1220	R*	150		160	40					
1N1663	S	MR1223SB	MR1220	R*	200		160	40					
1N1664	S	MR1225SB	MR1220	R*	300		160	40					
1N1665	S	MR1227SB	MR1220	R*	400		160	40					
1N1666	S	MR1228SB	MR1220	R*	500		160	40					
1N1670	S			R*	50		240	50					
1N1671	S			R*	100		240	50					
1N1672	S			R*	150		240	50					
1N1673	S			R*	200		240	50					
1N1674	S			R*	300		240	50					
1N1675	S			R*	400		240	50					
1N1676	S			R*	500		240	50					
1N1680	S			R*	150	1.1	50	25	700				
1N1681	S			R*	250	1.1	50	25	700				
1N1682	S			R*	300	1.1	50	25	700				
1N1683	S			R*	350	1.1	50	25	700				
1N1684	S			R*	400	1.1	50	25	700				
1N1685	S			R*	450	1.1	50	25	700				
1N1686	S			R*	500	1.1	50	25	700				
1N1687	S			R*	600	1.1	50	25	700				
1N1688	S			R*	700	1.1	50	25	700				
1N1689	S			R*	800	1.1	50	25	700				
1N1690	S			R*	900	1.1	50	25	700				
1N1691	S			R*	1000	1.1	50	25	700				
1N1692	S	1N4002	1N4001	R*	100	0.6	0.25	0.5	20				
1N1693	S	1N4003	1N4001	R*	200	0.6	0.25	0.5	20				
1N1694	S	1N4004	1N4001	R*	300	0.6	0.25	0.5	20				
1N1695	S	1N4004	1N4001	R*	400	0.6	0.25	0.5	20				
1N1696	S	1N4005	1N4001	R*	500	0.6		0.5	20				
1N1697	S	1N4005	1N4001	R*	600	0.6		0.5	20				
1N1698	S			R*	6600	33	0.062						
1N1699	S			R*	10K	37	0.058						
1N1700	S			R*	12K	45	0.05						
1N1701	S	1N4001	1N4001	R*	50	1.3	0.3	0.2	8.0				
1N1702	S	1N4002	1N4001	R*	100	1.3	0.3	0.2	8.0				
1N1703	S	1N4003	1N4001	R*	200	1.3	0.3	0.2	8.0				
1N1704	S	1N4004	1N4001	R*	300	1.3	0.3	0.2	8.0				
1N1705	S	1N4004	1N4001	R*	400	1.3	0.3	0.2	8.0				
1N1706	S	1N4005	1N4001	R*	500	1.3	0.3	0.2	8.0				
1N1707	S	1N4001	1N4001	R*	50	1.15	0.5	0.2	10				
1N1708	S	1N4002	1N4001	R*	100	1.15	0.5	0.2	10				
1N1709	S	1N4003	1N4001	R*	200	1.15	0.5	0.2	10				
1N1710	S	1N4004	1N4001	R*	300	1.15	0.5	0.2	10				
1N1711	S	1N4004	1N4001	R*	400	1.15	0.5	0.2	10				
1N1712	S	1N4005	1N4001	R*	500	1.15	0.5	0.2	10				
1N1730	S	1N4007	1N4001	R*	1000	5.0		0.1	2.5				
1N1730A	S			R*	1000		0.35		6.0				
1N1731	S	MR991A	MR990A	R*	1500	5.0		0.1	2.5				
1N1731A	S			R*	1500		0.35		6.0				
1N1732	S	MR992A	MR990A	R*	2000	9.0		0.1	2.5				
1N1732A	S			R*	2000		0.35		6.0				
1N1733	S	MR994A	MR990A	R*	3000	12		0.1	2.5				
1N1733A	S			R*	3000		0.35		6.0				
1N1734	S	MR996A	MR990A	R*	5000	18		0.1	2.5				
1N1734A	S			R*	5000		0.35		6.0				
1N1735	S	1N821 *	1N821	DR						0.01	6.2	-55	100
1N1736	S	1N941A *	1N941	DR						0.01	12.4	-55	100
1N1736A	S	1N942A *	1N941	DR						0.005	12.4	-55	100
1N1737	S	1N4060 *	1N429	DR						0.01	18.6	-55	100
1N1737A	S	1N4060A *	1N429	DR						0.005	18.6	-55	100
1N1738	S	1N4062 *	1N429	DR						0.01	24.8	-55	100
1N1738A	S	1N4062A *	1N429	DR						0.005	24.8	-55	100
1N1739	S	1N4064 *	1N429	DR						0.01	31.0	-55	100
1N1739A	S	1N4064A *	1N429	DR						0.005	31.0	-55	100
1N1740	S	1N4066 *	1N429	DR						0.01	37.2	-55	100
1N1740A	S	1N4066A *	1N429	DR						0.005	37.2	-55	100
1N1741	S	1N4067 *	1N429	DR						0.01	43.4	-55	100
1N1741A	S	1N4067A *	1N429	DR						0.005	43.4	-55	100
1N1742	S	1N4069 *	1N429	DR						0.01	49.6	-55	100
1N1742A	S	1N4069A *	1N429	DR						0.005	49.6	-55	100
1N1743	S	1N2974A	1N2970	DZ							10*	5.0	10W
1N1744	S	1N4740	1N4728	DZ							10*	10	1.0W
1N1745	S			R*	1500	15	0.32	0.2	3.5				
1N1746	S			R*	1500	7.5	0.5	0.2	3.5				
1N1747	S			R*	1800	18	0.31	0.2	3.5				
1N1748	S			R*	1800	9.0	0.38	0.2	3.5				
1N1749	S			R*	2400	24	0.37	0.2	3.5				

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1750	S			R*	2400	12	0.32	0.2	3.5				
1N1751	S			R*	3600	27	0.42	0.2	3.5				
1N1752	S			R*	3600	18	0.41	0.2	3.5				
1N1753	S			R*	4800	36	0.38	0.2	3.5				
1N1754	S			R*	4800	24	0.37	0.2	3.5				
1N1755	S			R*	6000	45	0.33	0.2	3.5				
1N1756	S			R*	6000	30	0.41	0.2	3.5				
1N1757	S			R*	7200	54	0.33	0.2	3.5				
1N1758	S			R*	7200	36	0.38	0.2	3.5				
1N1759	S			R*	8000	60	0.29	0.2	3.5				
1N1760	S			R*	12K	60	0.29	0.2	3.5				
1N1761	S			R*	14K	52	0.34	0.2	3.5				
1N1762	S			R*	16K	60	0.29	0.2	3.5				
1N1763	S	1N4004	1N4001	R*	400	3.0	0.5	0.1	35				
1N1763A	S			R*	400	1.2	1.0	0.5	25				
1N1764	S	1N4005	1N4001	R*	500	3.0	0.5	0.1	35				
1N1764A	S			R*	500	1.2	1.0	0.5	25				
1N1765	S	1N4734 *	1N4728	DZ							5.6*	10	1.0W
1N1765A	S	1N4734A *	1N4728	DZ							5.6*	5.0	1.0W
1N1766	S	1N4735 *	1N4728	DZ							6.2*	10	1.0W
1N1766A	S	1N4735A *	1N4728	DZ							6.2*	5.0	1.0W
1N1767	S	1N4736 *	1N4728	DZ							6.8*	10	1.0W
1N1767A	S	1N4736A *	1N4728	DZ							6.8*	5.0	1.0W
1N1768	S	1N4737 *	1N4728	DZ							7.5*	10	1.0W
1N1768A	S	1N4737A *	1N4728	DZ							7.5*	5.0	1.0W
1N1769	S	1N4738 *	1N4728	DZ							8.2*	10	1.0W
1N1769A	S	1N4738A *	1N4728	DZ							8.2*	5.0	1.0W
1N1770	S	1N4739 *	1N4728	DZ							9.1*	10	1.0W
1N1770A	S	1N4739A *	1N4728	DZ							9.1*	5.0	1.0W
1N1771	S	1N4740 *	1N4728	DZ							10*	10	1.0W
1N1771A	S	1N4740A *	1N4728	DZ							10*	5.0	1.0W
1N1772	S	1N4741 *	1N4728	DZ							11*	10	1.0W
1N1772A	S	1N4741A *	1N4728	DZ							11*	5.0	1.0W
1N1773	S	1N4742 *	1N4728	DZ							12*	10	1.0W
1N1773A	S	1N4742A *	1N4728	DZ							12*	5.0	1.0W
1N1774	S	1N4743 *	1N4728	DZ							13*	10	1.0W
1N1174A	S	1N4743A *	1N4728	DZ							13*	5.0	1.0W
1N1775	S	1N4744 *	1N4728	DZ							15*	10	1.0W
1N1775A	S	1N4744A *	1N4728	DZ							15*	5.0	1.0W
1N1776	S	1N4745 *	1N4728	DZ							16*	10	1.0W
1N1776A	S	1N4745A *	1N4728	DZ							16*	5.0	1.0W
1N1777	S	1N4746 *	1N4728	DZ							18*	10	1.0W
1N1777A	S	1N4746A *	1N4728	DZ							18*	5.0	1.0W
1N1778	S	1N4747 *	1N4728	DZ							20*	10	1.0W
1N1778A	S	1N4747A *	1N4728	DZ							20*	5.0	1.0W
1N1779	S	1N4748 *	1N4728	DZ							22*	10	1.0W
1N1779A	S	1N4748A *	1N4728	DZ							22*	5.0	1.0W
1N1780	S	1N4749 *	1N4728	DZ							24*	10	1.0W
1N1780A	S	1N4749A *	1N4728	DZ							24*	5.0	1.0W
1N1781	S	1N4750 *	1N4728	DZ							27*	10	1.0W
1N1781A	S	1N4750A *	1N4728	DZ							27*	5.0	1.0W
1N1782	S	1N4751 *	1N4728	DZ							30*	10	1.0W
1N1782A	S	1N4751A *	1N4728	DZ							30*	5.0	1.0W
1N1783	S	1N4752 *	1N4728	DZ							33*	10	1.0W
1N1783A	S	1N4752A *	1N4728	DZ							33*	5.0	1.0W
1N1784	S	1N4753 *	1N4728	DZ							36*	10	1.0W
1N1784A	S	1N4753A *	1N4728	DZ							36*	5.0	1.0W
1N1785	S	1N4754 *	1N4728	DZ							39*	10	1.0W
1N1785A	S	1N4754A *	1N4728	DZ							39*	5.0	1.0W
1N1786	S	1N4755 *	1N4728	DZ							43*	10	1.0W
1N1786A	S	1N4755A *	1N4728	DZ							43*	5.0	1.0W
1N1787	S	1N4756 *	1N4728	DZ							47*	10	1.0W
1N1787A	S	1N4756A *	1N4728	DZ							47*	5.0	1.0W
1N1788	S	1N4757 *	1N4728	DZ							51*	10	1.0W
1N1788A	S	1N4757A *	1N4728	DZ							51*	5.0	1.0W
1N1789	S	1N4758 *	1N4728	DZ							56*	10	1.0W
1N1789A	S	1N4758A *	1N4728	DZ							56*	5.0	1.0W
1N1790	S	1N4759 *	1N4728	DZ							62*	10	1.0W
1N1790A	S	1N4759A *	1N4728	DZ							62*	5.0	1.0W
1N1791	S	1N4760 *	1N4728	DZ							68*	10	1.0W
1N1791A	S	1N4760A *	1N4728	DZ							68*	5.0	1.0W
1N1792	S	1N4761 *	1N4728	DZ							75*	10	1.0W
1N1792A	S	1N4761A *	1N4728	DZ							75*	5.0	1.0W
1N1793	S	1N4762 *	1N4728	DZ							82*	10	1.0W
1N1793A	S	1N4762A *	1N4728	DZ							82*	5.0	1.0W
1N1794	S	1N4763 *	1N4728	DZ							91*	10	1.0W
1N1794A	S	1N4763A *	1N4728	DZ							91*	5.0	1.0W
1N1795	S	1N4764 *	1N4728	DZ							100*	10	1.0W
1N1795A	S	1N4764A *	1N4728	DZ							100*	5.0	1.0W
1N1796	S	1M110ZS10*	1N4728	DZ							110*	10	1.0W
1N1796A	S	1M110ZS5 *	1N4728	DZ							110*	5.0	1.0W
1N1797	S	1M120ZS10*	1N4728	DZ							120*	10	1.0W

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1797A	S	1M120ZS5 *	1N4728	DZ							120*	5.0	1.0W
1N1798	S	1M130ZS10 *	1N4728	DZ							130*	10	1.0W
1N1798A	S	1M130ZS5 *	1N4728	DZ							130*	5.0	1.0W
1N1799	S	1M150ZS10 *	1N4728	DZ							150*	10	1.0W
1N1799A	S	1M150ZS5 *	1N4728	DZ							150*	5.0	1.0W
1N1800	S	1M160ZS10 *	1N4728	DZ							160*	10	1.0W
1N1800A	S	1M160ZS5 *	1N4728	DZ							160*	5.0	1.0W
1N1801	S	1M180ZS10 *	1N4728	DZ							180*	10	1.0W
1N1801A	S	1M180ZS5 *	1N4728	DZ							180*	5.0	1.0W
1N1802	S	1M200ZS10 *	1N4728	DZ							200*	10	1.0W
1N1802A	S	1M200ZS5 *	1N4728	DZ							200*	5.0	1.0W
1N1803	S	1N3997R *	1N3993	DZ							5.6*	10	10W
1N1803A	S	1N3997RA *	1N3993	DZ							5.6*	5.0	10W
1N1804	S	1N3998R *	1N3993	DZ							6.2*	10	10W
1N1804A	S	1N3998RA *	1N3993	DZ							6.2*	5.0	10W
1N1805	S	1N2970A *	1N2970	DZ							6.8*	10	10W
1N1805A	S	1N2970B *	1N2970	DZ							6.8*	5.0	10W
1N1806	S	1N2971A *	1N2970	DZ							7.5*	10	10W
1N1806A	S	1N2971B *	1N2970	DZ							7.5*	5.0	10W
1N1807	S	1N2972A *	1N2970	DZ							8.2*	10	10W
1N1807A	S	1N2972B *	1N2970	DZ							8.2*	5.0	10W
1N1808	S	1N2973A *	1N2970	DZ							9.1*	10	10W
1N1808A	S	1N2973B *	1N2970	DZ							9.1*	5.0	10W
1N1809	S	1N3007A *	1N2970	DZ							110*	10	10W
1N1809A	S	1N3007B *	1N2970	DZ							110*	5.0	10W
1N1810	S	1N3008A *	1N2970	DZ							120*	10	10W
1N1810A	S	1N3008B *	1N2970	DZ							120*	5.0	10W
1N1811	S	1N3009A *	1N2970	DZ							130*	10	10W
1N1811A	S	1N3009B *	1N2970	DZ							130*	5.0	10W
1N1812	S	1N3011A *	1N2970	DZ							150*	10	10W
1N1812A	S	1N3011B *	1N2970	DZ							150*	5.0	10W
1N1813	S	1N3012A *	1N2970	DZ							160*	10	10W
1N1813A	S	1N3012B *	1N2970	DZ							160*	5.0	10W
1N1814	S	1N3014A *	1N2970	DZ							180*	10	10W
1N1814A	S	1N3014B *	1N2970	DZ							180*	5.0	10W
1N1815	S	1N3015A *	1N2970	DZ							200*	10	10W
1N1815A	S	1N3015B *	1N2970	DZ							200*	5.0	10W
1N1816	S	1N2977A *	1N2970	DZ							13*	10	10W
1N1816A	S	1N2977B *	1N2970	DZ							13*	5.0	10W
1N1817	S	1N2979A *	1N2970	DZ							15*	10	10W
1N1817A	S	1N2979B *	1N2970	DZ							15*	5.0	10W
1N1818	S	1N2980A *	1N2970	DZ							16*	10	10W
1N1818A	S	1N2980B *	1N2970	DZ							16*	5.0	10W
1N1819	S	1N2982A *	1N2970	DZ							18*	10	10W
1N1819A	S	1N2982B *	1N2970	DZ							18*	5.0	10W
1N1820	S	1N2984A *	1N2970	DZ							20*	10	10W
1N1820A	S	1N2984B *	1N2970	DZ							20*	5.0	10W
1N1821	S	1N2985A *	1N2970	DZ							22*	10	10W
1N1821A	S	1N2985B *	1N2970	DZ							22*	5.0	10W
1N1822	S	1N2986A *	1N2970	DZ							24*	10	10W
1N1822A	S	1N2986B *	1N2970	DZ							24*	5.0	10W
1N1823	S	1N2988A *	1N2970	DZ							27*	10	10W
1N1823A	S	1N2988B *	1N2970	DZ							27*	5.0	10W
1N1824	S	1N2989A *	1N2970	DZ							30*	10	10W
1N1824A	S	1N2989B *	1N2970	DZ							30*	5.0	10W
1N1825	S	1N2990A *	1N2970	DZ							33*	10	10W
1N1825A	S	1N2990B *	1N2970	DZ							33*	5.0	10W
1N1826	S	1N2991A *	1N2970	DZ							36*	10	10W
1N1826A	S	1N2991B *	1N2970	DZ							36*	5.0	10W
1N1827	S	1N2992A *	1N2970	DZ							39*	10	10W
1N1827A	S	1N2992B *	1N2970	DZ							39*	5.0	10W
1N1828	S	1N2993A *	1N2970	DZ							43*	10	10W
1N1828A	S	1N2993B *	1N2970	DZ							43*	5.0	10W
1N1829	S	1N2995A *	1N2970	DZ							47*	10	10W
1N1829A	S	1N2995B *	1N2970	DZ							47*	5.0	10W
1N1830	S	1N2997A *	1N2970	DZ							51*	10	10W
1N1830A	S	1N2997B *	1N2970	DZ							51*	5.0	10W
1N1831	S	1N2999A *	1N2970	DZ							56*	10	10W
1N1831A	S	1N2999B *	1N2970	DZ							56*	5.0	10W
1N1832	S	1N3000A *	1N2970	DZ							62*	10	10W
1N1832A	S	1N3000B *	1N2970	DZ							62*	5.0	10W
1N1833	S	1N3001A *	1N2970	DZ							68*	10	10W
1N1833A	S	1N3001B *	1N2970	DZ							68*	5.0	10W
1N1834	S	1N3002A *	1N2970	DZ							75*	10	10W
1N1834A	S	1N3002B *	1N2970	DZ							75*	5.0	10W
1N1835	S	1N3003A *	1N2970	DZ							82*	10	10W
1N1835A	S	1N3003B *	1N2970	DZ							82*	5.0	10W
1N1836	S	1N3004A *	1N2970	DZ							91*	10	10W
1N1836A	S	1N3004B *	1N2970	DZ							91*	5.0	10W
1N1838	G	Microwave X-Ku-band Mixer; NF = 32 dB											
1N1839	S			R*	6.8		0.085		0.26				
1N1840	S			R*	10		0.077		0.23				

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TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1841	S			R*	15		0.063		0.19				
1N1842	S			R*	22		0.05		0.15				
1N1843	S			R*	33		0.04		0.12				
1N1844	S			R*	47		0.03		0.095				
1N1845	S			R*	68		0.023	0.001	0.072				
1N1846	S			R*	100		0.016	0.001	0.050				
1N1847	S			R*	150		0.011	0.003	0.035				
1N1848	S			R*	220		0.009	0.005	0.028				
1N1849	S			R*	330			0.005	0.024				
1N1850	S			R*	470		0.006	0.005	0.020				
1N1851	S			R*	6.8		0.085		0.26				
1N1852	S			R*	10		0.077		0.23				
1N1853	S			R*	15		0.063		0.190				
1N1854	S			R*	22		0.05		0.150				
1N1855	S			R*	33		0.04		0.120				
1N1856	S			R*	47		0.03		0.095				
1N1857	S			R*	68		0.023	0.001	0.072				
1N1858	S			R*	100		0.016	0.001	0.050				
1N1859	S			R*	150		0.011	0.003	0.035				
1N1860	S			R*	220		0.009	0.005	0.028				
1N1861	S			R*	330			0.005	0.024				
1N1862	S			R*	470		0.006	0.005	0.020				
1N1863	S			R*	6.8		0.085		0.260				
1N1864	S			R*	10		0.077		0.230				
1N1865	S			R*	15		0.063		0.190				
1N1866	S			R*	22		0.05		0.150				
1N1867	S			R*	33		0.04		0.120				
1N1868	S			R*	47		0.03		0.095				
1N1869	S			R*	68		0.023	0.001	0.072				
1N1870	S			R*	100		0.016	0.001	0.050				
1N1871	S			R*	150		0.011	0.003	0.035				
1N1872	S			R*	220		0.009	0.005	0.028				
1N1873	S			R*	330			0.005	0.024				
1N1874	S			R*	470		0.006	0.005	0.020				
1N1875	S	1N4738	1N4728	DZ							8.2*	10	1.0W
1N1876	S	1N4740	1N4728	DZ							10*	10	1.0W
1N1877	S	1N4742	1N4728	DZ							12*	10	1.0W
1N1878	S	1N4744	1N4728	DZ							15*	10	1.0W
1N1879	S	1N4746	1N4728	DZ							18*	10	1.0W
1N1880	S	1N4748	1N4728	DZ							22*	10	1.0W
1N1881	S	1N4750	1N4728	DZ							27*	10	1.0W
1N1882	S	1N4752	1N4728	DZ							33*	10	1.0W
1N1883	S	1N4754	1N4728	DZ							39*	10	1.0W
1N1884	S	1N4756	1N4728	DZ							47*	10	1.0W
1N1885	S	1N4758	1N4728	DZ							56*	10	1.0W
1N1886	S	1N4760	1N4728	DZ							68*	10	1.0W
1N1887	S	1N4762	1N4728	DZ							82*	10	1.0W
1N1888	S	1N4764	1N4728	DZ							100*	10	1.0W
1N1889	S	1M120ZS10	1N4728	DZ							120*	10	1.0W
1N1890	S	1M150ZS10	1N4728	DZ							150*	10	1.0W
1N1891	S	1N2972A	1N2970	DZ							8.2*	10	10W
1N1892	S	1N2974A	1N2970	DZ							10*	10	10W
1N1893	S	1N2976A	1N2970	DZ							10*	10	10W
1N1894	S	1N2979A	1N2970	DZ							15*	10	10W
1N1895	S	1N2982A	1N2970	DZ							18*	10	10W
1N1896	S	1N2985A	1N2970	DZ							22*	10	10W
1N1897	S	1N2988A	1N2970	DZ							27*	10	10W
1N1898	S	1N2990A	1N2970	DZ							33*	10	10W
1N1899	S	1N2992A	1N2970	DZ							39*	10	10W
1N1900	S	1N2995A	1N2970	DZ							47*	10	10W
1N1901	S	1N2999A	1N2970	DZ							56*	10	10W
1N1902	S	1N3001A	1N2970	DZ							68*	10	10W
1N1903	S	1N3003A	1N2970	DZ							82*	10	10W
1N1904	S	1N3005A	1N2970	DZ							100*	10	10W
1N1905	S	1N3008A	1N2970	DZ							120*	10	10W
1N1906	S	1N3011A	1N2970	DZ							150*	10	10W
1N1907	S	1N4001	1N4001	R*	50	1.0	1.5	0.01	30				
1N1908	S	1N4002	1N4001	R*	100	1.0	1.5	0.01	30				
1N1909	S	1N4003	1N4001	R*	200	1.0	1.5	0.01	30				
1N1910	S			R*	300	1.0	1.5	0.01	30				
1N1911	S	1N4004	1N4001	R*	400	1.0	1.5	0.01	30				
1N1912	S	1N4005	1N4001	R*	500	1.0	1.5	0.01	30				
1N1913	S	1N4005	1N4001	R*	600	1.0	1.5	0.01	30				
1N1914	S	1N4006	1N4001	R*	700	1.0	1.5	0.01	30				
1N1915	S	1N4006	1N4001	R*	800	1.0	1.5	0.01	30				
1N1916	S	1N4007	1N4001	R*	900	1.0	1.5	0.01	30				
1N1917	S			R*	50	1.0	4.0	0.01	30				
1N1918	S			R*	100	1.0	4.0	0.01	30				
1N1919	S			R*	200	1.0	4.0	0.01	30				
1N1920	S			R*	300	1.0	4.0	0.01	30				
1N1921	S			R*	400	1.0	4.0	0.01	30				
1N1922	S			R*	500	1.0	4.0	0.01	30				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N1923	S			R*	600	1.0	4.0	0.01	30				
1N1924	S			R*	700	1.0	4.0	0.01	30				
1N1925	S			R*	800	1.0	4.0	0.01	30				
1N1926	S			R*	900	1.0	4.0	0.01	30				
1N1927	S	1N5228A	1N5221	DZ							3.9*	10	200M
1N1928	S	1N5230A	1N5221	DZ							4.7*	10	200M
1N1929	S	1N5232A	1N5221	DZ							5.6*	10	200M
1N1930	S	1N5235A	1N5221	DZ							6.8*	10	200M
1N1931	S	1N5237A	1N5221	DZ							8.2*	10	200M
1N1932	S	1N5240A	1N5221	DZ							10*	10	200M
1N1933	S	1N5242A	1N5221	DZ							12*	10	200M
1N1934	S	1N5245A	1N5221	DZ							15*	10	200M
1N1935	S	1N5248A	1N5221	DZ							18*	10	200M
1N1936	S	1N5251A	1N5221	DZ							22*	10	200M
1N1937	S	1N5254A	1N5221	DZ							27*	10	200M
1N1938	S	1N5257A	1N5221	DZ							33*	10	200M
1N1939	S	1N5259A	1N5221	DZ							39*	10	200M
1N1940	S	1N5261A	1N5221	DZ							47*	10	200M
1N1941	S	1N5263A	1N5221	DZ							56*	10	200M
1N1942	S	1N5266A	1N5221	DZ							68*	10	200M
1N1943	S	1N5268A	1N5221	DZ							82*	10	200M
1N1944	S	1N5271A	1N5221	DZ							100*	10	200M
1N1945	S	1N5273A	1N5221	DZ							120*	10	200M
1N1946	S	1N5276A	1N5221	DZ							150*	10	200M
1N1947	S	1N5279A	1N5221	DZ							180*	10	200M
1N1948	S	.5M110ZSB10		DZ							220*	10	200M
1N1949	S	.5M135ZSB10		DZ							270*	10	200M
1N1950	S	.5M165ZSB10		DZ							330*	10	200M
1N1951	S	.5M195ZSB10		DZ							390*	10	200M
1N1952	S	.5M155ZSC10		DZ							470*	10	200M
1N1953	S	.5M185ZSC10		DZ							560*	10	200M
1N1954	S	1N5228A	1N5221	DZ							3.9*	10	400M
1N1955	S	1N5230A	1N5221	DZ							4.7*	10	400M
1N1956	S	1N5232A	1N5221	DZ							5.6*	10	400M
1N1957	S	1N5235A	1N5221	DZ							6.8*	10	400M
1N1958	S	1N5237A	1N5221	DZ							8.2*	10	400M
1N1959	S	1N5240A	1N5221	DZ							10*	10	400M
1N1960	S	1N5242A	1N5221	DZ							12*	10	400M
1N1961	S	1N5245A	1N5221	DZ							15*	10	400M
1N1962	S	1N5248A	1N5221	DZ							18*	10	400M
1N1963	S	1N5251A	1N5221	DZ							22*	10	400M
1N1964	S	1N5254A	1N5221	DZ							27*	10	400M
1N1965	S	1N5257A	1N5221	DZ							33*	10	400M
1N1966	S	1N5259A	1N5221	DZ							39*	10	400M
1N1967	S	1N5261A	1N5221	DZ							47*	10	400M
1N1968	S	1N5263A	1N5221	DZ							56*	10	400M
1N1969	S	1N5266A	1N5221	DZ							68*	10	400M
1N1970	S	1N5268A	1N5221	DZ							82*	10	400M
1N1971	S	1N5271A	1N5221	DZ							100*	10	400M
1N1972	S	1N5273A	1N5221	DZ							120*	10	400M
1N1973	S	1N5276A	1N5221	DZ							150*	10	400M
1N1974	S	1N5279A	1N5221	DZ							180*	10	400M
1N1975	S	.5M110ZSB10		DZ							220*	10	400M
1N1976	S	.5M135ZSB10		DZ							270*	10	400M
1N1977	S	.5M165ZSB10		DZ							330*	10	400M
1N1978	S	.5M195ZSB10		DZ							390*	10	400M
1N1979	S	.5M155ZSC10		DZ							470*	10	400M
1N1980	S	.5M185ZSC10		DZ							560*	10	400M
1N1981	S	1N5228A	1N5221	DZ							3.9*	10	150M
1N1982	S	1N5230A	1N5221	DZ							4.7*	10	150M
1N1983	S	1N5232A	1N5221	DZ							5.6*	10	150M
1N1984	S	1N5235A	1N5221	DZ							6.8*	10	150M
1N1985	S	1N5237A	1N5221	DZ							8.2*	10	150M
1N1986	S	1N5240A	1N5221	DZ							10*	10	150M
1N1987	S	1N5242A	1N5221	DZ							12*	10	150M
1N1988	S	1N5245A	1N5221	DZ							15*	10	150M
1N1989	S	1N5248A	1N5221	DZ							18*	10	150M
1N1990	S	1N5251A	1N5221	DZ							22*	10	150M
1N1991	S	1N5254A	1N5221	DZ							27*	10	150M
1N1992	S	1N5257A	1N5221	DZ							33*	10	150M
1N1993	S	1N5259A	1N5221	DZ							39*	10	150M
1N1994	S	1N5261A	1N5221	DZ							47*	10	150M
1N1995	S	1N5263A	1N5221	DZ							56*	10	150M
1N1996	S	1N5266A	1N5221	DZ							68*	10	150M
1N1997	S	1N5268A	1N5221	DZ							82*	10	150M
1N1998	S	1N5271A	1N5221	DZ							100*	10	150M
1N1999	S	1N5273A	1N5221	DZ							120*	10	150M
1N2000	S	1N5276A	1N5221	DZ							150*	10	150M
1N2001	S	1N5279A	1N5221	DZ							180*	10	150M
1N2002	S	.5M110ZSB10		DZ							220*	10	150M
1N2003	S	.5M135ZSB10		DZ							270*	10	150M
1N2004	S	.5M165ZSB10		DZ							330*	10	150M

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2005	S	.5M195ZSB10		DZ							390*	10	150M
1N2006	S	.5M155ZSC10		DZ							470*	10	150M
1N2007	S	.5M185ZSC10		DZ							560*	10	150M
1N2008	S	1N3005A*	1N2970	DZ							100*	10	10W
1N2009	S	1N3007A*	1N2970	DZ							110*	10	10W
1N2010	S	1N3008A*	1N2970	DZ							120*	10	10W
1N2011	S	1N3009A*	1N2970	DZ							130*	10	10W
1N2012	S	1N3011A*	1N2970	DZ							150*	10	10W
1N2013	S			R*	50	1.2	0.25	0.25	10				
1N2014	S			R*	100	1.2	0.25	0.25	10				
1N2015	S			R*	150	1.2	0.25	0.25	10				
1N2016	S			R*	200	1.2	0.25	0.25	10				
1N2017	S			R*	250	1.2	0.25	0.25	10				
1N2018	S			R*	300	1.2	0.25	0.25	10				
1N2019	S			R*	350	1.2	0.25	0.25	10				
1N2020	S			R*	400	1.2	0.25	0.25	10				
1N2021	S	1N1185	1N1183	R*	150	1.5	10	5.0	110				
1N2022	S	1N1187	1N1183	R*	250	1.5	10	5.0	110				
1N2023	S	1N1187	1N1183	R*	300	1.5	10	5.0	110				
1N2024	S	1N1188	1N1183	R*	350	1.5	10	5.0	110				
1N2025	S	1N1188	1N1183	R*	400	1.5	10	5.0	110				
1N2026	S	MR1120	MR1120	R*	50	2.0	1.0	0.5	25				
1N2027	S	MR1122	MR1120	R*	200	2.0	1.0	0.5	25				
1N2028	S	MR1123	MR1120	R*	300	2.0	1.0	0.5	25				
1N2029	S	MR1124	MR1120	R*	400	2.0	1.0	0.5	25				
1N2030	S	MR1125	MR1120	R*	500	2.0	1.0	0.5	25				
1N2031	S	MR1126	MR1120	R*	600	2.0	1.0	0.5	25				
1N2032	S	1N4732*	1N4728	DZ						4.3	5.4		250M
1N2033	S	1N4734*	1N4728	DZ						5.2	6.4		750M
1N2034	S	1N4736*	1N4728	DZ						6.2	8.0		750M
1N2035	S	1N4739*	1N4728	DZ						7.5	10.0		750M
1N2036	S	1N4740*	1N4728	DZ						9.0	12.0		750M
1N2037	S	1N4743*	1N4728	DZ						11.0	14.5		750M
1N2038	S	1N4745*	1N4728	DZ						13.5	18.0		750M
1N2039	S	1N4747*	1N4728	DZ						17.0	21.0		750M
1N2040	S	1N4749*	1N4728	DZ						20.0	27.0		750M
1N2041	S	1N3995*	1N3993	DZ						4.3	5.4		10W
1N2042	S	1N3997*	1N3993	DZ						5.2	6.4		10W
1N2043	S	1N2970RA *	1N2970	DZ						6.2	8.0		10W
1N2044	S	1N2973RA *	1N2970	DZ						7.5	10.0		10W
1N2045	S	1N2974RB *	1N2970	DZ						9.0	12.0		10W
1N2046	S	1N2977RA *	1N2970	DZ						11.0	14.5		10W
1N2047	S	1N2980RA *	1N2970	DZ						13.5	18.0		10W
1N2048	S	1N2983RA *	1N2970	DZ						17.0	21.0		10W
1N2049	S	1N2986RA *	1N2970	DZ						20.0	27.0		10W
1N2054	S	MR1230SB	MR1230	R*	50	1.6	250	55	4500				
1N2055	S	MR1231SB	MR1230	R*	100	1.6	250	55	4500				
1N2056	S	MR1232SB	MR1230	R*	150	1.6	250	55	4500				
1N2057	S	MR1233SB	MR1230	R*	200	1.6	250	55	4500				
1N2058	S	MR1234SB	MR1230	R*	250	1.6	250	55	4500				
1N2059	S	MR1235SB	MR1230	R*	300	1.6	250	55	4500				
1N2060	S	MR1236SB	MR1230	R*	350	1.6	250	55	4500				
1N2061	S	MR1237SB	MR1230	R*	400	1.6	250	55	4500				
1N2062	S	MR1238SB	MR1230	R*	450	1.6	250	55	4500				
1N2063	S	MR1238SB	MR1230	R*	500	1.6	250	55	4500				
1N2064	S	MR1239SB	MR1230	R*	600	1.6	250	55	4500				
1N2065	S			R*	700	1.6	250	55	4500				
1N2066	S			R*	800	1.6	250	55	4500				
1N2067	S			R*	900	1.6	250	55	4500				
1N2068	S			R*	1000	1.6	250	55	4500				
1N2069	S	1N4003	1N4001	R*	200	0.6	0.75	0.2	22				
1N2069A	S	1N4003	1N4001	R*	200	0.5	0.75	0.05	22				
1N2070	S	1N4004	1N4001	R*	400	0.6	0.75	0.2	22				
1N2070A	S	1N4004	1N4001	R*	400	0.5	0.75	0.05	22				
1N2071	S	1N4005	1N4001	R*	600	0.6	0.75	0.2	22				
1N2071A	S	1N4005	1N4001	R*	600	0.5	0.75	0.05	22				
1N2072	S	1N4001	1N4001	R*	50	1.1	0.625	0.25	30				
1N2073	S	1N4002	1N4001	R*	100	1.1	0.625	0.25	30				
1N2074	S	1N4003	1N4001	R*	150	1.1	0.625	0.25	30				
1N2075	S	1N4003	1N4001	R*	200	1.1	0.625	0.25	30				
1N2076	S	1N4004	1N4001	R*	250	1.1	0.625	0.25	30				
1N2077	S	1N4004	1N4001	R*	300	1.1	0.625	0.25	30				
1N2078	S	1N4004	1N4001	R*	400	1.1	0.625	0.25	30				
1N2079	S	1N4005	1N4001	R*	500	1.1	0.625	0.25	30				
1N2080	S	1N4001	1N4001	R*	50	0.75	0.5	0.35	15				
1N2081	S	1N4002	1N4001	R*	100	0.75	0.5	0.35	15				
1N2082	S	1N4003	1N4001	R*	200	0.75	0.5	0.35	15				
1N2083	S	1N4004	1N4001	R*	300	0.75	0.5	0.35	15				
1N2084	S	1N4004	1N4001	R*	400	0.75	0.5	0.35	15				
1N2085	S	1N4005	1N4001	R*	500	0.75	0.5	0.35	15				
1N2086	S			R*	600	0.75	0.5	0.35	15				
1N2088	S			R*	500	1.2	0.75	0.5	30				

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2089	S			R*	600	1.2	0.75	0.5	30				
1N2090	S			R*	50	0.5	0.5	0.25	15				
1N2091	S			R*	100	0.5	0.5	0.25	15				
1N2092	S			R*	200	0.5	0.5	0.25	15				
1N2093	S			R*	300	0.5	0.5	0.25	15				
1N2094	S			R*	400	0.5	0.5	0.25	15				
1N2095	S			R*	500	0.5	0.5	0.25	15				
1N2096	S			R*	600	0.5	0.5	0.25	15				
1N2102	S	Microwave L-S-band Detector											
1N2103	S	1N4001	1N4001	R*	50	1.2	0.75	0.3	10				
1N2104	S	1N4002	1N4001	R*	100	1.2	0.75	0.3	10				
1N2105	S	1N4003	1N4001	R*	200	1.2	0.75	0.3	10				
1N2106	S	1N4004	1N4001	R*	300	1.2	0.75	0.3	10				
1N2107	S	1N4004	1N4001	R*	400	1.2	0.75	0.3	10				
1N2108	S	1N4005	1N4001	R*	500	1.2	0.75	0.3	10				
1N2109	S			R*	50	1.2	2.0	0.3	10				
1N2110	S			R*	100	1.2	2.0	0.3	10				
1N2111	S			R*	200	1.2	2.0	0.3	10				
1N2112	S			R*	300	1.2	2.0	0.3	10				
1N2113	S			R*	400	1.2	2.0	0.3	10				
1N2114	S			R*	500	1.2	2.0	0.3	10				
1N2115	S	1N4004	1N4001	R*	365	0.8	0.2	0.25	10				
1N2116	S			R*	400	1.4	0.5	0.4	15				
1N2117	S	1N4006	1N4001	R*	720	1.3	0.75	0.010	15				
1N2127	S	Microwave L-X-band Detector											
1N2127A	S	Microwave L-X-band Detector											
1N2128	S	MR1200FL	MR1200	R*	50	2.0	60	10	700				
1N2128A	S	MR1200FL	MR1200	R*	50	2.0	60	10	900				
1N2129	S	MR1201FL	MR1200	R*	100	2.0	60	10	700				
1N2129A	S	MR1201FL	MR1200	R*	100	2.0	60	10	900				
1N2130	S	MR1202FL	MR1200	R*	150	2.0	60	10	700				
1N2130A	S	MR1202FL	MR1200	R*	150	2.0	60	10	900				
1N2131	S	MR1203FL	MR1200	R*	200	2.0	60	10	700				
1N2131A	S	MR1203FL	MR1200	R*	200	2.0	60	10	900				
1N2132	S	MR1204FL	MR1200	R*	250	2.0	60	10	700				
1N2132A	S	MR1204FL	MR1200	R*	250	2.0	60	10	900				
1N2133	S	MR1205FL	MR1200	R*	300	2.0	60	10	700				
1N2133A	S	MR1205FL	MR1200	R*	300	2.0	60	10	900				
1N2134	S	MR1206FL	MR1200	R*	350	2.0	60	10	700				
1N2134A	S	MR1206FL	MR1200	R*	350	2.0	60	10	900				
1N2135	S	MR1207FL	MR1200	R*	400	2.0	60	10	700				
1N2135A	S	MR1207FL	MR1200	R*	400	2.0	60	10	900				
1N2136	S			R*	450	2.0	60	10	700				
1N2136A	S			R*	450	2.0	60	10	900				
1N2137	S			R*	500	2.0	60	10	700				
1N2137A	S			R*	500	2.0	60	10	900				
1N2138	S			R*	600	2.0	60	10	700				
1N2138A	S			R*	600	2.0	60	10	900				
1N2139	S			R*	20K	60	0.052	0.2	3.5				
1N2146	S			DS	120	1.1	500M	1.0*	0.1				
1N2147	S			R*	50	1.2	6.0	0.5	150				
1N2147A	S			R*	50	1.0	6.0	0.1	150				
1N2148	S			R*	100	1.2	6.0	0.5	150				
1N2148A	S			R*	100	1.0	6.0	0.1	150				
1N2149	S			R*	200	1.2	6.0	0.5	150				
1N2149A	S			R*	200	1.0	6.0	0.1	150				
1N2150	S			R*	300	1.2	6.0	0.5	150				
1N2150A	S			R*	300	1.0	6.0	0.1	150				
1N2151	S			R*	400	1.2	6.0	0.5	150				
1N2151A	S			R*	400	1.0	6.0	0.1	150				
1N2152	S			R*	500	1.2	6.0	0.5	150				
1N2152A	S			R*	500	1.0	6.0	0.1	150				
1N2153	S			R*	600	1.2	6.0	0.5	150				
1N2153A	S			R*	600	1.0	6.0	0.1	150				
1N2154	S	1N1183	1N1183	R*	50	0.6	25	5.0	300				
1N2155	S	1N1184	1N1183	R*	100	0.6	25	4.5	300				
1N2156	S	1N1186	1N1183	R*	200	0.6	25	4.0	300				
1N2157	S	1N1187	1N1183	R*	300	0.6	25	3.5	300				
1N2158	S	1N1188	1N1183	R*	400	0.6	25	3.0	300				
1N2159	S	1N1189	1N1183	R*	500	0.6	25	2.5	300				
1N2160	S	1N1190	1N1183	R*	600	0.6	25	2.0	300				
1N2163	S		1N2163	DR						0.005	9.4	-65	200
1N2163A	S		1N2163	DR						0.005	9.4	-65	200
1N2164	S		1N2163	DR						0.005	9.4	-65	200
1N2164A	S		1N2163	DR						0.005	9.4	-65	200
1N2165	S		1N2163	DR						0.005	9.4	-65	200
1N2165A	S		1N2163	DR						0.005	9.4	-65	200
1N2166	S		1N2163	DR						0.001	9.4	-65	200
1N2166A	S		1N2163	DR						0.001	9.4	-65	200
1N2167	S		1N2163	DR						0.001	9.4	-65	200
1N2167A	S		1N2163	DR						0.001	9.4	-65	200

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2168	S		1N2163	DR						0.001	9.4	-65	200
1N2168A	S		1N2163	DR						0.001	9.4	-65	200
1N2169	S		1N2163	DR						0.0005	9.4	-65	200
1N2169A	S		1N2163	DR						0.0005	9.4	-65	200
1N2170	S		1N2163	DR						0.0005	9.4	-65	200
1N2170A	S		1N2163	DR						0.0005	9.4	-65	200
1N2171	S		1N2163	DR						0.0005	9.4	-65	200
1N2171A	S		1N2163	DR						0.0005	9.4	-65	200
1N2172	S			R*	50	1.5	50	0.25	525				
1N2173	S			R*	100	1.5	50	0.25	525				
1N2174	S			R*	200	1.5	50	0.25	525				
1N2175		Photosensitive Device; $I_{R(dark)}$ = 0.5 μA @ 50 V, Sensitivity = 0.22 μA/mW/cm^2											
1N2176	S			R*	50	1.1	3.0	0.3	15				
1N2177	S			R*	100	1.1	3.0	0.3	15				
1N2178	S			R*	150	1.1	3.0	0.3	15				
1N2179	S			R*	200	1.1	3.0	0.3	15				
1N2180	S			R*	300	1.1	3.0	0.3	15				
1N2181	S			R*	400	1.1	3.0	0.3	15				
1N2182	S			R*	500	1.1	3.0	0.3	15				
1N2183	S			R*	600	1.1	3.0	0.3	15				
1N2184	S			R*	50	1.5	3.0	5.0	40				
1N2185	S			R*	100	1.5	3.0	5.0	40				
1N2186	S			R*	150	1.5	3.0	5.0	40				
1N2187	S			R*	200	1.5	3.0	5.0	40				
1N2188	S			R*	300	1.5	3.0	5.0	40				
1N2189	S			R*	400	1.5	3.0	5.0	40				
1N2190	S			R*	500	1.5	3.0	5.0	40				
1N2191	S			R*	600	1.5	3.0	5.0	40				
1N2192	S			R*	800	1.5	3.0	5.0	40				
1N2193	S			R*	1000	1.5	3.0	5.0	40				
1N2194	S			R*	50	1.25	6.0	10	100				
1N2195	S			R*	100	1.25	6.0	10	100				
1N2196	S			R*	150	1.25	6.0	10	100				
1N2197	S			R*	200	1.25	6.0	10	100				
1N2198	S			R*	300	1.25	6.0	10	100				
1N2199	S			R*	400	1.25	6.0	10	100				
1N2200	S			R*	500	1.25	6.0	10	100				
1N2201	S			R*	600	1.25	6.0	10	100				
1N2202	S			R*	800	1.25	6.0	10	100				
1N2203	S			R*	1000	1.25	6.0	10	100				
1N2204	S			R*	50	1.25	12	10	200				
1N2205	S			R*	100	1.25	12	10	200				
1N2206	S			R*	150	1.25	12	10	200				
1N2207	S			R*	200	1.25	12	10	200				
1N2208	S			R*	300	1.25	12	10	200				
1N2209	S			R*	400	1.25	12	10	200				
1N2210	S			R*	500	1.25	12	10	200				
1N2211	S			R*	600	1.25	12	10	200				
1N2212	S			R*	800	1.25	12	10	200				
1N2213	S			R*	1000	1.25	12	10	200				
1N2214	S	1M5.5ZS1		DZ							5.6*	10	1.0W
1N2217	S	MR1120	MR1120	R*	50		1.5	0.003	20				
1N2218	S	MR1125	MR1120	R*	500	1.2	0.4	0.003	20				
1N2219	S			R*	500		1.5	0.003	20				
1N2220	S	MR1126	MR1120	R*	600	1.2	0.4	0.003	20				
1N2221	S			R*	600		1.5	0.003	20				
1N2222	S	MR1128	MR1120	R*	800	1.2	0.3	0.003	20				
1N2222A	S			R*	800	1.2	0.3	0.003	20				
1N2223	S			R*	800		1.0	0.003	20				
1N2223A	S			R*	800		1.0	0.003	20				
1N2224	S	MR1130	MR1120	R*	1000	1.2	0.3	0.003	20				
1N2224A	S			R*	1000	1.2	0.3	0.003	20				
1N2225	S			R*	1000		1.0	0.003	20				
1N2225A	S			R*	1000		1.0	0.003	20				
1N2226	S			R*	1200	1.2	0.3	0.003	20				
1N2226A	S			R*	1200	1.2	0.3	0.003	20				
1N2227	S			R*	1200		1.0	0.003	20				
1N2227A	S			R*	1200		1.0	0.003	20				
1N2228	S	MR1120	MR1120	R*	50	1.2	1.0	0.003	100				
1N2228A	S	MR1120	MR1120	R*	50	1.2	1.6	0.003	100				
1N2229	S			R*	50		5.0	0.003	100				
1N2229A	S			R*	50		5.0	0.003	100				
1N2230	S	MR1122	MR1120	R*	200	1.2	1.0	0.003	100				
1N2230A	S	MR1122	MR1120	R*	200	1.2	1.6	0.003	100				
1N2231	S			R*	200		5.0	0.003	100				
1N2231A	S	MR1123	MR1120	R*	200		5.0	0.003	100				
1N2232	S	MR1123	MR1120	R*	300	1.2	1.0	0.003	100				
1N2232A	S			R*	300	1.2	1.6	0.003	100				
1N2233	S			R*	300		5.0	0.003	100				
1N2233A	S			R*	300		5.0	0.003	100				
1N2234	S	MR1124	MR1120	R*	400	1.2	1.0	0.003	100				
1N2234A	S	MR1124	MR1120	R*	400	1.2	1.6	0.003	100				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2235	S			R*	400		5.0	0.003	100				
1N2235A	S			R*	400		5.0	0.003	100				
1N2236	S	MR1125	MR1120	R*	500	1.2	1.0	0.003	100				
1N2236A	S	MR1125	MR1120	R*	500	1.2	1.6	0.003	100				
1N2237	S			R*	500		5.0	0.003	100				
1N2237A	S			R*	500		5.0	0.003	100				
1N2238	S	MR1126	MR1120	R*	600	1.2	1.0	0.003	100				
1N2238A	S	MR1126	MR1120	R*	600	1.2	1.6	0.003	100				
1N2239	S			R*	600		5.0	0.003	100				
1N2239A	S			R*	600		5.0	0.003	100				
1N2240	S	MR1128	MR1120	R*	800	1.2	1.5	0.003	100				
1N2240A	S	MR1128	MR1120	R*	800	1.2	1.5	0.003	100				
1N2241	S			R*	800		5.0	0.003	100				
1N2241A	S			R*	800		5.0	0.003	100				
1N2242	S	MR1130	MR1120	R*	1000	1.2	1.5	0.003	100				
1N2242A	S	MR1130	MR1120	R*	1000	1.2	1.6	0.003	100				
1N2243	S			R*	1000		5.0	0.003	100				
1N2243A	S			R*	1000		5.0	0.003	100				
1N2244	S			R*	1200	1.2	1.5	0.003	100				
1N2244A	S			R*	1200	1.2	1.6	0.003	100				
1N2245	S			R*	1200		5.0	0.003	100				
1N2245A	S			R*	1200		5.0	0.003	100				
1N2246	S			R*	50	1.2	3.0	0.005	200				
1N2246A	S			R*	50	1.2	3.0	0.003	200				
1N2247	S			R*	50		10	0.005	200				
1N2247A	S			R*	50		10	0.003	200				
1N2248	S			R*	100	1.2	3.0	0.005	200				
1N2248A	S			R*	100	1.2	3.0	0.003	200				
1N2249	S			R*	100		10	0.005	200				
1N2249A	S			R*	100		10	0.003	200				
1N2250	S			R*	200	1.2	3.0	0.005	200				
1N2250A	S			R*	200	1.2	3.0	0.003	200				
1N2251	S			R*	200		5.0	0.005	200				
1N2251A	S			R*	200		10	0.003	200				
1N2252	S			R*	300	1.2	3.0	0.005	200				
1N2252A	S			R*	300	1.2	3.0	0.003	200				
1N2253	S			R*	300		10	0.005	200				
1N2253A	S			R*	300		10	0.003	200				
1N2254	S			R*	400	1.2	3.0	0.005	200				
1N2254A	S			R*	400	1.2	3.0	0.003	200				
1N2255	S			R*	400		10	0.005	200				
1N2255A	S			R*	400		10	0.003	200				
1N2256	S			R*	500	1.2	3.0	0.005	200				
1N2256A	S			R*	500	1.2	3.0	0.003	200				
1N2257	S			R*	500		10	0.005	200				
1N2257A	S			R*	500		10	0.005	200				
1N2258	S			R*	600	1.2	3.0	0.005	200				
1N2258A	S			R*	600	1.2	3.0	0.003	200				
1N2259	S			R*	600		10	0.005	200				
1N2259A	S			R*	600		10	0.003	200				
1N2260	S			R*	800	1.2	3.0	0.003	200				
1N2260A	S			R*	800	1.2	3.0	0.005	200				
1N2261	S			R*	800		10	0.01	200				
1N2261A	S			R*	800		10	0.005	200				
1N2262	S			R*	1000	1.2	3.0	0.010	200				
1N2262A	S			R*	1000	1.2	3.0	0.005	200				
1N2263	S			R*	1000		10	0.01	200				
1N2263A	S			R*	1000		10	0.005	200				
1N2264	S			R*	1200	1.2	3.0	0.010	200				
1N2264A	S			R*	1200	1.2	3.0	0.005	200				
1N2265	S			R*	1200		10	0.01	200				
1N2265A	S			R*	1200		10	0.005	200				
1N2266	S	MR1120	MR1120	R*	50	1.2	0.3	0.003	20				
1N2267	S			R*	50		1.0	0.003	20				
1N2268	S	MR1125	MR1120	R*	500	1.2	0.3	0.003	20				
1N2269	S			R*	500		1.0	0.003	20				
1N2270	S	MR1126	MR1120	R*	600	1.2	0.3	0.003	20				
1N2271	S			R*	600		1.0	0.003	20				
1N2272	S	MR1120	MR1120	R*	50	1.2	6.0	1.0	400				
1N2273	S	MR1121	MR1120	R*	100	1.2	6.0	1.0	400				
1N2274	S	MR1122	MR1120	R*	200	1.2	6.0	1.0	400				
1N2275	S	MR1123	MR1120	R*	300	1.2	6.0	1.0	400				
1N2276	S	MR1124	MR1120	R*	400	1.2	6.0	1.0	400				
1N2277	S	MR1125	MR1120	R*	500	1.2	6.0	1.0	400				
1N2278	S	MR1126	MR1120	R*	600	1.2	6.0	1.0	400				
1N2279	S	MR1128	MR1120	R*	800	1.2	6.0	1.0	400				
1N2280	S			R*	1000	1.2	6.0	1.0	400				
1N2281	S			R*	1200	1.2	6.0	1.0	400				
1N2282	S			R*	300	1.5	20	5.0	400				
1N2283	S			R*	400	1.5	20	5.0	400				
1N2284	S			R*	500	1.5	20	5.0	400				
1N2285	S			R*	600	1.5	20	5.0	400				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2286	S			R*	800	1.5	20	5.0	400				
1N2287	S			R*	1000	1.5	20	5.0	400				
1N2288	S			R*	1200	1.5	20	5.0	400				
1N2289	S			R*	100		1.5	0.003	20				
1N2289A	S			R*	100		1.5	0.003	20				
1N2290	S			R*	100		5.0	0.003	100				
1N2290A	S			R*	100		5.0	0.003	100				
1N2291	S			R*	200		1.5	0.003	20				
1N2291A	S			R*	200		1.5	0.003	20				
1N2292	S			R*	300		1.5	0.003	20				
1N2292A	S			R*	300		1.5	0.003	20				
1N2293	S			R*	400		1.5	0.003	20				
1N2293A	S			R*	400		1.5	0.003	20				
1N2294	S			R*	50	1.1	22	10	160				
1N2295	S			R*	100	1.1	22	10	160				
1N2296	S			R*	150	1.1	22	10	160				
1N2297	S			R*	200	1.1	22	10	160				
1N2298	S			R*	250	1.1	22	10	160				
1N2299	S			R*	300	1.1	22	10	160				
1N2300	S			R*	350	1.1	22	10	160				
1N2301	S			R*	400	1.1	22	10	160				
1N2302	S			R*	50	1.1	22	10	160				
1N2303	S			R*	100	1.1	22	10	160				
1N2304	S			R*	150	1.1	22	10	160				
1N2305	S			R*	200	1.1	22	10	160				
1N2306	S			R*	250	1.1	22	10	160				
1N2307	S			R*	300	1.1	22	10	160				
1N2308	S			R*	350	1.1	22	10	160				
1N2309	S			R*	400	1.1	22	10	160				
1N2310	S			R*	50	1.1	35	20	300				
1N2311	S			R*	100	1.1	35	20	300				
1N2312	S			R*	150	1.1	35	20	300				
1N2313	S			R*	200	1.1	35	20	300				
1N2314	S			R*	250	1.1	35	20	300				
1N2315	S			R*	300	1.1	35	20	300				
1N2316	S			R*	350	1.1	35	20	300				
1N2317	S			R*	400	1.1	35	20	300				
1N2318	S			R*	50	1.1	35	20	300				
1N2319	S			R*	100	1.1	35	20	300				
1N2320	S			R*	150	1.1	35	20	300				
1N2321	S			R*	200	1.1	35	20	300				
1N2322	S			R*	250	1.1	35	20	300				
1N2323	S			R*	300	1.1	35	20	300				
1N2324	S			R*	350	1.1	35	20	300				
1N2325	S			R*	400	1.1	35	20	300				
1N2326	G			DS	1.0	0.150	2.0M						
1N2327	S			DS	300	3.3	400M	1.5*					
1N2328	S			DS	300	3.3	400M	1.5*					
1N2348	S	MR1120	MR1120	R*	50	1.1	3.0	0.3	15				
1N2349	S	MR1121	MR1120	R*	100	1.1	3.0	0.3	15				
1N2350	S	MR1122	MR1120	R*	150	1.1	3.0	0.3	15				
1N2357	S			R*	1400		0.4	0.001	15				
1N2358	S			R*	1500		0.4	0.001	15				
1N2359	S			R*	1600		0.4	0.001	15				
1N2360	S			R*	1800		0.4	0.001	15				
1N2361	S			R*	2000		0.4	0.001	15				
1N2362	S			R*	1400		1.0	0.001	15				
1N2362A	S			R*	1400		5.0	0.001	20				
1N2362B	S			R*	1400		10	0.001	25				
1N2363	S			R*	1400		1.0	0.001	15				
1N2363A	S			R*	1400		5.0	0.001	20				
1N2363B	S			R*	1400		10	0.001	25				
1N2364	S			R*	1500		1.0	0.001	15				
1N2364A	S			R*	1500		5.0	0.001	20				
1N2364B	S			R*	1500		10	0.001	25				
1N2365	S			R *	1500		1.0	0.001	15				
1N2365A	S			R*	1500		5.0	0.001	20				
1N2365B	S			R*	1500		10	0.001	25				
1N2366	S			R*	1600		1.0	0.001	15				
1N2366A	S			R*	1600		5.0	0.001	20				
1N2366B	S			R*	1600		10	0.001	25				
1N2367	S			R*	1600		1.0	0.001	15				
1N2367A	S			R*	1600		5.0	0.001	20				
1N2367B	S			R*	1600		10	0.001	25				
1N2368	S			R*	1800		1.0	0.001	15				
1N2368A	S			R*	1800		5.0	0.001	20				
1N2368B	S			R*	1800		10	0.001	25				
1N2369	S			R*	1800		1.0	0.001	15				
1N2369A	S			R*	1800		5.0	0.001	20				
1N2369B	S			R*	1800		10	0.001	25				
1N2370	S			R*	2000		1.0	0.001	15				
1N2370A	S			R*	2000		5.0	0.001	20				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2370B	S			R*	2000		10	0.001	25				
1N2371	S			R*	2000		1.0	0.001	15				
1N2371A	S			R*	2000		5.0	0.001	20				
1N2371B	S			R*	2000		10	0.001	25				
1N2372	S			R*	1000	2.0	0.2	0.5	12				
1N2373	S	1N4005	1N4001	R*	600	3.0	0.1	0.250	12				
1N2374	S	1N4007	1N4001	R*	1000	3.0	0.1	0.250	12				
1N2375	S	MR991A	MR990A	R*	1500	4.5	0.1	0.250	12				
1N2376	S	MR992A	MR990A	R*	2000	7.5	0.1	0.250	12				
1N2377	S	MR993A	MR990A	R*	2400	9.0	0.075	0.250	12				
1N2378	S	MR994A	MR990A	R*	3000	9.0	0.075	0.250	12				
1N2379	S	MR995A	MR990A	R*	4000	15.0	0.05	0.250	12				
1N2380	S	1N2383	1N1730	R*	6000	22.5	0.05	0.250	12				
1N2381	S	1N2385	1N1730	R*	10K	37.5	0.025	0.250	12				
1N2382	S		1N1730	R*	4000	18	0.15	0.2	6.0				
1N2382A	S			R*	4000	6.0	0.35	0.2	6.0				
1N2383	S		1N1730	R*	6000	27	0.1	0.2	6.0				
1N2383A	S			R*	6000	9.0	0.35	0.2	6.0				
1N2384	S		1N1730	R*	8000	27	0.07	0.2	6.0				
1N2384A	S			R*	8000	12	0.275	0.2	6.0				
1N2385	S			R*	10K	39	0.07	0.2	6.0				
1N2385A	S			R*	10K	15	0.2	0.2	6.0				
1N2386	G			DS	5.0								
1N2387	S	1N4751A*	1N4728	DZ							30*	5.0	1.0W
1N2389	S			R*	1600	4.8	0.6	0.5	15				
1N2390	S			R*	50	1.2	1.5	0.3	35				
1N2391	S			R*	100	1.2	1.5	0.3	35				
1N2392	S			R*	200	1.2	1.5	0.3	35				
1N2393	S			R*	300	1.2	1.5	0.3	35				
1N2394	S			R*	400	1.2	1.5	0.3	35				
1N2395	S			R*	500	1.2	1.5	0.3	35				
1N2396	S			R*	600	1.2	1.5	0.3	35				
1N2397	S			R*	700	1.2	1.5	0.3	35				
1N2398	S			R*	800	1.2	1.5	0.3	35				
1N2399	S			R*	50	1.2	1.5	0.3	35				
1N2400	S			R*	100	1.2	1.5	0.3	35				
1N2401	S			R*	200	1.2	1.5	0.3	35				
1N2402	S			R*	300	1.2	1.5	0.3	35				
1N2403	S			R*	400	1.2	1.5	0.3	35				
1N2404	S			R*	500	1.2	1.5	0.3	35				
1N2405	S			R*	600	1.2	1.5	0.3	35				
1N2406	S			R*	700	1.2	1.5	0.3	35				
1N2407	S			R*	800	1.2	1.5	0.3	35				
1N2408	S			R*	50	1.2	1.5	0.3	35				
1N2409	S			R*	100	1.2	1.5	0.3	35				
1N2410	S			R*	200	1.2	1.5	0.3	35				
1N2411	S			R*	300	1.2	1.5	0.3	35				
1N2412	S			R*	400	1.2	1.5	0.3	35				
1N2413	S			R*	500	1.2	1.5	0.3	35				
1N2414	S			R*	600	1.2	1.5	0.3	35				
1N2415	S			R*	700	1.2	1.5	0.3	35				
1N2416	S			R*	800	1.2	1.5	0.3	35				
1N2417	S			R*	50	1.2	1.5	0.3	35				
1N2418	S			R*	100	1.2	1.5	0.3	35				
1N2419	S			R*	200	1.2	1.5	0.3	35				
1N2420	S			R*	300	1.2	1.5	0.3	35				
1N2421	S			R*	400	1.2	1.5	0.3	35				
1N2422	S			R*	500	1.2	1.5	0.3	35				
1N2423	S			R*	600	1.2	1.5	0.3	35				
1N2424	S			R*	700	1.2	1.5	0.3	35				
1N2425	S			R*	800	1.2	1.5	0.3	35				
1N2482	S	1N4003	1N4001	R*	200	1.2	0.75	0.5	30				
1N2483	S	1N4004	1N4001	R*	400	1.2	0.75	0.5	30				
1N2484	S	1N4005	1N4001	R*	500	1.2	0.75	0.5	30				
1N2485	S	1N4003	1N4001	R*	200	1.2	0.75	0.5	30				
1N2486	S	1N4004	1N4001	R*	300	1.2	0.75	0.5	30				
1N2487	S	1N4004	1N4001	R*	400	1.2	0.75	0.5	30				
1N2488	S	1N4005	1N4001	R*	500	1.2	0.75	0.5	30				
1N2489	S	1N4005	1N4001	R*	600	1.2	0.75	0.5	30				
1N2490	S			R*	1600	4.8	0.5	0.5	15				
1N2491	S	MR1120	MR1120	R*	50	1.5	6.0	2.0	150				
1N2492	S	MR1121	MR1120	R*	100	1.5	6.0	2.0	150				
1N2493	S	MR1122	MR1120	R*	200	1.5	6.0	2.0	150				
1N2494	S	MR1123	MR1120	R*	300	1.5	6.0	2.0	150				
1N2495	S	MR1124	MR1120	R*	400	1.5	6.0	2.0	150				
1N2496	S	MR1125	MR1120	R*	500	1.5	6.0	2.0	150				
1N2497	S	MR1126	MR1120	R*	600	1.5	6.0	2.0	150				
1N2498	S	1N2974A *	1N2970	DZ							10*	10	10W
1N2498A	S	1N2974B *	1N2970	DZ							10*	5.0	10W
1N2499	S	1N2975A *	1N2970	DZ							11*	10	10W
1N2499A	S	1N2975B *	1N2970	DZ							11*	5.0	10W
1N2500	S	1N2976A *	1N2970	DZ							12*	10	10W

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2500A	S	1N2976B *	1N2970	DZ							12*	5.0	10W
1N2501	S	1N4006	1N4001	R*	800	1.7	0.15	0.2	2.5				
1N2502	S	1N4007	1N4001	R*	1000	1.7	0.15	0.2	2.5				
1N2503	S			R*	1200	1.7	0.15	0.2	2.5				
1N2504	S			R*	1500	1.7	0.15	0.2	2.5				
1N2505	S	1N4006	1N4001	R*	800	1.7	0.3	0.2	2.5				
1N2506	S	1N4006	1N4001	R*	1000	1.7	0.3	0.2	2.5				
1N2507	S			R*	1200	1.7	0.3	0.2	2.5				
1N2508	S			R*	1500	1.7	0.3	0.2	2.5				
1N2509	S	Microwave C-band Mixer; NF = 10 dB											
1N2510	S	Microwave X-band Mixer; NF = 9.5 dB											
1N2512	S			R*	100	1.1		0.002	30				
1N2513	S			R*	200	1.1		0.002	30				
1N2514	S			R*	300	1.1		0.002	30				
1N2515	S			R*	400	1.1		0.002	30				
1N2516	S			R*	500	1.1		0.002	30				
1N2517	S			R*	600	1.1		0.002	30				
1N2518	S			R*	100	1.1		0.002	30				
1N2519	S			R*	200	1.1		0.002	30				
1N2520	S			R*	300	1.1		0.002	30				
1N2521	S			R*	400	1.1		0.002	30				
1N2522	S			R*	500	1.1		0.002	30				
1N2523	S			R*	600	1.1		0.002	30				
1N2524	S			R*	50	1.2	2.5	0.5	50				
1N2525	S			R*	100	1.2	2.5	0.5	50				
1N2526	S			R*	200	1.2	2.5	0.5	50				
1N2527	S			R*	300	1.2	2.5	0.5	50				
1N2528	S			R*	400	1.2	2.5	0.5	50				
1N2529	S			R*	500	1.2	2.5	0.5	50				
1N2530	S			R*	600	1.2	2.5	0.5	50				
1N2531	S			R*	700	1.2	2.5	0.5	50				
1N2532	S			R*	800	1.2	2.5	0.5	50				
1N2533	S			R*	900	1.2	2.5	0.5	50				
1N2534	S			R*	1000	1.2	2.5	0.5	50				
1N2535	S			R*	50	1.0	2.5	0.1	50				
1N2536	S			R*	100	1.0	2.5	0.1	50				
1N2537	S			R*	200	1.0	2.5	0.1	50				
1N2538	S			R*	300	1.0	2.5	0.1	50				
1N2539	S			R*	400	1.0	2.5	0.1	50				
1N2540	S			R*	500	1.0	2.5	0.1	50				
1N2541	S			R*	600	1.0	2.5	0.1	50				
1N2542	S			R*	700	1.0	2.5	0.1	50				
1N2543	S			R*	800	1.0	2.5	0.1	50				
1N2544	S			R*	900	1.0	2.5	0.1	50				
1N2545	S			R*	1000	1.0	2.5	0.1	50				
1N2546	S			R*	50	1.5	2.5	1.0	50				
1N2547	S			R*	100	1.5	2.5	1.0	50				
1N2548	S			R*	200	1.5	2.5	1.0	50				
1N2549	S			R*	300	1.5	2.5	1.0	50				
1N2550	S			R*	400	1.5	2.5	1.0	50				
1N2551	S			R*	500	1.5	2.5	1.0	50				
1N2552	S			R*	600	1.5	2.5	1.0	50				
1N2553	S			R*	700	1.5	2.5	1.0	50				
1N2554	S			R*	800	1.5	2.5	1.0	50				
1N2555	S			R*	900	1.5	2.5	1.0	50				
1N2556	S			R*	1000	1.5	2.5	1.0	50				
1N2557	S			R*	700	1.2	6.0	0.5	150				
1N2558	S			R*	800	1.2	6.0	0.5	150				
1N2559	S			R*	900	1.2	6.0	0.5	150				
1N2560	S			R*	1000	1.2	6.0	0.5	150				
1N2561	S			R*	700	1.0	6.0	0.1	150				
1N2562	S			R*	800	1.0	6.0	0.1	150				
1N2563	S			R*	900	1.0	6.0	0.1	150				
1N2564	S			R*	1000	1.0	6.0	0.1	150				
1N2565	S			R*	50	1.5	6.0	1.0	150				
1N2566	S			R*	100	1.5	6.0	1.0	150				
1N2567	S			R*	200	1.5	6.0	1.0	150				
1N2568	S			R*	300	1.5	6.0	1.0	150				
1N2569	S			R*	400	1.5	6.0	1.0	150				
1N2570	S			R*	500	1.5	6.0	1.0	150				
1N2571	S			R*	600	1.5	6.0	1.0	150				
1N2572	S			R*	700	1.5	6.0	1.0	150				
1N2573	S			R*	800	1.5	6.0	1.0	150				
1N2574	S			R*	900	1.5	6.0	1.0	150				
1N2575	S			R*	1000	1.5	6.0	1.0	150				
1N2576	S			R*	50	1.2	12	1.0	250				
1N2577	S			R*	100	1.2	12	1.0	250				
1N2578	S			R*	200	1.2	12	1.0	250				
1N2579	S			R*	300	1.2	12	1.0	250				
1N2580	S			R*	400	1.2	12	1.0	250				
1N2581	S			R*	500	1.2	12	1.0	250				
1N2582	S			R*	600	1.2	12	1.0	250				

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2583	S			R*	700	1.2	12	1.0	250				
1N2584	S			R*	800	1.2	12	1.0	250				
1N2585	S			R*	900	1.2	12	1.0	250				
1N2586	S			R*	1000	1.2	12	1.0	250				
1N2587	S			R*	50	1.0	12	0.2	250				
1N2588	S			R*	100	1.0	12	0.2	250				
1N2589	S			R*	200	1.0	12	0.2	250				
1N2590	S			R*	300	1.0	12	0.2	250				
1N2591	S			R*	400	1.0	12	0.2	250				
1N2592	S			R*	500	1.0	12	0.2	250				
1N2593	S			R*	600	1.0	12	0.2	250				
1N2594	S			R*	700	1.0	12	0.2	250				
1N2595	S			R*	800	1.0	12	0.2	250				
1N2596	S			R*	900	1.0	12	0.2	250				
1N2597	S			R*	1000	1.0	12	0.2	250				
1N2598	S			R*	50	1.5	12	2.0	250				
1N2599	S			R*	100	1.5	12	2.0	250				
1N2600	S			R*	200	1.5	12	2.0	250				
1N2601	S			R*	300	1.5	12	2.0	250				
1N2602	S			R*	400	1.5	12	2.0	250				
1N2603	S			R*	500	1.5	12	2.0	250				
1N2604	S			R*	600	1.5	12	2.0	250				
1N2605	S			R*	700	1.5	12	2.0	250				
1N2606	S			R*	800	1.5	12	2.0	250				
1N2607	S			R*	900	1.5	12	2.0	250				
1N2608	S			R*	1000	1.5	12	2.0	250				
1N2609	S	1N4001	1N4001	R*	50	1.1	0.75	0.3	30				
1N2610	S	1N4002	1N4001	R*	100	1.1	0.75	0.3	30				
1N2611	S	1N4003	1N4001	R*	200	1.1	0.75	0.3	30				
1N2612	S	1N4004	1N4001	R*	300	1.1	0.75	0.3	30				
1N2613	S	1N4004	1N4001	R*	400	1.1	0.75	0.3	30				
1N2614	S	1N4005	1N4001	R*	500	1.1	0.75	0.3	30				
1N2615	S	1N4005	1N4001	R*	600	1.1	0.75	0.3	30				
1N2616	S	1N4006	1N4001	R*	800	1.1	0.75	0.3	30				
1N2617	S	1N4007	1N4001	R*	1000	1.1	0.75	0.3	30				
1N2618	S			R*	1200	1.1	0.75	0.3	30				
1N2619	S			R*	1500	1.1	0.75	0.3	30				
1N2620	S		1N2620	DR						0.01	9.7	0	75
1N2620A	S		1N2620	DR						0.01	9.7	-55	100
1N2620B	S		1N2620	DR						0.01	9.7	-55	150
1N2621	S		1N2620	DR						0.005	9.7	0	75
1N2621A	S		1N2620	DR						0.005	9.7	-55	100
1N2621B	S		1N2620	DR						0.005	9.7	-55	150
1N2622	S		1N2620	DR						0.002	9.7	0	75
1N2622A	S		1N2620	DR						0.002	9.7	-55	100
1N2622B	S		1N2620	DR						0.002	9.7	-55	150
1N2623	S		1N2620	DR						0.001	9.7	0	75
1N2623A	S		1N2620	DR						0.001	9.7	-55	100
1N2623B	S		1N2620	DR						0.001	9.7	-55	150
1N2624	S		1N2620	DR						0.0005	9.7	0	75
1N2624A	S		1N2620	DR						0.0005	9.7	-55	100
1N2624B	S		1N2620	DR						0.0005	9.7	-55	150
1N2625	S	1N937	1N935	DR						0.0002	9.4	0	75
1N2625A	S	1N937A	1N935	DR						0.0002	9.4	-55	100
1N2625B	S	1N937B	1N935	DR						0.0002	9.4	-55	150
1N2626	S	1N938	1N935	DR						0.0001	9.4	0	75
1N2626A	S	1N938A	1N935	DR						0.0001	9.4	-55	100
1N2626B	S	1N938B	1N935	DR						0.0001	9.4	-55	150
1N2627 } 1N2628 }		Varactor Diodes, see Table on Page 1-94											
1N2629	G			DS	5.0								
1N2630	S			R*	1500	2.25	0.085	0.5	5.0				
1N2631	S			R*	1600	3.0	0.6	0.5	5.0				
1N2632	S			R*	2800	6.0	0.2	0.5	5.0				
1N2633	S			R*	1600	3.0	0.6	0.5	5.0				
1N2634	S			R*	1600	3.0	0.6	0.5	5.0				
1N2635	S			R*	1500	2.25	0.085	0.5	5.0				
1N2636	S			R*	1500	2.25	0.085	0.5	5.0				
1N2637	S			R*		28.0	0.25	0.5	5.0				
1N2638	S			R*	100	1.3	1.5	0.3	15				
1N2641	S			R*	200	1.3	1.5	0.3	15				
1N2644	S			R*	300	1.3	1.5	0.3	15				
1N2647	S			R*	400	1.3	1.5	0.3	15				
1N2650	S			R*	600	2.6	1.5	0.3	15				
1N2653	S			R*	800	2.6	1.5	0.3	15				
1N2656	S			R*	1200	3.9	1.5	0.8	15				
1N2659	S			R*	1600	5.2	1.5	0.8	15				
1N2662	S			R*	2000	6.5	1.5	0.8	15				
1N2664	S			R*	2400	7.8	1.5	0.8	15				
1N2666	S			R*	3200	10.4	1.5	0.8	15				
1N2667	S			R*	4000	13	1.5	0.8	15				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2668	S			R*	4800	15.6	1.5	0.8	15				
1N2669	S			R*	100	1.3	3.6	0.3	15				
1N2673	S			R*	200	1.3	3.6	0.3	15				
1N2677	S			R*	300	1.3	3.6	0.3	15				
1N2681	S			R*	400	1.3	3.6	0.3	15				
1N2685	S			R*	600	2.6	3.6	0.3	15				
1N2687	S			R*	800	2.6	3.6	0.3	15				
1N2689	S			R*	900	3.9	3.6	0.8	15				
1N2690	S			R*	1200	3.9	3.6	0.8	15				
1N2691	S			R*	1600	5.2	3.6	0.8	15				
1N2692	S			R*	100	1.3	7.2	0.3	15				
1N2694	S			R*	200	1.3	7.2	0.3	15				
1N2696	S			R*	300	1.3	7.2	0.3	15				
1N2698	S			R*	400	1.3	7.2	0.3	15				
1N2700	S			R*	600	2.6	7.2	0.3	15				
1N2701	S			R*	800	2.6	7.2	0.3	15				
1N2702	S			R*	100	1.3	3.0	0.2	15				
1N2705	S			R*	200	1.3	3.0	0.2	15				
1N2708	S			R*	300	1.3	3.0	0.2	15				
1N2711	S			R*	400	1.3	3.0	0.2	15				
1N2714	S			R*	600	2.6	3.0	0.2	15				
1N2717	S			R*	800	2.6	3.0	0.2	15				
1N2720	S			R*	1200	3.9	3.0	0.8	15				
1N2722	S			R*	1600	5.2	3.0	0.8	15				
1N2723	S			R*	2000	6.5	3.0	0.8	15				
1N2724	S			R*	2400	7.8	3.0	0.8	15				
1N2725	S			R*	100	1.3	3.0	0.3	15				
1N2728	S			R*	200	1.3	3.0	0.3	15				
1N2731	S			R*	300	1.3	3.0	0.3	15				
1N2734	S			R*	400	1.3	3.0	0.3	15				
1N2737	S			R*	600	2.6	3.0	0.3	15				
1N2738	S			R*	800	2.6	3.0	0.3	15				
1N2739	S			R*	1200	3.9	3.0	0.8	15				
1N2740	S			R*	100	1.3	3.6	0.3	15				
1N2742	S			R*	200	1.3	3.6	0.3	15				
1N2744	S			R*	300	1.3	3.6	0.3	15				
1N2746	S			R*	400	1.3	3.6	0.3	15				
1N2748	S			R*	600	2.6	3.6	0.3	15				
1N2749	S			R*	800	2.6	3.6	0.3	15				
1N2750	S			R*	100	1.3	3.0	0.3	15				
1N2753	S			R*	200	1.3	3.0	0.3	15				
1N2756	S			R*	300	1.3	3.0	0.3	15				
1N2759	S			R*	400	1.3	3.0	0.3	15				
1N2762	S			R*	600	2.6	3.0	0.3	15				
1N2763	S			R*	800	2.6	3.0	0.3	15				
1N2764	S			R*	1200	3.9	3.0	0.8	15				
1N2765	S	1N823A	1N821	DR						0.005	6.8	-55	100
1N2765A	S	1N825A	1N821	DR						0.0025	6.8	-55	100
1N2766	S	1N1736A	1N429	DR						0.005	13.6	-55	100
1N2766A	S	1N1736A	1N429	DR						0.0025	13.6	-55	100
1N2767	S	1N4061	1N429	DR						0.005	20.4	-55	100
1N2767A	S	1N4061A	1N429	DR						0.0025	20.4	-55	100
1N2768	S	1N4063	1N429	DR						0.005	27.2	-55	100
1N2768A	S	1N4063A	1N429	DR						0.0025	27.2	-55	100
1N2769	S	1N4065	1N429	DR						0.005	34.0	-55	100
1N2769A	S	1N4065A	1N429	DR						0.0025	34.0	-55	100
1N2770	S	1N4067	1N429	DR						0.005	40.8	-55	100
1N2770A	S	1N4067A	1N429	DR						0.0025	40.8	-55	100
	S												
1N2772	S			R*	700	1.8	0.5		15				
1N2773	S			R*	800	1.8	0.5		15				
1N2774	S			R*	900	1.8	0.5		15				
1N2775	S			R*	1000	1.8	0.5		15				
1N2776	S			R*	1100	1.8	0.5		15				
1N2777	S			R*	1200	1.8	0.5		15				
1N2778	S			R*	1300	1.8	0.5		15				
1N2779	S			R*	1400	1.8	0.5		15				
1N2780	S			R*	1500	1.8	0.5		15				
1N2781	S			R*	1600	1.8	0.5		15				
1N2782	S			DS	5.0			2.0*					
1N2783	S	1N3000A	1N2970	DZ							62*	10	6.0W
1N2784	S			R*	200	1.5	8.0	5.0	200				
1N2785	S			R*	400	1.5	8.0	5.0	200				
1N2786	S			R*	200	1.2	10	10.0	180				
1N2787	S			R*	400	1.2	10	10.0	180				
1N2788	S			R*	200	1.3	12.5	5.0	340				
1N2789	S			R*	400	1.3	12.5	5.0	340				
1N2790	S	1N3156	1N3154	DR						0.002	8.5	-55	100
1N2791	S			DS		1.[illegible]	50M	0.05*	4.0				
1N2793	S	1N1183	1N1183	R*	50	1.25	5.0	5.0	75				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2794	S	1N1184	1N1183	R*	100	1.25	5.0	5.0	75				
1N2795	S	1N1185	1N1183	R*	150	1.25	5.0	5.0	75				
1N2796	S	1N1186	1N1183	R*	200	1.25	5.0	5.0	75				
1N2797	S	1N1187	1N1183	R*	250	1.25	5.0	5.0	75				
1N2798	S	1N1187	1N1183	R*	300	1.25	5.0	5.0	75				
1N2799	S	1N1188	1N1183	R*	350	1.25	5.0	5.0	75				
1N2800	S	1N1188	1N1183	R*	400	1.25	5.0	5.0	75				
1N2801	G			DS	20	0.36	5.0M	2.0*	500				
1N2802	S	Microwave X-band Mixer; NF = 7.5 dB											
1N2803	S			R*	400	1.2	250	36	3500				
1N2804	S		1N2804	DZ							6.8*	20	50W
1N2804A	S		1N2804	DZ							6.8*	10	50W
1N2804B	S		1N2804	DZ							6.8*	5.0	50W
1N2805	S		1N2804	DZ							7.5*	20	50W
1N2805A	S		1N2804	DZ							7.5*	10	50W
1N2805B	S		1N2804	DZ							7.5*	5.0	50W
1N2806	S		1N2804	DZ							8.2*	20	50W
1N2806A	S		1N2804	DZ							8.2*	10	50W
1N2806B	S		1N2804	DZ							8.2*	5.0	50W
1N2807	S		1N2804	DZ							9.1*	20	50W
1N2807A	S		1N2804	DZ							9.1*	10	50W
1N2807B	S		1N2804	DZ							9.1*	5.0	50W
1N2808	S		1N2804	DZ							10*	20	50W
1N2808A	S		1N2804	DZ							10*	10	50W
1N2808B	S		1N2804	DZ							10*	5.0	50W
1N2809	S		1N2804	DZ							11*	20	50W
1N2809A	S		1N2804	DZ							11*	10	50W
1N2809B	S		1N2804	DZ							11*	5.0	50W
1N2810	S		1N2804	DZ							12*	20	50W
1N2810A	S		1N2804	DZ							12*	10	50W
1N2810B	S		1N2804	DZ							12*	5.0	50W
1N2811	S		1N2804	DZ							13*	20	50W
1N2811A	S		1N2804	DZ							13*	10	50W
1N2811B	S		1N2804	DZ							13*	5.0	50W
1N2812	S		1N2804	DZ							14*	20	50W
1N2812A	S		1N2804	DZ							14*	10	50W
1N2812B	S		1N2804	DZ							14*	5.0	50W
1N2813	S		1N2804	DZ							15*	20	50W
1N2813A	S		1N2804	DZ							15*	10	50W
1N2813B	S		1N2804	DZ							15*	5.0	50W
1N2814	S		1N2804	DZ							16*	20	50W
1N2814A	S		1N2804	DZ							16*	10	50W
1N2814B	S		1N2804	DZ							16*	5.0	50W
1N2815	S		1N2804	DZ							17*	20	50W
1N2815A	S		1N2804	DZ							17*	10	50W
1N2815B	S		1N2804	DZ							17*	5.0	50W
1N2816	S		1N2804	DZ							18*	20	50W
1N2816A	S		1N2804	DZ							18*	10	50W
1N2816B	S		1N2804	DZ							18*	5.0	50W
1N2817	S		1N2804	DZ							19*	20	50W
1N2817A	S		1N2804	DZ							19*	10	50W
1N2817B	S		1N2804	DZ							19*	5.0	50W
1N2818	S		1N2804	DZ							20*	20	50W
1N2818A	S		1N2804	DZ							20*	10	50W
1N2818B	S		1N2804	DZ							20*	5.0	50W
1N2819	S		1N2804	DZ							22*	20	50W
1N2819A	S		1N2804	DZ							22*	10	50W
1N2819B	S		1N2804	DZ							22*	5.0	50W
1N2820	S		1N2804	DZ							24*	20	50W
1N2820A	S		1N2804	DZ							24*	10	50W
1N2820B	S		1N2804	DZ							24*	5.0	50W
1N2821	S		1N2804	DZ							25*	20	50W
1N2821A	S		1N2804	DZ							25*	10	50W
1N2821B	S		1N2804	DZ							25*	5.0	50W
1N2822	S		1N2804	DZ							27*	20	50W
1N2822A	S		1N2804	DZ							27*	10	50W
1N2822B	S		1N2804	DZ							27*	5.0	50W
1N2823	S		1N2804	DZ							30*	20	50W
1N2823A	S		1N2804	DZ							30*	10	50W
1N2823B	S		1N2804	DZ							30*	5.0	50W
1N2824	S		1N2804	DZ							33*	20	50W
1N2824A	S		1N2804	DZ							33*	10	50W
1N2824B	S		1N2804	DZ							33*	5.0	50W
1N2825	S		1N2804	DZ							36*	20	50W
1N2825A	S		1N2804	DZ							36*	10	50W
1N2825B	S		1N2804	DZ							36*	5.0	50W
1N2826	S		1N2804	DZ							39*	20	50W
1N2826A	S		1N2804	DZ							39*	10	50W
1N2826B	S		1N2804	DZ							39*	5.0	50W
1N2827	S		1N2804	DZ							43*	20	50W
1N2827A	S		1N2804	DZ							43*	10	50W
1N2827B	S		1N2804	DZ							43*	5.0	50W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2828	S		1N2804	DZ							45*	20	50W
1N2828A	S		1N2804	DZ							45*	10	50W
1N2828B	S		1N2804	DZ							45*	5.0	50W
1N2829	S		1N2804	DZ							45*	20	50W
1N2829A	S		1N2804	DZ							47*	10	50W
1N2829B	S		1N2804	DZ							47*	5.0	50W
1N2830	S		1N2804	DZ							50*	20	50W
1N2830A	S		1N2804	DZ							50*	10	50W
1N2830B	S		1N2804	DZ							50*	5.0	50W
1N2831	S		1N2804	DZ							51*	20	50W
1N2831A	S		1N2804	DZ							51*	10	50W
1N2831B	S		1N2804	DZ							51*	5.0	50W
1N2832	S		1N2804	DZ							56*	20	50W
1N2832A	S		1N2804	DZ							56*	10	50W
1N2832B	S		1N2804	DZ							56*	5.0	50W
1N2833	S		1N2804	DZ							62*	20	50W
1N2833A	S		1N2804	DZ							62*	10	50W
1N2833B	S		1N2804	DZ							62*	5.0	50W
1N2834	S		1N2804	DZ							68*	20	50W
1N2834A	S		1N2804	DZ							68*	10	50W
1N2834B	S		1N2804	DZ							68*	5.0	50W
1N2835	S		1N2804	DZ							75*	20	50W
1N2835A	S		1N2804	DZ							75*	10	50W
1N2835B	S		1N2804	DZ							75*	5.0	50W
1N2836	S		1N2804	DZ							82*	20	50W
1N2836A	S		1N2804	DZ							82*	10	50W
1N2836B	S		1N2804	DZ							82*	5.0	50W
1N2837	S		1N2804	DZ							91*	20	50W
1N2837A	S		1N2804	DZ							91*	10	50W
1N2837B	S		1N2804	DZ							91*	5.0	50W
1N2838	S		1N2804	DZ							100*	20	50W
1N2838A	S		1N2804	DZ							100*	10	50W
1N2838B	S		1N2804	DZ							100*	5.0	50W
1N2839	S		1N2804	DZ							105*	20	50W
1N2839A	S		1N2804	DZ							105*	10	50W
1N2839B	S		1N2804	DZ							105*	5.0	50W
1N2840	S		1N2804	DZ							110*	20	50W
1N2840A	S		1N2804	DZ							110*	10	50W
1N2840B	S		1N2804	DZ							110*	5.0	50W
1N2841	S		1N2804	DZ							120*	20	50W
1N2841A	S		1N2804	DZ							120*	10	50W
1N2841B	S		1N2804	DZ							120*	5.0	50W
1N2842	S		1N2804	DZ							130*	20	50W
1N2842A	S		1N2804	DZ							130*	10	50W
1N2842B	S		1N2804	DZ							130*	5.0	50W
1N2843	S		1N2804	DZ							140*	20	50W
1N2843A	S		1N2804	DZ							140*	10	50W
1N2843B	S		1N2804	DZ							140*	5.0	50W
1N2844	S		1N2804	DZ							160*	20	50W
1N2844A	S		1N2804	DZ							160*	10	50W
1N2844B	S		1N2804	DZ							160*	5.0	50W
1N2845	S		1N2804	DZ							180*	20	50W
1N2845A	S		1N2804	DZ							180*	10	50W
1N2845B	S		1N2804	DZ							180*	5.0	50W
1N2846	S		1N2804	DZ							200*	20	50W
1N2846A	S		1N2804	DZ							200*	10	50W
1N2846B	S		1N2804	DZ							200*	5.0	50W
1N2847	S			R*	100	2.0	1.5	0.3	15				
1N2848	S			R*	200	2.0	1.5	0.2	15				
1N2849	S			R*	300	2.0	1.5	0.2	15				
1N2850	S			R*	400	2.0	1.5	0.2	15				
1N2851	S			R*	500	2.0	1.5	0.2	15				
1N2852	S			R*	600	2.0	1.5	0.2	15				
1N2855	S			R*	600	1.2	250	25	3500				
1N2856	S			R*	800	1.2	250	20	4500				
1N2857	S			R*	1000	1.2	250	15	4500				
1N2858	S	1N4001	1N4001	R*	50	1.2	0.75	0.3	40				
1N2858A	S			R*	50	1.2	1.0	0.3	25				
1N2859	S	1N4002	1N4001	R*	100	1.2	0.75	0.3	40				
1N2859A	S			R*	100	1.2	1.0	0.3	25				
1N2860	S	1N4003	1N4001	R*	200	1.2	0.75	0.3	40				
1N2860A	S			R*	200	1.2	1.0	0.3	25				
1N2861	S	1N4004	1N4001	R*	300	1.2	0.75	0.2	40				
1N2861A	S			R*	300	1.2	1.0	0.3	25				
1N2862	S	1N4004	1N4001	R*	400	1.2	0.75	0.2	40				
1N2862A	S			R*	400	1.2	1.0	0.3	25				
1N2863	S	1N4005	1N4001	R*	500	1.2	0.75	0.2	40				
1N2863A	S			R*	500	1.2	1.0	0.3	25				
1N2864	S	1N4005	1N4001	R*	600	1.2	0.75	0.2	40				
1N2864A	S			R*	600	1.2	1.0	0.3	25				
1N2865	S			R*	1000	2.5	0.7	0.1	7.0				
1N2866	S			R*	1500	2.5	0.7	0.1	7.0				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2867	S			R*	1000	2.5	0.7	0.1	7.0				
1N2868	S			R*	1500	2.5	0.7	0.1	7.0				
1N2878	S	1N4006	1N4001	DS	700	2.0	250M	0.5*					
1N2879	S	1N4006	1N4001	DS	700	2.0	250M	0.5*					
1N2880	S	1N4007	1N4001	DS	1.0K	2.0	250M	0.5*					
1N2881	S	1N4007	1N4001	DS	1.0K	2.0	250M	0.5*					
1N2882	S	1N4007	1N4001	DS	500	3.0	250M	0.5*					
1N2883	S	1N4007	1N4001	DS	500	3.0	250M	0.5*					
1N2884	S	MR991A	MR990A	DS	400	4.0	250M	0.5*					
1N2885	S	MR991A	MR990A	DS	400	4.0	250M	0.5*					
1N2886	S	MR991A	MR990A	DS	500	3.0	250M	0.5*					
1N2887	S	MR991A	MR990A	DS	500	3.0	250M	0.5*					
1N2888	S			DS	750	5.0	250M	0.5*					
1N2889	S	MR992A	MR990A	DS	750	5.0	250M	0.5*					
1N2890	S	MR992A	MR990A	DS	2.0K	4.0	250M	0.5*					
1N2891	S	MR992A	MR990A	DS	2.0K	4.0	250M	0.5*					
1N2892	S	MR993A	MR990A	DS	100	6.0	250M	0.5*					
1N2893	S	MR993A	MR990A	DS	100	6.0	250M	0.5*					
1N2894	S	MR994A	MR990A	DS	450	7.0	250M	0.5*					
1N2895	S	MR994A	MR990A	DS	450	7.0	250M	0.5*					
1N2896	S	MR994A	MR990A	DS	500	5.0	250M	0.5*					
1N2897	S	MR994A	MR990A	DS	500	5.0	250M	0.5*					
1N2898	S	MR995A	MR990A	DS	800	8.0	250M	0.5*					
1N2899	S	MR995A	MR990A	DS	800	8.0	250M	0.5*					
1N2900	S	MR995A	MR990A	DS	3.0K	6.0	250M	0.5*					
1N2901	S	MR995A	MR990A	DS	3.0K	6.0	250M	0.5*					
1N2902	S			DS	150	9.0	250M	0.5*					
1N2903	S			DS	150	9.0	250M	0.5*					
1N2904	S			DS	500	7.0	250M	0.5*					
1N2905	S			DS	500	7.0	250M	0.5*					
1N2906	S			DS	500	10	250M	0.5*					
1N2907	S			DS	500	10	250M	0.5*					
1N2908	S			DS	850	11	250M	0.5*					
1N2909	S			DS	850	11	250M	0.5*					
1N2910	S			DS	4.0K	8.0	250M	0.5*					
1N2911	S			DS	4.0K	8.0	250M	0.5*					
1N2912	S			DS	200	12	250M	0.5*					
1N2913	S			DS	200	12	250M	0.5*					
1N2914	S			DS	500	9.0	250M	0.5*					
1N2915	S			DS	500	9.0	250M	0.5*					
1N2916	S			DS	550	13	250M	0.5*					
1N2917	S			DS	550	13	250M	0.5*					
1N2918	S			DS	5.0K	10	250M	0.5*					
1N2919	S			DS	5.0K	10	250M	0.5*					
1N2920	S			DS	500	11	250M	0.5*					
1N2921	S			DS	500	11	250M	0.5*					
1N2922	S			DS	6.0K	12	250M	0.5*					
1N2923	S			DS	6.0K	12	250M	0.5*					
1N2924	S			DS	500	13	250M	0.5*					
1N2925	S			DS	500	13	250M	0.5*					
1N2926		Microwave X-K band Detector											
1N2926A		Microwave X-K band Detector											
1N2927,A thru 1N2934,A		Tunnel Diodes, see Table on Page 1-102											
1N2937	S	1N2996A	1N2970	DZ						42.5	57.5		10W
1N2938	S			DZ						0.75	1.05		2.0W
1N2939,A thru 1N2941,A		Tunnel Diodes, see Table on Page 1-102											
1N2969		Tunnel Diode, see Table on Page 1-102											
1N2969A		Tunnel Diode, see Table on Page 1-102											
1N2970	S		1N2970	DZ							6.8*	20	10W
1N2970A	S		1N2970	DZ							6.8*	10	10W
1N2970B	S		1N2970	DZ							6.8*	5.0	10W
1N2971	S		1N2970	DZ							7.5*	20	10W
1N2971A	S		1N2970	DZ							7.5*	10	10W
1N2971B	S		1N2970	DZ							7.5*	5.0	10W
1N2972	S		1N2970	DZ							8.2*	20	10W
1N2972A	S		1N2970	DZ							8.2*	10	10W
1N2972B	S		1N2970	DZ							8.2*	5.0	10W
1N2973	S		1N2970	DZ							9.1*	20	10W
1N2973A	S		1N2970	DZ							9.1*	10	10W
1N2973B	S		1N2970	DZ							9.1*	5.0	10W
1N2974	S		1N2970	DZ							10*	20	10W
1N2974A	S		1N2970	DZ							10*	10	10W
1N2974B	S		1N2970	DZ							10*	5.0	10W
1N2975	S		1N2970	DZ							11*	20	10W
1N2975A	S		1N2970	DZ							11*	10	10W
1N2975B	S		1N2970	DZ							11*	5.0	10W
1N2976	S		1N2970	DZ							12*	20	10W
1N2976A	S		1N2970	DZ							12*	10	10W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N2976B	S		1N2970	DZ							12*	5.0	10W
1N2977	S		1N2970	DZ							13*	20	10W
1N2977A	S		1N2970	DZ							13*	10	10W
1N2977B	S		1N2970	DZ							13*	5.0	10W
1N2978	S		1N2970	DZ							14*	20	10W
1N2978A	S		1N2970	DZ							14*	10	10W
1N2978B	S		1N2970	DZ							14*	5.0	10W
1N2979	S		1N2970	DZ							15*	20	10W
1N2979A	S		1N2970	DZ							15*	10	10W
1N2979B	S		1N2970	DZ							15*	5.0	10W
1N2980	S		1N2970	DZ							16*	20	10W
1N2980A	S		1N2970	DZ							16*	10	10W
1N2980B	S		1N2970	DZ							16*	5.0	10W
1N2981	S		1N2970	DZ							17*	20	10W
1N2981A	S		1N2970	DZ							17*	10	10W
1N2981B	S		1N2970	DZ							17*	5.0	10W
1N2982	S		1N2970	DZ							18*	20	10W
1N2982A	S		1N2970	DZ							18*	10	10W
1N2982B	S		1N2970	DZ							18*	5.0	10W
1N2983	S		1N2970	DZ							19*	20	10W
1N2983A	S		1N2970	DZ							19*	10	10W
1N2983B	S		1N2970	DZ							19*	5.0	10W
1N2984	S		1N2970	DZ							20*	20	10W
1N2984A	S		1N2970	DZ							20*	10	10W
1N2984B	S		1N2970	DZ							20*	5.0	10W
1N2985	S		1N2970	DZ							22*	20	10W
1N2985A	S		1N2970	DZ							22*	10	10W
1N2985B	S		1N2970	DZ							22*	5.0	10W
1N2986	S		1N2970	DZ							24*	20	10W
1N2986A	S		1N2970	DZ							24*	10	10W
1N2986B	S		1N2970	DZ							24*	5.0	10W
1N2987	S		1N2970	DZ							25*	20	10W
1N2987A	S		1N2970	DZ							25*	10	10W
1N2987B	S		1N2970	DZ							25*	5.0	10W
1N2988	S		1N2970	DZ							27*	20	10W
1N2988A	S		1N2970	DZ							27*	10	10W
1N2988B	S		1N2970	DZ							27*	5.0	10W
1N2989	S		1N2970	DZ							30*	20	10W
1N2989A	S		1N2970	DZ							30*	10	10W
1N2989B	S		1N2970	DZ							30*	5.0	10W
1N2990	S		1N2970	DZ							33*	20	10W
1N2990A	S		1N2970	DZ							33*	10	10W
1N2990B	S		1N2970	DZ							33*	5.0	10W
1N2991	S		1N2970	DZ							36*	20	10W
1N2991A	S		1N2970	DZ							36*	10	10W
1N2991B	S		1N2970	DZ							36*	5.0	10W
1N2992	S		1N2970	DZ							39*	20	10W
1N2992A	S		1N2970	DZ							39*	10	10W
1N2992B	S		1N2970	DZ							39*	5.0	10W
1N2993	S		1N2970	DZ							43*	20	10W
1N2993A	S		1N2970	DZ							43*	10	10W
1N2993B	S		1N2970	DZ							43*	5.0	10W
1N2994	S		1N2970	DZ							45*	20	10W
1N2994A	S		1N2970	DZ							45*	10	10W
1N2994B	S		1N2970	DZ							45*	5.0	10W
1N2995	S		1N2970	DZ							47*	20	10W
1N2995A	S		1N2970	DZ							47*	10	10W
1N2995B	S		1N2970	DZ							47*	5.0	10W
1N2996	S		1N2970	DZ							50*	20	10W
1N2996A	S		1N2970	DZ							50*	10	10W
1N2996B	S		1N2970	DZ							50*	5.0	10W
1N2997	S		1N2970	DZ							51*	20	10W
1N2997A	S		1N2970	DZ							51*	10	10W
1N2997B	S		1N2970	DZ							51*	5.0	10W
1N2998	S		1N2970	DZ							52*	20	10W
1N2998A	S		1N2970	DZ							52*	10	10W
1N2998B	S		1N2970	DZ							52*	5.0	10W
1N2999	S		1N2970	DZ							56*	20	10W
1N2999A	S		1N2970	DZ							56*	10	10W
1N2999B	S		1N2970	DZ							56*	5.0	10W
1N3000	S		1N2970	DZ							62*	20	10W
1N3000A	S		1N2970	DZ							62*	10	10W
1N3000B	S		1N2970	DZ							62*	5.0	10W
1N3001	S		1N2970	DZ							68*	20	10W
1N3001A	S		1N2970	DZ							68*	10	10W
1N3001B	S		1N2970	DZ							68*	5.0	10W
1N3002	S		1N2970	DZ							75*	20	10W
1N3002A	S		1N2970	DZ							75*	10	10W
1N3002B	S		1N2970	DZ							75*	5.0	10W
1N3003	S		1N2970	DZ							82*	20	10W
1N3003A	S		1N2970	DZ							82*	10	10W
1N3003B	S		1N2970	DZ							82*	5.0	10W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3004	S		1N2970	DZ							91*	20	10W
1N3004A	S		1N2970	DZ							91*	10	10W
1N3004B	S		1N2970	DZ							91*	5.0	10W
1N3005	S		1N2970	DZ							100*	20	10W
1N3005A	S		1N2970	DZ							100*	10	10W
1N3005B	S		1N2970	DZ							100*	5.0	10W
1N3006	S		1N2970	DZ							105*	20	10W
1N3006A	S		1N2970	DZ							105*	10	10W
1N3006B	S		1N2970	DZ							105*	5.0	10W
1N3007	S		1N2970	DZ							110*	20	10W
1N3007A	S		1N2970	DZ							110*	10	10W
1N3007B	S		1N2970	DZ							110*	5.0	10W
1N3008	S		1N2970	DZ							120*	20	10W
1N3008A	S		1N2970	DZ							120*	10	10W
1N3008B	S		1N2970	DZ							120*	5.0	10W
1N3009	S		1N2970	DZ							130*	20	10W
1N3009A	S		1N2970	DZ							130*	10	10W
1N3009B	S		1N2970	DZ							130*	5.0	10W
1N3010	S		1N2970	DZ							140*	20	10W
1N3010A	S		1N2970	DZ							140*	10	10W
1N3010B	S		1N2970	DZ							140*	5.0	10W
1N3011	S		1N2970	DZ							150*	20	10W
1N3011A	S		1N2970	DZ							150*	10	10W
1N3011B	S		1N2970	DZ							150*	5.0	10W
1N3012	S		1N2970	DZ							160*	20	10W
1N3012A	S		1N2970	DZ							160*	10	10W
1N3012B	S		1N2970	DZ							160*	5.0	10W
1N3013	S		1N2970	DZ							175*	20	10W
1N3013A	S		1N2970	DZ							175*	10	10W
1N3013B	S		1N2970	DZ							175*	5.0	10W
1N3014	S		1N2970	DZ							180*	20	10W
1N3014A	S		1N2970	DZ							180*	10	10W
1N3014B	S		1N2970	DZ							180*	5.0	10W
1N3015	S		1N2970	DZ							200*	20	10W
1N3015A	S		1N2970	DZ							200*	10	10W
1N3015B	S		1N2970	DZ							200*	5.0	10W
1N3016	S		1N2970	DZ							6.8*	20	1.0W
1N3016A	S		1N2970	DZ							6.8*	10	1.0W
1N3016B	S		1N2970	DZ							6.8*	5.0	1.0W
1N3017	S		1N2970	DZ							7.5*	20	1.0W
1N3017A	S		1N2970	DZ							7.5*	10	1.0W
1N3017B	S		1N2970	DZ							7.5*	5.0	1.0W
1N3018	S		1N2970	DZ							8.2*	20	1.0W
1N3018A	S		1N2970	DZ							8.2*	10	1.0W
1N3018B	S		1N2970	DZ							8.2*	5.0	1.0W
1N3019	S		1N2970	DZ							9.1*	20	1.0W
1N3019A	S		1N2970	DZ							9.1*	10	1.0W
1N3019B	S		1N2970	DZ							9.1*	5.0	1.0W
1N3020	S		1N2970	DZ							10*	20	1.0W
1N3020A	S		1N2970	DZ							10*	10	1.0W
1N3020B	S		1N2970	DZ							10*	5.0	1.0W
1N3021	S		1N2970	DZ							11*	20	1.0W
1N3021A	S		1N2970	DZ							11*	10	1.0W
1N3021B	S		1N2970	DZ							11*	5.0	1.0W
1N3022	S		1N2970	DZ							12*	20	1.0W
1N3022A	S		1N2970	DZ							12*	10	1.0W
1N3022B	S		1N2970	DZ							12*	5.0	1.0W
1N3023	S		1N2970	DZ							13*	20	1.0W
1N3023A	S		1N2970	DZ							13*	10	1.0W
1N3023B	S		1N2970	DZ							13*	5.0	1.0W
1N3024	S		1N2970	DZ							15*	20	1.0W
1N3024A	S		1N2970	DZ							15*	10	1.0W
1N3024B	S		1N2970	DZ							15*	5.0	1.0W
1N3025	S		1N2970	DZ							16*	20	1.0W
1N3025A	S		1N2970	DZ							16*	10	1.0W
1N3025B	S		1N2970	DZ							16*	5.0	1.0W
1N3026	S		1N2970	DZ							18*	20	1.0W
1N3026A	S		1N2970	DZ							18*	10	1.0W
1N3026B	S		1N2970	DZ							18*	5.0	1.0W
1N3027	S		1N2970	DZ							20*	20	1.0W
1N3027A	S		1N2970	DZ							20*	10	1.0W
1N3027B	S		1N2970	DZ							20*	5.0	1.0W
1N3028	S		1N2970	DZ							22*	20	1.0W
1N3028A	S		1N2970	DZ							22*	10	1.0W
1N3028B	S		1N2970	DZ							22*	5.0	1.0W
1N3029	S		1N2970	DZ							24*	20	1.0W
1N3029A	S		1N2970	DZ							24*	10	1.0W
1N3029B	S		1N2970	DZ							24*	5.0	1.0W
1N3030	S		1N2970	DZ							27*	20	1.0W
1N3030A	S		1N2970	DZ							27*	10	1.0W
1N3030B	S		1N2970	DZ							27*	5.0	1.0W
1N3031	S		1N2970	DZ							30*	20	1.0W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3031A	S		1N2970	DZ							30*	10	1.0W
1N3031B	S		1N2970	DZ							30*	5.0	1.0W
1N3032	S		1N2970	DZ							33*	20	1.0W
1N3032A	S		1N2970	DZ							33*	10	1.0W
1N3032B	S		1N2970	DZ							33*	5.0	1.0W
1N3033	S		1N2970	DZ							36*	20	1.0W
1N3033A	S		1N2970	DZ							36*	10	1.0W
1N3033B	S		1N2970	DZ							36*	5.0	1.0W
1N3034	S		1N2970	DZ							39*	20	1.0W
1N3034A	S		1N2970	DZ							39*	10	1.0W
1N3034B	S		1N2970	DZ							39*	5.0	1.0W
1N3035	S		1N2970	DZ							43*	20	1.0W
1N3035A	S		1N2970	DZ							43*	10	1.0W
1N3035B	S		1N2970	DZ							43*	5.0	1.0W
1N3036	S		1N2970	DZ							47*	20	1.0W
1N3036A	S		1N2970	DZ							47*	10	1.0W
1N3036B	S		1N2970	DZ							47*	5.0	1.0W
1N3037	S		1N2970	DZ							51*	20	1.0W
1N3037A	S		1N2970	DZ							51*	10	1.0W
1N3037B	S		1N2970	DZ							51*	5.0	1.0W
1N3038	S		1N2970	DZ							56*	20	1.0W
1N3038A	S		1N2970	DZ							56*	10	1.0W
1N3038B	S		1N2970	DZ							56*	5.0	1.0W
1N3039	S		1N2970	DZ							62*	20	1.0W
1N3039A	S		1N2970	DZ							62*	10	1.0W
1N3039B	S		1N2970	DZ							62*	5.0	1.0W
1N3040	S		1N2970	DZ							68*	20	1.0W
1N3040A	S		1N2970	DZ							68*	10	1.0W
1N3040B	S		1N2970	DZ							68*	5.0	1.0W
1N3041	S		1N2970	DZ							75*	20	1.0W
1N3041A	S		1N2970	DZ							75*	10	1.0W
1N3041B	S		1N2970	DZ							75*	5.0	1.0W
1N3042	S		1N2970	DZ							82*	20	1.0W
1N3042A	S		1N2970	DZ							82*	10	1.0W
1N3042B	S		1N2970	DZ							82*	5.0	1.0W
1N3043	S		1N2970	DZ							91*	20	1.0W
1N3043A	S		1N2970	DZ							91*	10	1.0W
1N3043B	S		1N2970	DZ							91*	5.0	1.0W
1N3044	S		1N2970	DZ							100*	20	1.0W
1N3044A	S		1N2970	DZ							100*	10	1.0W
1N3044B	S		1N2970	DZ							100*	5.0	1.0W
1N3045	S		1N2970	DZ							110*	20	1.0W
1N3045A	S		1N2970	DZ							110*	10	1.0W
1N3045B	S		1N2970	DZ							110*	5.0	1.0W
1N3046	S		1N2970	DZ							120*	20	1.0W
1N3046A	S		1N2970	DZ							120*	10	1.0W
1N3046B	S		1N2970	DZ							120*	5.0	1.0W
1N3047	S		1N2970	DZ							130*	20	1.0W
1N3047A	S		1N2970	DZ							130*	10	1.0W
1N3047B	S		1N2970	DZ							130*	5.0	1.0W
1N3048	S		1N2970	DZ							150*	20	1.0W
1N3048A	S		1N2970	DZ							150*	10	1.0W
1N3048B	S		1N2970	DZ							150*	5.0	1.0W
1N3049	S		1N2970	DZ							160*	20	1.0W
1N3049A	S		1N2970	DZ							160*	10	1.0W
1N3049B	S		1N2970	DZ							160*	5.0	1.0W
1N3050	S		1N2970	DZ							180*	20	1.0W
1N3050A	S		1N2970	DZ							180*	10	1.0W
1N3050B	S		1N2970	DZ							180*	5.0	1.0W
1N3051	S		1N2970	DZ							200*	20	1.0W
1N3051A	S		1N2970	DZ							200*	10	1.0W
1N3051B	S		1N2970	DZ							200*	5.0	1.0W
1N3052	S			R*	12K	70	0.1	0.2	6.0				
1N3053	S			R*	14K	75	0.1	0.2	6.0				
1N3054	S			R*	16K	80	0.1	0.2	6.0				
1N3055	S			R*	18K	85	0.1	0.2	6.0				
1N3056	S			R*	20K	90	0.1	0.2	6.0				
1N3057	S			R*	22K	95	0.1	0.2	6.0				
1N3058	S			R*	24K	100	0.1	0.2	6.0				
1N3059	S			R*	26K	105	0.1	0.2	6.0				
1N3060	S			R*	28K	120	0.1	0.2	6.0				
1N3061	S			R*	30K	125	0.1	0.2	6.0				
1N3062	S			DS	75	1.0	20M	0.1*	2.0				
1N3063	S			DS	75	0.85	10M	0.1*	2.0				
1N3064	S			DS	75	1.0	10M	0.1*	4.0				
1N3065	S			DS	75	1.0	20M	0.1*	2.0				
1N3066	S			DS	75	1.0	10M	0.1*	2.0				
1N3067	S			DS	30	1.0	5.0M	0.1*	2.0				
1N3068	S			DS	30	1.0	5.0M	0.1*	50				
1N3069	S			DS	65	1.0	50M	0.1*	50				
1N3070	S			DS	200	1.0	100M	0.1*	50				
1N3071	S			DS	200	1.0	100M	0.1*	50				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F (volts) @ I_F		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3072	S	1N4001	1N4001	R*	50	1.5	0.2	0.5	10				
1N3073	S	1N4002	1N4001	R*	100	1.5	0.2	0.5	10				
1N3074	S	1N4003	1N4001	R*	150	1.5	0.2	0.5	10				
1N3075	S	1N4003	1N4001	R*	200	1.5	0.2	0.5	10				
1N3076	S	1N4004	1N4001	R*	250	1.5	0.2	0.5	10				
1N3077	S	1N4004	1N4001	R*	300	1.5	0.2	0.5	10				
1N3078	S	1N4004	1N4001	R*	350	1.5	0.2	0.5	10				
1N3079	S	1N4004	1N4001	R*	400	1.5	0.2	0.5	10				
1N3080	S	1N4005	1N4001	R*	500	1.5	0.2	0.5	10				
1N3081	S	1N4005	1N4001	R*	600	1.5	0.2	0.5	10				
1N3082	S	1N4003	1N4001	R*	200	1.25	0.5	0.2	15				
1N3083	S	1N4004	1N4001	R*	400	1.25	0.5	0.2	15				
1N3084	S	1N4005	1N4001	R*	600	1.25	0.5	0.2	15				
1N3085	S	MR1221SB	MR1220	R*	100	1.1	150	40	1500				
1N3086	S	MR1223SB	MR1220	R*	200	1.1	150	40	1500				
1N3087	S	MR1225SB	MR1200	R*	300	1.1	150	40	1500				
1N3088	S	MR1227SB	MR1200	R*	400	1.1	150	40	1500				
1N3089	S	MR1228SB	MR1200	R*	500	1.1	150	40	1500				
1N3090	S	MR1229SB	MR1220	R*	600	1.1	150	40	1500				
1N3091	S			R*	800	1.1	150	40	1500				
1N3092	S			R*	1000	1.1	150	40	1500				
1N3093	G	X-band Switch											
1N3097	G			DS	30	0.5	10M	4.0*	0.5				
1N3098	S	1N3046A	1N2970	DZ						110	130		1.0W
1N3099	S	1N3048A	1N2970	DZ						130	160		1.0W
1N3100	S	1N3050A	1N2970	DZ						160	200		1.0W
1N3101	S	1N3051A	1N2970	DZ						200	240		1.0W
1N3102	S	1N3008A	1N2970	DZ						110	130		10W
1N3103	S	1N3011A	1N2970	DZ						130	160		10W
1N3104	S	1N3014A	1N2970	DZ						160	200		10W
1N3105	S	1N3015A	1N2970	DZ						200	240		10W
1N3106	S			R*	800	1.6	0.75	0.3	30				
1N3107	S			R*	1200	3.2	0.5	0.3	15				
1N3108	S			R*	800	1.6	1.5	0.3	30				
1N3109	S			R*	1200	3.2	0.7	0.3	15				
1N3110	G			DS	8.0	0.45	5.0M	20*					
1N3111	S	MR1220SB	MR1220	R*	50	1.1	150	40	1500				
1N3112	S	1N4737A	1N4728	DZ						7.13	7.88		1.0W
1N3113 thru 1N3120		Tunnel Diodes, see Table on Page 1-102											
1N3121	G			DS	50	0.25	0.1M	3.5*	0.5				
1N3122	G			DS	20	0.3	1.0M	4.5*					
1N3123	S			DS	40	1.5	10M	0.1*	4.0				
1N3124	S			DS	40	1.0	20M	0.1*	4.0				
1N3125	G			DS	40	0.4	5.0M	100*	0.3				
1N3128 thru 1N3130		Tunnel Diodes, see Table on Page 1-102											
1N3138		Tunnel Diode, see Table on Page 1-102											
1N3139	S			R*	50	1.55	70	15	1200				
1N3140	S			R*	100	1.55	70	15	1200				
1N3141	S			R*	150	1.55	70	15	1200				
1N3142	S			R*	200	1.55	70	15	1200				
1N3143	G	Microwave C-X-band Detector											
1N3144	G			DS	20	0.3	1.0M	20*	0.5				
1N3145	G			DS	65	0.45	10M	25*					
1N3146	G			DS	20	1.0	50M	100*	2.0				
1N3147	S			DS	45	1.0	100M		1.0				
1N3148	S	1N3155A	1N3154	DR						0.005	8.5	-55	100
1N3149		Tunnel Diode, see Table on Page 1-102											
1N3149A		Tunnel Diode, see Table on Page 1-102											
1N3150		Tunnel Diode, see Table on Page 1-102											
1N3151	S			R*	7200	27	0.1	250	12				
1N3154	S		1N3154	DR						0.01	8.8	-55	100
1N3154A	S		1N3154	DR						0.01	8.8	-55	150
1N3155	S		1N3154	DR						0.005	8.8	-55	100
1N3155A	S		1N3154	DR						0.005	8.8	-55	150
1N3156	S		1N3154	DR						0.002	8.8	-55	100
1N3156A	S		1N3154	DR						0.002	8.8	-55	150
1N3157	S		1N3154	DR						0.001	8.8	-55	100
1N3157A	S		1N3154	DR						0.001	8.8	-55	150
1N3159	G			DS	15	0.45	10M		0.3				
1N3160	G			DS	60	1.0	5.0M	12*					
1N3161	S	MR1230SB	MR1230	R*	50	1.30	240	16	3000				
1N3162	S	MR1231SB	MR1230	R*	100	1.30	240	16	3000				
1N3163	S	MR1232SB	MR1230	R*	150	1.30	240	16	3000				
1N3164	S	MR1233SB	MR1230	R*	200	1.30	240	16	3000				
1N3165	S	MR1234SB	MR1230	R*	250	1.30	240	16	3000				
1N3166	S	MR1235SB	MR1230	R*	300	1.30	240	16	3000				
1N3167	S	MR1236SB	MR1230	R*	350	1.30	240	16	3000				
1N3168	S	MR1237SB	MR1230	R*	400	1.30	240	16	3000				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3169	S	MR1238SB	MR1230	R*	500	1.30	240	16	3000				
1N3170	S	MR1239SB	MR1230	R*	600	1.30	240	16	3000				
1N3171	S			R*	700	1.92	240	16	3000				
1N3171A	S			R*	700	1.9	240	16	3000				
1N3172	S			R*	800	1.92	240	16	3000				
1N3172A	S			R*	800	1.9	240	16	3000				
1N3173	S			R*	900	1.92	240	16	3000				
1N3173A	S			R*	900	1.9	240	16	3000				
1N3174	S			R*	1000	1.92	240	16	3000				
1N3174A	S			R*	1000	1.9	240	16	3000				
1N3175	S			R*	1200	1.4	240	15	3000				
1N3176	S			R*	1400	1.4	240	15	3000				
1N3177	S			R*	1600	1.4	240	15	3000				
1N3179	S			DS	200	1.0	100M	10*					
1N3180	S			DS	110	1.5	500M	5.0*					
1N3181	S	1N5237A	1N5221	DZ							8.2*	10	500M
1N3182		Varactor Diode, see Table on Page 1-94											
1N3183	S			R*	350	1.0	0.5		4.0				
1N3184	S			R*	500	1.0	0.5		4.0				
1N3185	S			R*	700	2.0	0.5		4.0				
1N3186	S			R*	1000	2.0	0.5		4.0				
1N3187	S			R*	1500	3.0	0.5		4.0				
1N3188	S			R*	2000	4.0	0.5		4.0				
1N3189	S	1N4003	1N4001	R*	200	1.1	1.0	0.2	30				
1N3190	S	1N4004	1N4001	R*	400	1.1	1.0	0.2	30				
1N3191	S	1N4005	1N4001	R*	600	1.1	1.0	0.2	30				
1N3192	S			DS	200	1.0	100M	10*					
1N3193	S	1N4003	1N4001	R*	200	1.2	0.75	0.2	40				
1N3194	S	1N4004	1N4001	R*	400	1.2	0.75	0.2	40				
1N3195	S	1N4005	1N4001	R*	600	1.2	0.75	0.2	40				
1N3196	S	1N4006	1N4001	R*	800	1.2	0.75	0.2	40				
1N3197	G			DS	30	1.0	150M	50*	0.3				
1N3198	S	1N5221B	1N5221	DZ							2.25*		400M
1N3199	S	1N3155	1N3154	DR						0.005	8.8	50	100
1N3200	S	1N3156	1N3154	DR						0.003	8.8	50	100
1N3201	S	1N3156	1N3154	DR						0.002	8.8	50	100
1N3202	S	1N3157	1N3154	DR						0.001	8.8	50	100
1N3203	G			DS	25	0.5	35M	50*	0.3				
1N3206	S			DS	80	1.0	10M	5.0*	4.0				
1N3207	S			DS	50	1.0	150M	0.05*	6.0				
1N3208	S		1N3189	R*	50	1.5	15	10	250				
1N3209	S		1N3189	R*	100	1.5	15	10	250				
1N3210	S		1N3189	R*	200	1.5	15	10	250				
1N3211	S		1N3189	R*	300	1.5	15	10	250				
1N3212	S		1N3189	R*	400	1.5	15	10	250				
1N3213	S		1N248B	R*	500	1.5	15	10	250				
1N3214	S		1N248B	R*	600	1.5	15	10	250				
1N3215	S			DS	80	0.7	1.0M	10*	0.25				
1N3217 thru 1N3222		Tunnel Diodes, see Table on Page 1-102											
1N3223	S			DS	150	1.5	4.0M	20*	800				
1N3225	G			DS	40	1.0	5.0M	33*	0.5				
1N3227	S			R*	100	3.3	0.5	0.250	12.5				
1N3228	S			R*	200	3.3	0.5	0.250	12.5				
1N3229	S			R*	400	3.3	0.5	0.250	12.5				
1N3230	S			R*	600	3.3	0.5	0.250	12.5				
1N3231	S			R*	800	3.3	0.5	0.250	12.5				
1N3232	S			R*	1000	3.3	0.5	0.250	12.5				
1N3233	S			R*	1200	3.3	0.5	0.250	12.5				
1N3234	S			R*	1500	3.3	0.5	0.250	12.5				
1N3235	S			R*	1800	3.3	0.5	0.250	12.5				
1N3236	S			R*	2000	3.3	0.5	0.250	12.5				
1N3237	S			R*	50	2.2	0.75	0.250	15.0				
1N3238	S			R*	100	2.2	0.75	0.250	15.0				
1N3239	S			R*	200	2.2	0.75	0.250	15.0				
1N3240	S			R*	400	2.2	0.75	0.250	15.0				
1N3241	S			R*	600	2.2	0.75	0.250	15.0				
1N3242	S			R*	800	2.2	0.75	0.250	15.0				
1N3243	S			R*	1000	2.2	0.75	0.250	15.0				
1N3244	S			R*	1200	2.2	0.75	0.250	15.0				
1N3245	S			R*	1500	2.2	0.75	0.250	15.0				
1N3246	S			R*	50	1.1	1.0	0.250	20.0				
1N3247	S			R*	100	1.1	1.0	0.250	20.0				
1N3248	S			R*	200	1.1	1.0	0.250	20.0				
1N3249	S			R*	400	1.1	1.0	0.250	20.0				
1N3250	S			R*	600	1.1	1.0	0.250	20.0				
1N3251	S			R*	800	1.1	1.0	0.250	20.0				
1N3252	S			R*	1000	1.1	1.0	0.250	20.0				
1N3253	S	1N4003	1N4001	R*	200	1.2	0.75	0.2	40				
1N3254	S	1N4004	1N4001	R*	400	1.2	0.75	0.2	40				
1N3255	S	1N4005	1N4001	R*	600	1.2	0.75	0.2	40				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3256	S	1N4006	1N4001	R*	800	1.2	0.5	0.2	40				
1N3260	S	MR1220SB	MR1220	R*	50	1.6	160	12	2000				
1N3261	S	MR1221SB	MR1220	R*	100	1.6	160	12	2000				
1N3262	S	MR1222SB	MR1220	R*	150	1.6	160	12	2000				
1N3263	S	MR1223SB	MR1220	R*	200	1.6	160	12	2000				
1N3264	S	MR1224SB	MR1220	R*	250	1.6	160	12	2000				
1N3265	S	MR1225SB	MR1220	R*	300	1.6	160	12	2000				
1N3266	S	MR1226SB	MR1220	R*	350	1.6	160	12	2000				
1N3267	S	MR1227SB	MR1220	R*	400	1.6	160	12	2000				
1N3268	S	MR1228SB	MR1220	R*	500	1.6	160	12	2000				
1N3269	S	MR1229SB	MR1220	R*	600	1.6	160	12	2000				
1N3270	S			R*	700	1.6	160	12	2000				
1N3271	S			R*	800	1.6	160	12	2000				
1N3272	S			R*	900	1.6	160	12	2000				
1N3273	S			R*	1000	1.6	160	12	2000				
1N3274	S			R*	1200	1.4	160	12	2000				
1N3275	S			R*	1400	1.4	160	12	2000				
1N3276	S			R*	1600	1.4	160	12	2000				
1N3277	S			R*	200	1.3	0.75		25				
1N3278	S			R*	400	1.3	0.75		25				
1N3279	S			R*	600	1.3	0.75		25				
1N3280	S			R*	800	1.3	0.75		25				
1N3281	S			R*	1000	1.3	0.75		25				
1N3282	S		1N3213	R*	1000	3.7	0.1		2.5				
1N3283	S		1N3213	R*	1500	3.7	0.1		2.5				
1N3284	S		1N3213	R*	2000	3.7	0.1		2.5				
1N3285	S		1N3213	R*	2500	3.7	0.1		2.5				
1N3286	S		1N3213	R*	3000	3.7	0.1		2.5				
1N3287	G			DS	6.0	0.312	1.0M	15*					
1N3288	S			R*	100	1.5	100	200	1600				
1N3288A	S	MR1811R		R*	100	1.5	100	24	2300				
1N3289	S			R*	200	1.5	100	300	1600				
1N3289A	S	MR1813R		R*	200	1.5	100	24	2300				
1N3290	S			R*	300	1.5	100	400	1600				
1N3290A	S	MR1815R		R*	300	1.5	100	24	2300				
1N3291	S			R*	400	1.5	100	525	1600				
1N3291A	S	MR1817R		R*	400	1.5	100	24	2300				
1N3292	S			R*	500	1.5	100	650	1600				
1N3292A	S			R*	500	1.5	100	21	1600				
1N3292B	S	MR1818SB		R*	500	1.5	100	21	2300				
1N3293	S			R*	600	1.5	100	800	1600				
1N3293A	S	MR1819SB		R*	600	1.5	100	17	2300				
1N3294	S			R*	800	1.5	100	1050	1600				
1N3294A	S			R*	800	1.5	100	13	2300				
1N3295	S			R*	1000	1.5	100	1300	1600				
1N3295A	S			R*	1000	1.5	100	11	2300				
1N3296	S			R*	1200	1.5	100	1600	1600				
1N3296A	S			R*	1200	1.5	100	9.0	2300				
1N3297	S			R*	1400	1.5	100	1800	1600				
1N3297A	S			R*	1400	1.5	100	7.0	2300				
1N3298	S			DS	70	0.9	500M	0.2*	20				
1N3298A	S			DS	70	0.9	0.5A	0.2*					
1N3299 thru 1N3304,A		4-Layer Diodes, see Table on Page 1-106											
1N3305	S		1N2804	DZ							6.8*	20	50W
1N3305A	S		1N2804	DZ							6.8*	10	50W
1N3305B	S		1N2804	DZ							6.8*	5.0	50W
1N3306	S		1N2804	DZ							7.5*	20	50W
1N3306A	S		1N2804	DZ							7.5*	10	50W
1N3306B	S		1N2804	DZ							7.5*	5.0	50W
1N3307	S		1N2804	DZ							8.2*	20	50W
1N3307A	S		1N2804	DZ							8.2*	10	50W
1N3307B	S		1N2804	DZ							8.2*	5.0	50W
1N3308	S		1N2804	DZ							9.1*	20	50W
1N3308A	S		1N2804	DZ							9.1*	10	50W
1N3308B	S		1N2804	DZ							9.1*	5.0	50W
1N3309	S		1N2804	DZ							10*	20	50W
1N3309A	S		1N2804	DZ							10*	10	50W
1N3309B	S		1N2804	DZ							10*	5.0	50W
1N3310	S		1N2804	DZ							11*	20	50W
1N3310A	S		1N2804	DZ							11*	10	50W
1N3310B	S		1N2804	DZ							11*	5.0	50W
1N3311	S		1N2804	DZ							12*	20	50W
1N3311A	S		1N2804	DZ							12*	10	50W
1N3311B	S		1N2804	DZ							12*	5.0	50W
1N3312	S		1N2804	DZ							13*	20	50W
1N3312A	S		1N2804	DZ							13*	10	50W
1N3312B	S		1N2804	DZ							13*	5.0	50W
1N3313	S		1N2804	DZ							14*	20	50W
1N3313A	S		1N2804	DZ							14*	10	50W
1N3313B	S		1N2804	DZ							14*	5.0	50W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3314	S		1N2804	DZ							15*	20	50W
1N3314A	S		1N2804	DZ							15*	10	50W
1N3314B	S		1N2804	DZ							15*	5.0	50W
1N3315	S		1N2804	DZ							16*	20	50W
1N3315A	S		1N2804	DZ							16*	10	50W
1N3315B	S		1N2804	DZ							16*	5.0	50W
1N3316	S		1N2804	DZ							17*	20	50W
1N3316A	S		1N2804	DZ							17*	10	50W
1N3316B	S		1N2804	DZ							17*	5.0	50W
1N3317	S		1N2804	DZ							18*	20	50W
1N3317A	S		1N2804	DZ							18*	10	50W
1N3317B	S		1N8204	DZ							18*	5.0	50W
1N3318	S		1N2804	DZ							19*	20	50W
1N3318A	S		1N2804	DZ							19*	10	50W
1N3318B	S		1N2804	DZ							19*	5.0	50W
1N3319	S		1N2804	DZ							20*	20	50W
1N3319A	S		1N2804	DZ							20*	10	50W
1N3319B	S		1N2804	DZ							20*	5.0	50W
1N3320	S		1N2804	DZ							22*	20	50W
1N3320A	S		1N2804	DZ							22*	10	50W
1N3320B	S		1N2804	DZ							22*	5.0	50W
1N3321	S		1N2804	DZ							24*	20	50W
1N3321A	S		1N2804	DZ							24*	10	50W
1N3321B	S		1N2804	DZ							24*	5.0	50W
1N3322	S		1N2804	DZ							25*	20	50W
1N3322A	S		1N2804	DZ							25*	10	50W
1N3322B	S		1N2804	DZ							25*	5.0	50W
1N3323	S		1N2804	DZ							27*	20	50W
1N3323A	S		1N2804	DZ							27*	10	50W
1N3323B	S		1N2804	DZ							27*	5.0	50W
1N3324	S		1N2804	DZ							30*	20	50W
1N3324A	S		1N2804	DZ							30*	10	50W
1N3324B	S		1N2804	DZ							30*	5.0	50W
1N3325	S		1N2804	DZ							33*	20	50W
1N3325A	S		1N2804	DZ							33*	10	50W
1N3325B	S		1N2804	DZ							33*	5.0	50W
1N3326	S		1N2804	DZ							36*	20	50W
1N3326A	S		1N2804	DZ							36*	10	50W
1N3326B	S		1N2804	DZ							36*	5.0	50W
1N3327	S		1N2804	DZ							39*	20	50W
1N3327A	S		1N2804	DZ							39*	10	50W
1N3327B	S		1N2804	DZ							39*	5.0	50W
1N3328	S		1N2804	DZ							43*	20	50W
1N3328A	S		1N2804	DZ							43*	10	50W
1N3328B	S		1N2804	DZ							43*	5.0	50W
1N3329	S		1N2804	DZ							45*	20	50W
1N3329A	S		1N2804	DZ							45*	10	50W
1N3329B	S		1N2804	DZ							45*	5.0	50W
1N3330	S		1N2804	DZ							47*	20	50W
1N3330A	S		1N2804	DZ							47*	10	50W
1N3330B	S		1N2804	DZ							47*	5.0	50W
1N3331	S		1N2804	DZ							50*	20	50W
1N3331A	S		1N2804	DZ							50*	10	50W
1N3331B	S		1N2804	DZ							50*	5.0	50W
1N3332	S		1N2804	DZ							51*	20	50W
1N3332A	S		1N2804	DZ							51*	10	50W
1N3332B	S		1N2804	DZ							51*	5.0	50W
1N3333	S		1N2804	DZ							52*	20	50W
1N3333A	S		1N2804	DZ							52*	10	50W
1N3333B	S		1N2804	DZ							52*	5.0	50W
1N3334	S		1N2804	DZ							56*	20	50W
1N3334A	S		1N2804	DZ							56*	10	50W
1N3334B	S		1N2804	DZ							56*	5.0	50W
1N3335	S		1N2804	DZ							62*	20	50W
1N3335A	S		1N2804	DZ							62*	10	50W
1N3335B	S		1N2804	DZ							62*	5.0	50W
1N3336	S		1N2804	DZ							68*	20	50W
1N3336A	S		1N2804	DZ							68*	10	50W
1N3336B	S		1N2804	DZ							68*	5.0	50W
1N3337	S		1N2804	DZ							75*	20	50W
1N3337A	S		1N2804	DZ							75*	10	50W
1N3337B	S		1N2804	DZ							75*	5.0	50W
1N3338	S		1N2804	DZ							82*	20	50W
1N3338A	S		1N2804	DZ							82*	10	50W
1N3338B	S		1N2804	DZ							82*	5.0	50W
1N3339	S		1N2804	DZ							91*	20	50W
1N3339A	S		1N2804	DZ							91*	10	50W
1N3339B	S		1N2804	DZ							91*	5.0	50W
1N3340	S		1N2804	DZ							100*	20	50W
1N3340A	S		1N2804	DZ							100*	10	50W
1N3340B	S		1N2804	DZ							100*	5.0	50W
1N3341	S		1N2804	DZ							105*	20	50W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3341A	S		1N2804	DZ							105*	10	50W
1N3341B	S		1N2804	DZ							105*	5.0	50W
1N3342	S		1N2804	DZ							110*	20	50W
1N3342A	S		1N2804	DZ							110*	10	50W
1N3342B	S		1N2804	DZ							110*	5.0	50W
1N3343	S		1N2804	DZ							120*	20	50W
1N3343A	S		1N2804	DZ							120*	10	50W
1N3343B	S		1N2804	DZ							120*	5.0	50W
1N3344	S		1N2804	DZ							130*	20	50W
1N3344A	S		1N2804	DZ							130*	10	50W
1N3344B	S		1N2804	DZ							130*	5.0	50W
1N3345	S		1N2804	DZ							140*	20	50W
1N3345A	S		1N2804	DZ							140*	10	50W
1N3345B	S		1N2804	DZ							140*	5.0	50W
1N3346	S		1N2804	DZ							150*	20	50W
1N3346A	S		1N2804	DZ							150*	10	50W
1N3346B	S		1N2804	DZ							150*	5.0	50W
1N3347	S		1N2804	DZ							160*	20	50W
1N3347A	S		1N2804	DZ							160*	10	50W
1N3347B	S		1N2804	DZ							160*	5.0	50W
1N3348	S		1N2804	DZ							175*	20	50W
1N3348A	S		1N2804	DZ							175*	10	50W
1N3348B	S		1N2804	DZ							175*	5.0	50W
1N3349	S		1N2804	DZ							180*	20	50W
1N3349A	S		1N2804	DZ							180*	10	50W
1N3349B	S		1N2804	DZ							180*	5.0	50W
1N3350	S		1N2804	DZ							200*	20	50W
1N3350A	S		1N2804	DZ							200*	10	50W
1N3350B	S		1N2804	DZ							200*	5.0	50W
1N3353	G	Backward Diode											
1N3354	S			R*	10	1.2	3.0	0.020	30				
1N3355	S			R*	15	1.2	3.0	0.020	30				
1N3356	S			R*	25	1.2	3.0	0.010	30				
1N3357	S			R*	50	1.2	3.0	0.010	30				
1N3358	S			R*	75	1.2	3.0	0.010	30				
1N3359	S			R*	100	1.2	3.0	0.010	30				
1N3360	S			R*	150	1.2	3.0	0.010	30				
1N3361	S			R*	200	1.2	3.0	0.010	30				
1N3362	S			R*	300	1.2	3.0	0.010	30				
1N3363	S			R*	400	1.2	3.0	0.010	30				
1N3364	S			R*	500	1.2	3.0	0.010	30				
1N3365	S			R*	600	1.2	3.0	0.010	30				
1N3366	S			R*	700	1.2	3.0	0.010	30				
1N3367	S			R*	800	2.0	3.0	0.010	30				
1N3368	S			R*	900	2.0	3.0	0.010	30				
1N3369	S			R*	1000	2.5	3.0	0.025	30				
1N3370	S			R*	1200	2.5	3.0	0.025	30				
1N3371	S			R*	1500	2.5	3.0	0.025	30				
1N3372	S			R*	10	1.0	20	0.315	200				
1N3373	S			R*	25	1.0	20	0.315	200				
1N3374	S			R*	50	1.0	20	0.315	200				
1N3375	S			R*	100	1.0	20	0.315	200				
1N3376	S			R*	150	1.0	20	0.315	200				
1N3377	S			R*	200	1.0	20	0.315	200				
1N3378	S			R*	300	1.0	20	0.315	200				
1N3379	S			R*	400	1.0	20	0.315	200				
1N3380	S			R*	500	1.0	20	0.315	200				
1N3381	S			DS	15	1.0	500M	10*					
1N3382	S			DS	15	1.0	500M	10*					
1N3383	S			DS	50	1.0	500M	10*					
1N3384	S			DS	75	1.0	500M	15*					
1N3385	S			DS	100	1.0	500M	20*					
1N3386	S			DS	150	1.0	500M	20*					
1N3387	S			DS	200	1.0	500M	20*					
1N3388	S			DS	250	1.0	500M	25*					
1N3389	S			DS	300	1.0	500M	25*					
1N3390	S			DS	400	1.0	500M	25*					
1N3391	S			DS	500	1.0	500M	25*					
1N3392	S			DZ							1.5*	10	500M
1N3393	S	.5M1.8ZZS10		DZ							1.8*	10	500M
1N3394	S	.5M2.2ZZS10		DZ							2.2*	10	500M
1N3395	S	.5M2.7ZZS10		DZ							2.7*	10	500M
1N3396	S	.5M3.3ZZS10		DZ							3.3*	10	500M
1N3397	S	.5M3.9ZZS10		DZ							3.9*	10	500M
1N3398	S	.5M4.7ZZS10		DZ							4.7*	10	500M
1N3399	S	.5M5.6ZZS10		DZ							5.6*	10	500M
1N3400	S	.5M6.8ZZS10		DZ							6.8*	10	500M
1N3401	S	.5M8.2ZZS10		DZ							8.2*	10	500M
1N3402	S	.5M10ZZS10		DZ							10*	10	500M
1N3403	S	.5M12ZZS10		DZ							12*	10	500M
1N3404	S	.5M15AAS10		DZ							15*	10	500M
1N3405	S	.5M18ZZS10		DZ							18*	10	500M

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3406	S	.5M22ZZS10		DZ							22*	10	500M
1N3407	S	.5M27ZZS10		DZ							27*	10	500M
1N3408	S	.5M33ZZS10		DZ							33*	10	500M
1N3409	S	.5M39ZZS10		DZ							39*	10	500M
1N3410	S	.5M47ZZS10		DZ							47*	10	500M
1N3411	S	1N5234A	1N5221	DZ							6.2*	10	500M
1N3412	S	1N5235A	1N5221	DZ							6.8*	10	500M
1N3413	S	1N5236A	1N5221	DZ							7.5*	10	500M
1N3414	S	1N5237A	1N5221	DZ							8.2*	10	500M
1N3415	S	1N5240A	1N5221	DZ							10*	10	500M
1N3416	S	1N5242A	1N5221	DZ							12*	10	500M
1N3417	S	1N5245A	1N5221	DZ							15*	10	500M
1N3418	S	1N5248A	1N5221	DZ							18*	10	500M
1N3419	S	1N5251A	1N5221	DZ							22*	10	500M
1N3420	S	1N5254A	1N5221	DZ							27*	10	500M
1N3421	S	1N5256A	1N5221	DZ							30*	10	500M
1N3422	S	1N5257A	1N5221	DZ							33*	10	500M
1N3423	S	1N5259A	1N5221	DZ							39*	10	500M
1N3424	S	1N5261A	1N5221	DZ							47*	10	500M
1N3425	S	1N5263A	1N5221	DZ							56*	10	500M
1N3426	S	1N5266A	1N5222	DZ							68*	10	500M
1N3427	S	1N5268A	1N5221	DZ							82*	10	500M
1N3428	S	1N5271A	1N5221	DZ							100*	10	500M
1N3429	S	1N5273A	1N5221	DZ							120*	10	500M
1N3430	S	1N5276A	1N5221	DZ							150*	10	500M
1N3431	S	1N5279A	1N5221	DZ							180*	10	500M
1N3432	S	1N5281B	1N5221	DZ							220*	10	500M
1N3433	S	1N4738	1N4728	DZ							8.2*		2.0W
1N3434	S	1N4740	1N4728	DZ							10.0*		2.0W
1N3435	S	1N4742	1N4728	DZ							12.0*		2.0W
1N3436	S	1N4744	1N4728	DZ							15.0*		2.0W
1N3437	S	1N4746	1N4728	DZ							18.0*		2.0W
1N3438	S	1N4748	1N4728	DZ							22.0*		2.0W
1N3439	S	1N4750	1N4728	DZ							27.0*		2.0W
1N3440	S	1N4752	1N4728	DZ							33.0*		2.0W
1N3441	S	1N4754	1N4728	DZ							39.0*		2.0W
1N3442	S	1N4756	1N4728	DZ							47.0*		2.0W
1N3443	S	1N4735	1N4728	DZ							6.2*	10	2.0W
1N3444	S	1N4736	1N4728	DZ							6.8*	10	2.0W
1N3445	S	1N4738	1N4728	DZ							8.2*	10	2.0W
1N3446	S	1N4740	1N4728	DZ							10*	10	2.0W
1N3447	S	1N4742	1N4728	DZ							12*	10	2.0W
1N3448	S	1N4744	1N4728	DZ							15*	10	2.0W
1N3449	S	1N4746	1N4728	DZ							18*	10	2.0W
1N3450	S	1N4748	1N4728	DZ							22*	10	2.0W
1N3451	S	1N4750	1N4728	DZ							27*	10	2.0W
1N3452	S	1N4751	1N4728	DZ							30*	10	2.0W
1N3453	S	1N4752	1N4728	DZ							33*	10	2.0W
1N3454	S	1N4754	1N4728	DZ							39*	10	2.0W
1N3455	S	1N4756	1N4728	DZ							47*	10	2.0W
1N3456	S	1N4758	1N4728	DZ							56*	10	2.0W
1N3457	S	1N4760	1N4728	DZ							68*	10	2.0W
1N3458	S	1N4762	1N4728	DZ							82*	10	2.0W
1N3459	S	1N4764	1N4728	DZ							100*	10	2.0W
1N3460	S	1M120ZS10	1N4728	DZ							120*	10	2.0W
1N3461	S	1M150ZS10	1N4728	DZ							150*	10	2.0W
1N3462	S	1M180ZS10	1N4728	DZ							180*	10	2.0W
1N3463	S	1M200ZS5	1N4728	DZ							220*	10	2.0W
1N3464	S			R*	8500	30.0	0.1	0.001	2.0				
1N3465	G			DS	60	1.0	200M	20*					
1N3466	G			DS	40	1.0	200M	15*					
1N3467	G			DS	15	0.5	20M	15*	2.0				
1N3468	G			DS	15	0.5	20M	60*	2.0				
1N3469	G			DS	35	0.5	600M	15*					
1N3470	G			DS	35	0.5	600M	30*					
1N3471	S			DS	40	1.0	10M	20N	2.0				
1N3473	S			R*	200	1.4	0.75	0.5	20				
1N3474	S			R*	400	1.4	0.75	0.5	20				
1N3475	S			R*	600	1.4	0.75	0.5	20				
1N3476	S			R*	800	1.4	0.5	0.5	20				
1N3477	S	1N5221A	1N5221	DZ							2.2*	10	250M
1N3477A	S	1N5221B	1N5221	DZ							2.2*	5.0	250M
1N3478	S			DS	200	1.0	500M	10*					
1N3479	S			DS	400	1.0	500M	10*					
1N3480	S			DS	600	1.0	500M	10*					
1N3481	G	RF Power Switch: P_i(max) = 10 mW, f = 9,000 MHz											
1N3482	G	RF Power Switch: P_i(max) = 10 mW, f = 9,000 MHz											
1N3483	G			DS	8.0	0.6	10M	30*					
1N3484	G			DS	75	0.45	10M	4.0*					
1N3485	S			DS	175	1.0	10M	25N	0.05				
1N3486	S			R*	1000	2.0	0.4	0.05	10				
1N3487	S			R*	1200	2.0	0.4	0.05	10				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3488		Varactor Diode, see Table on Page 1-94											
1N3489													
1N3490		4-Layer Diodes, see Table on Page 1-106											
1N3491	S			R*	50	1.7	18	1.0	300				
1N3492	S			R*	100	1.7	18	1.0	300				
1N3493	S			R*	200	1.7	18	1.0	300				
1N3494	S			R*	300	1.7	18	1.0	300				
1N3495	S			R*	400	1.7	18	1.0	300				
1N3496	S	1N823 *	1N821	DR						0.005	6.5	0	75
1N3497	S	1N825 *	1N821	DR						0.002	6.5	0	75
1N3498	S	1N827 *	1N821	DR						0.001	6.5	0	75
1N3499	S	1N829 *	1N821	DR						0.0005	6.5	0	75
1N3500	S	1N821 *	1N821	DR						0.01	6.5	0	75
1N3501	S	MZ640 *	MZ600	DR							6.5	25	100
1N3502	S	MZ620 *	MZ600	DR							6.5	25	100
1N3503	S	MZ610 *	MZ600	DR							6.5	25	100
1N3504	S	MZ605 *	MZ600	DR							6.5	25	100
1N3506	S	1N5226B *	1N5221	DZ							3.3*	5.0	400M
1N3507	S	1N5227B *	1N5221	DZ							3.6*	5.0	400M
1N3508	S	1N5228B *	1N5221	DZ							3.9*	5.0	400M
1N3509	S	1N5229B *	1N5221	DZ							4.3*	5.0	400M
1N3510	S	1N5230B *	1N5221	DZ							4.7*	5.0	400M
1N3511	S	1N5231B *	1N5221	DZ							5.1*	5.0	400M
1N3512	S	1N5232B *	1N5221	DZ							5.6*	5.0	400M
1N3513	S	1N5234B *	1N5221	DZ							6.2*	5.0	400M
1N3514	S	1N5235B *	1N5221	DZ							6.8*	5.0	400M
1N3515	S	1N5236B *	1N5221	DZ							7.5*	5.0	400M
1N3516	S	1N5237B *	1N5221	DZ							8.2*	5.0	400M
1N3517	S	1N5239B *	1N5221	DZ							9.1*	5.0	400M
1N3518	S	1N5240B *	1N5221	DZ							10*	5.0	400M
1N3519	S	1N5241B *	1N5221	DZ							11*	5.0	400M
1N3520	S	1N5242B *	1N5221	DZ							12*	5.0	400M
1N3521	S	1N5243B *	1N5221	DZ							13*	5.0	400M
1N3522	S	1N5245B *	1N5221	DZ							15*	5.0	400M
1N3523	S	1N5246B *	1N5221	DZ							16*	5.0	400M
1N3524	S	1N5248B *	1N5221	DZ							18*	5.0	400M
1N3525	S	1N5250B *	1N5221	DZ							20*	5.0	400M
1N3526	S	1N5251B *	1N5221	DZ							22*	5.0	400M
1N3527	S	1N5252B *	1N5221	DZ							24*	5.0	400M
1N3528	S	1N5254B *	1N5221	DZ							27*	5.0	400M
1N3529	S	1N5256B *	1N5221	DZ							30*	5.0	400M
1N3530	S	1N5257B *	1N5221	DZ							33*	5.0	400M
1N3531	S	1N5258B *	1N5221	DZ							36*	5.0	400M
1N3532	S	1N5259B *	1N5221	DZ							39*	5.0	400M
1N3533	S	1N5260B *	1N5221	DZ							43*	5.0	400M
1N3534	S	1N5261B *	1N5221	DZ							47*	5.0	400M
1N3535	S			DS	200	0.549	100M						
1N3536	S			DS	70	0.65	1.0M	25N					
1N3537	S	1M12ZZS10		DZ							12*		1.0W
1N3538	S			DS	150		2.5M	2.0*					
1N3539	S	Backward Diode											
1N3539A	S	Backward Diode											
1N3540	S	Backward Diode											
1N3540A	S	Backward Diode											
1N3541	S	Backward Diode											
1N3541A	S	Backward Diode											
1N3542	S	Backward Diode											
1N3542A	S	Backward Diode											
1N3543	S	Backward Diode											
1N3543A	S	Backward Diode											
1N3544	S	1N4002	1N4001	R*	100	1.5	0.6	0.2	15				
1N3545	S	1N4003	1N4001	R*	200	1.5	0.6	0.2	15				
1N3546	S	1N4004	1N4001	R*	300	1.5	0.6	0.2	15				
1N3547	S	1N4004	1N4001	R*	400	1.5	0.6	0.2	15				
1N3548	S	1N4005	1N4001	R*	500	1.5	0.6	0.2	15				
1N3549	S	1N4005	1N4001	R*	600	1.5	0.6	0.2	15				
1N3550	S			DS	180	1.0	50M		1.5				
1N3551													
1N3552		Varactor Diodes, see Table on Page 1-94											
1N3553	S	1N821*	1N821	DR						0.0001	6.3	-55	100
1N3554 thru 1N3557		Varactor Diodes, see Table on Page 1-94											
1N3558	S	Matched Pair of 1N751A's, Zener Diode											
1N3559	G			DS	24	1.0	200M	20*					
1N3560 thru 1N3562		Tunnel Diodes, see Table on Page 1-102											
1N3563	S			R*	1000	1.2	0.4	0.2	40				
1N3564	G			DS	15	1.0	40M						
1N3565	S			DS	6.0	2.0	2.0A	25M					
1N3566	S			R*	800	2.25	1.0	0.5	20				

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F (volts) @ I_F		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3567	S			DS	50	1.0	100M	0.05*	2.0				
1N3568	S			DS	80	1.0	20M	1.0*	2.0				
1N3569	S	MR1121 *	MR1120	R*	100	1.3	3.5	0.4	35				
1N3570	S	MR1123 *	MR1120	R*	200	1.3	3.5	0.4	35				
1N3571	S	MR1123 *	MR1120	R*	300	1.3	3.5	0.4	35				
1N3572	S	MR1124 *	MR1120	R*	400	1.3	3.5	0.4	35				
1N3573	S	MR1125 *	MR1120	R*	500	1.3	3.5	0.4	35				
1N3574	S	MR1126 *	MR1120	R*	600	1.3	3.5	0.4	35				
1N3575	S			DS	60	0.74	1.0M	0.75N					
1N3576	S			DS	125	0.74	1.0M	0.75N					
1N3577	S			DS	175	0.74	1.0M	0.75N					
1N3578	S			DS	225	0.74	1.0M	0.75N					
1N3579	S			DS	275	0.74	1.0M	0.75N					
1N3580	S		1N2163	DR						0.01	12.28	0	75
1N3580A	S		1N2163	DR						0.01	12.28	-55	100
1N3580B	S		1N2163	DR						0.01	12.28	-55	150
1N3581	S		1N2163	DR						0.005	12.28	0	75
1N3581A	S		1N2163	DR						0.005	12.28	-55	100
1N3581B	S		1N2163	DR						0.005	12.28	-55	150
1N3582	S		1N2163	DR						0.002	12.28	0	75
1N3582A	S		1N2163	DR						0.002	12.28	-55	100
1N3582B	S		1N2163	DR						0.002	12.28	-55	150
1N3583	S		1N2163	DR						0.001	12.28	0	75
1N3583A	S		1N2163	DR						0.001	12.28	-55	100
1N3583B	S		1N2163	DR						0.001	12.28	-55	150
1N3584	S	1N945 *	1N941	DR						0.005	12.28	0	75
1N3584A	S	1N945A *	1N941	DR						0.005	12.28	-55	100
1N3584B	S	1N945B *	1N941	DR						0.005	12.28	-55	150
1N3585	S	MR1240SB	MR1240	R*	50	1.25	400	25	8000				
1N3586	S	MR1241SB	MR1240	R*	100	1.25	400	25	8000				
1N3587	S	MR1243SB	MR1240	R*	200	1.25	400	25	8000				
1N3588	S	MR1245SB	MR1240	R*	300	1.25	400	25	8000				
1N3589	S	MR1247SB	MR1240	R*	400	1.25	400	25	8000				
1N3590	S	MR1248SB	MR1240	R*	500	1.25	400	25	8000				
1N3591	S	MR1249SB	MR1240	R*	600	1.25	400	25	8000				
1N3592	G			DS	30	0.35	2.0M	4.0*	0.04				
1N3593	S			DS	40	1.0	10M	25N	10				
1N3594	S			DS	60	1.0	50M	0.1M	6.0				
1N3595	S			DS	125	1.0	200M	1.0M	3.0				
1N3596	S			DS	20	1.0	30M	0.1*	4.0				
1N3597	S			DS	150	1.2	400M	0.1*	0.3				
1N3598	S			DS	50	0.85	10M	0.1*	4.0				
1N3599	S			DS	150	1.0	100M	0.1*	50				
1N3600	S			DS	50	1.0	200M	100*	6.0				
1N3601	S			DS	75	1.0	10M	0.1*	5.0				
1N3602	S			DS	50	1.0	20M	0.1*	5.0				
1N3603	S			DS	30	1.0	30M	0.1*	5.0				
1N3604	S			DS	75	1.0	50M	0.05*	2.0				
1N3605	S			DS	40	0.55	0.1M	0.05*	2.0				
1N3606	S			DS	75	0.55	0.1M	0.05*	2.0				
1N3607	S			DS	75	1.0	50M	0.05*	2.0				
1N3608	S			DS	40	0.55	0.1M	0.05*	2.0				
1N3609	S			DS	75	0.55	0.1M	0.05*	2.0				
1N3611	S	1N4003	1N4001	DS	200	1.0	750M	10*					
1N3612	S	1N4004	1N4001	DS	400	1.0	750M	10*					
1N3613	S	1N4005	1N4001	DS	600	1.0	750M	10*					
1N3614	S	1N4006	1N4001	DS	800	1.0	750M	10*					
1N3615	S	MR1120	MR1120	R*	50	1.2	16	3.0	300				
1N3616	S	MR1121	MR1120	R*	100	1.2	16	2.5	300				
1N3617	S	MR1122	MR1120	R*	150	1.2	16	2.25	300				
1N3618	S	MR1122	MR1120	R*	200	1.2	16	2.0	300				
1N3619	S	MR1123	MR1120	R*	300	1.2	16	1.75	300				
1N3620	S	MR1124	MR1120	R*	400	1.2	16	1.5	300				
1N3621	S	MR1125	MR1120	R*	500	1.2	16	1.25	300				
1N3622	S	MR1126	MR1120	R*	600	1.2	16	1.0	300				
1N3623	S	MR1128	MR1120	R*	800	1.2	16	0.75	300				
1N3624	S	MR1130	MR1120	R*	1000	1.2	16	0.6	300				
1N3625	S			DS	225	1.0	40M	0.5*	0.5				
1N3626	G			DS	50	0.5	10M	1.0M	0.45				
1N3627 / 1N3628		Varactor Diodes, see Table on Page 1-94											
1N3629	S			R*	100	1.0	0.75	0.01	30				
1N3630	S			R*	200	1.0	0.75	0.01	30				
1N3631	S			R*	300	1.0	0.75	0.01	30				
1N3632	S			R*	400	1.0	0.75	0.01	30				
1N3633	S			R*	500	1.0	0.75	0.01	30				
1N3634	S			R*	600	1.0	0.75	0.01	30				
1N3635	S			R*	700	1.0	0.75	0.01	30				
1N3636	S			R*	800	1.0	0.75	0.01	30				
1N3637	S			R*	900	1.0	0.75	0.01	30				
1N3638	S			R*	1000	1.0	0.75	0.01	30				

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3639	S	1N4003	1N4001	R*	200	1.2	0.75	0.2	40				
1N3640	S	1N4004	1N4001	R*	400	1.2	0.75	0.2	40				
1N3641	S	1N4005	1N4001	R*	600	1.2	0.75	0.2	40				
1N3642	S	1N4006	1N4001	R*	800	1.2	0.75	0.2	40				
1N3643	S			DS	1000	5.0	250M	5.0*					
1N3644	S			DS	1500	5.0	250M	5.0*					
1N3645	S			DS	1000	5.0	250M	5.0*					
1N3646	S			DS	2500	5.0	250M	5.0*					
1N3647	S			DS	3000	5.0	250M	5.0*					
1N3648	S			R*	10K	23	0.35	0.5	30				
1N3649	S	MR1128	MR1120	R*	800	1.1	1.0	0.005	25				
1N3650	S	MR1130	MR1120	R*	1000	1.1	1.0	0.005	25				
1N3653	S			DS	90	1.0	400M	25N	4.0				
1N3654	S			DS	90	1.0	50M	25N	4.0				
1N3655	S	Microwave S-band Mixer:			NF = 8.3 to 6.0 dB								
1N3655A	S	Microwave S-band Mixer:			NF = 8.3 to 6.0 dB								
1N3655B	S	Microwave S-band Mixer:			NF = 8.3 to 6.0 dB								
1N3656	S			DS	200	1.2	500M	0.01M					
1N3657	S			DS	400	1.2	500M	0.01M					
1N3658	S			DS	600	1.2	500M	0.01M					
1N3659	S			R*	50	1.4	25	5.0	400				
1N3660	S			R*	100	1.4	25	4.5	400				
1N3661	S			R*	200	1.4	25	4.0	400				
1N3662	S			R*	300	1.4	25	3.5	400				
1N3663	S			R*	400	1.4	25	3.0	400				
1N3664	S			R*	500	1.4	25	2.5	400				
1N3665	S			R*	600	1.4	25	2.0	400				
1N3666	G			DS	80	1.0	200M	25*	0.3				
1N3667	S			R*	500	1.2	1.5	1.2	30				
1N3668	S			DS	30	1.0	5.0M	0.1*	0.15				
1N3669	S			DS	70	1.1	400M	0.25*	0.2				
1N3670	S	MR1128	MR1120	R*	700	2.05	12	3.0	200				
1N3670A	S	MR1128	MR1120	R*	700	1.5	12	0.9	240				
1N3671	S	MR1128	MR1120	R*	800	2.05	12	2.0	200				
1N3671A	S	MR1128	MR1120	R*	800	1.3	12	0.8	240				
1N3672	S	MR1130	MR1120	R*	900	2.05	12	2.0	200				
1N3672A	S	MR1130	MR1120	R*	900	1.15	12	0.7	240				
1N3673	S	MR1130	MR1120	R*	1000	2.05	12	1.0	200				
1N3673A	S	MR1130	MR1120	R*	1000	1.0	12	0.6	240				
1N3675	S	1N4736 *	1N4728	DZ							6.8*	20	750M
1N3675A	S	1N4736 *	1N4728	DZ							6.8*	10	750M
1N3675B	S	1N4736A *	1N4728	DZ							6.8*	5.0	750M
1N3676	S	1N4737 *	1N4728	DZ							7.5*	20	750M
1N3676A	S	1N4737 *	1N4728	DZ							7.5*	10	750M
1N3676B	S	1N4737A *	1N4728	DZ							7.5*	5.0	750M
1N3677	S	1N4738 *	1N4728	DZ							8.2*	20	750M
1N3677A	S	1N4738 *	1N4728	DZ							8.2*	10	750M
1N3677B	S	1N4738A *	1N4728	DZ							8.2*	5.0	750M
1N3678	S	1N4739 *	1N4728	DZ							9.1*	20	750M
1N3678A	S	1N4739 *	1N4728	DZ							9.1*	10	750M
1N3678B	S	1N4739A *	1N4728	DZ							9.1*	5.0	750M
1N3679	S	1N4740 *	1N4728	DZ							10*	20	750M
1N3679A	S	1N4740 *	1N4728	DZ							10*	10	750M
1N3679B	S	1N4740A *	1N4728	DZ							10*	5.0	750M
1N3680	S	1N4741 *	1N4728	DZ							11*	20	750M
1N3680A	S	1N4741 *	1N4728	DZ							11*	10	750M
1N3680B	S	1N4741A *	1N4728	DZ							11*	5.0	750M
1N3681	S	1N4742 *	1N4728	DZ							12*	20	750M
1N3681A	S	1N4742 *	1N4728	DZ							12*	10	750M
1N3681B	S	1N4742A *	1N4728	DZ							12*	5.0	750M
1N3682	S	1N4743 *	1N4728	DZ							13*	20	750M
1N3682A	S	1N4743 *	1N4728	DZ							13*	10	750M
1N3682B	S	1N4743A *	1N4728	DZ							13*	5.0	750M
1N3683	S	1N4744 *	1N4728	DZ							15*	20	750M
1N3683A	S	1N4744 *	1N4728	DZ							15*	10	750M
1N3683B	S	1N4744A *	1N4728	DZ							15*	5.0	750M
1N3684	S	1N4745 *	1N4728	DZ							16*	20	750M
1N3684A	S	1N4745 *	1N4728	DZ							16*	10	750M
1N3684B	S	1N4745A *	1N4728	DZ							16*	5.0	750M
1N3685	S	1N4746 *	1N4728	DZ							18*	20	750M
1N3685A	S	1N4746 *	1N4728	DZ							18*	10	750M
1N3685B	S	1N4746A *	1N4728	DZ							18*	5.0	750M
1N3686	S	1N4747 *	1N4728	DZ							20*	20	750M
1N3686A	S	1N4747 *	1N4728	DZ							20*	10	750M
1N3686B	S	1N4747A *	1N4728	DZ							20*	5.0	750M
1N3687	S	1N4748 *	1N4728	DZ							22*	20	750M
1N3687A	S	1N4748 *	1N4728	DZ							22*	10	750M
1N3687B	S	1N4748A *	1N4728	DZ							22*	5.0	750M
1N3688	S	1N4749 *	1N4728	DZ							24*	20	750M
1N3688A	S	1N4749 *	1N4728	DZ							24*	10	750M
1N3688B	S	1N4749A *	1N4728	DZ							24*	5.0	750M
1N3689	S	1N4750 *	1N4728	DZ							27*	20	750M

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3689A	S	1N4750 *	1N4728	DZ							27*	10	750M
1N3689B	S	1N4750A *	1N4728	DZ							27*	5.0	750M
1N3690	S	1N4751 *	1N4728	DZ							30*	20	750M
1N3690A	S	1N4751 *	1N4728	DZ							30*	10	750M
1N3690B	S	1N4751A *	1N4728	DZ							30*	5.0	750M
1N3691	S	1N4752 *	1N4728	DZ							33*	20	750M
1N3691A	S	1N4752 *	1N4728	DZ							33*	10	750M
1N3691B	S	1N4752A *	1N4728	DZ							33*	5.0	750M
1N3692	S	1N4753 *	1N4728	DZ							36*	20	750M
1N3692A	S	1N4753 *	1N4728	DZ							36*	10	750M
1N3692B	S	1N4753A *	1N4728	DZ							36*	5.0	750M
1N3693	S	1N4754 *	1N4728	DZ							39*	20	750M
1N3693A	S	1N4754 *	1N4728	DZ							39*	10	750M
1N3693B	S	1N4754A *	1N4728	DZ							39*	5.0	750M
1N3694	S	1N4755 *	1N4728	DZ							43*	20	750M
1N3694A	S	1N4755 *	1N4728	DZ							43*	10	750M
1N3694B	S	1N4755A *	1N4728	DZ							43*	5.0	750M
1N3695	S	1N4756 *	1N4728	DZ							47*	20	750M
1N3695A	S	1N4756 *	1N4728	DZ							47*	10	750M
1N3695B	S	1N4756A *	1N4728	DZ							47*	5.0	750M
1N3696	S	1N4757 *	1N4728	DZ							51*	20	750M
1N3696A	S	1N4757 *	1N4728	DZ							51*	10	750M
1N3696B	S	1N4757A *	1N4728	DZ							51*	5.0	750M
1N3697	S	1N4758 *	1N4728	DZ							56*	20	750M
1N3697A	S	1N4758 *	1N4728	DZ							56*	10	750M
1N3697B	S	1N4758A *	1N4728	DZ							56*	5.0	750M
1N3698	S	1N4759 *	1N4728	DZ							62*	20	750M
1N3698A	S	1N4759 *	1N4728	DZ							62*	10	750M
1N3698B	S	1N4759A *	1N4728	DZ							62*	5.0	750M
1N3699	S	1N4760 *	1N4728	DZ							68*	20	750M
1N3699A	S	1N4760 *	1N4728	DZ							68*	10	750M
1N3699B	S	1N4760A *	1N4728	DZ							68*	5.0	750M
1N3700	S	1N4761 *	1N4728	DZ							75*	20	750M
1N3700A	S	1N4761 *	1N4728	DZ							75*	10	750M
1N3700B	S	1N4761A *	1N4728	DZ							75*	5.0	750M
1N3701	S	1N4762 *	1N4728	DZ							82*	20	750M
1N3701A	S	1N4762 *	1N4728	DZ							82*	10	750M
1N3701B	S	1N4762A *	1N4728	DZ							82*	5.0	750M
1N3702	S	1N4763 *	1N4728	DZ							91*	20	750M
1N3702A	S	1N4763 *	1N4728	DZ							91*	10	750M
1N3702B	S	1N4763A *	1N4728	DZ							91*	5.0	750M
1N3703	S	1N4764 *	1N4728	DZ							100*	20	750M
1N3703A	S	1N4764 *	1N4728	DZ							100*	10	750M
1N3703B	S	1N4764A *	1N4782	DZ							100*	5.0	750M
1N3704	S	1M110ZS10 *	1N4728	DZ							110*	20	750M
1N3704A	S	1M110ZS10 *	1N4728	DZ							110*	10	750M
1N3704B	S	1M110ZS5 *	1N4728	DZ							110*	5.0	750M
1N3705	S	1M120ZS10 *	1N4728	DZ							120*	20	750M
1N3705A	S	1M120ZS10 *	1N4728	DZ							120*	10	750M
1N3705B	S	1M120ZS5 *	1N4728	DZ							120*	5.0	750M
1N3706	S	1M130ZS10 *	1N4728	DZ							130*	20	750M
1N3706A	S	1M130ZS10 *	1N4728	DZ							130*	10	750M
1N3706B	S	1M130ZS5 *	1N4728	DZ							130*	5.0	750M
1N3707	S	1M150ZS10 *	1N4728	DZ							150*	20	750M
1N3707A	S	1M150ZS10 *	1N4728	DZ							150*	10	750M
1N3707B	S	1M150ZS5 *	1N4728	DZ							150*	5.0	750M
1N3708	S	1M160ZS10 *	1N4728	DZ							160*	20	750M
1N3708A	S	1M160ZS10 *	1N4728	DZ							160*	10	750M
1N3708B	S	1M160ZS5 *	1N4728	DZ							160*	5.0	750M
1N3709	S	1M180ZS10 *	1N4728	DZ							180*	20	750M
1N3709A	S	1M180ZS10 *	1N4728	DZ							180*	10	750M
1N3709B	S	1M180ZS5 *	1N4728	DZ							180*	5.0	750M
1N3710	S	1M200ZS10 *	1N4728	DZ							200*	20	750M
1N3710A	S	1M200ZS10 *	1N4728	DZ							200*	10	750M
1N3710B	S	1M200ZS5 *	1N4728	DZ							200*	5.0	750M
1N3711	S			R*	6000	11	0.15	0.025	5.0				
1N3712 thru 1N3721		Tunnel Diodes, see Table on Page 1-102											
1N3722	S			DS	50	1.0	20M	0.1*	10				
1N3723	S			R*	1000	2.2	0.75	0.005	12				
1N3724	S			R*	1200	2.2	0.75	0.005	12				
1N3725	S			R*	1400	2.2	0.75	0.005	12				
1N3726	S			R*	1600	2.2	0.75	0.005	12				
1N3727	S			R*	1800	2.2	0.75	0.005	12				
1N3728	S			DS	550	1.2	400M	0.1*					
1N3729	S			DS	600	1.0	5.0M	0.1*	0.5				
1N3730	S			DS	80	1.0	750M	0.1*	15				
1N3731	S			DS	80	1.0	100M	5.0*	3.0				
1N3732	S	1N4733A	1N4728	DZ							5.1*	5.0	1.0W
1N3733	S	Microwave S-band Mixer											
1N3734	S	Photosensitive Device; BV = 100 V, Sensitivity = 0.05 μA/fc											

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3735	S	MR1231SB	MR1230	R*	100	1.3	250	16	4500				
1N3736	S	MR1233SB	MR1230	R*	200	1.3	250	16	4500				
1N3737	S	MR1235SB	MR1230	R*	300	1.3	250	16	4500				
1N3738	S	MR1237SB	MR1230	R*	400	1.3	250	16	4500				
1N3739	S	MR1238SB	MR1230	R*	500	1.3	250	13	4500				
1N3740	S	MR1239SB	MR1230	R*	600	1.3	250	12	4500				
1N3741	S			R*	800	1.3	250	9.0	4500				
1N3742	S			R*	1000	1.3	250	7.0	4500				
1N3743	S			R*	1200	1.3	250	7.0	4500				
1N3744	S			R*	1400	1.3	250	7.0	4500				
1N3745	S	Microwave X-band Mixer; NF = 9.5 dB											
1N3746	S	Microwave X-band Mixer; NF = 8.5 dB											
1N3747	S	Microwave X-band Mixer; NF = 7.5 dB											
1N3748	S			R*	200	1.5	0.5		20				
1N3749	S			R*	400	1.5	0.5		20				
1N3750	S			R*	600	1.5	0.5		20				
1N3751	S			R*	800	1.5	0.5		20				
1N3752	S			R*	1000	1.5	0.5		20				
1N3753	G			DS	55	1.0	150M	5.0*					
1N3754	S			R*	100	1.2	0.15	0.3	15				
1N3755	S			R*	200	1.2	0.15	0.3	15				
1N3756	S			R*	400	1.2	0.15	0.3	15				
1N3757	S			R*	200	1.0	1.0		30				
1N3758	S			R*	400	1.0	1.0		30				
1N3759	S			R*	600	1.0	1.0		30				
1N3760	S			R*	800	1.0	1.0		30				
1N3761	S			R*	1000	1.0	1.0		30				
1N3762	S			R*	5300	12	0.065	0.005	15				
1N3763	S	1N2767A		DR						0.002	20	-55	150
1N3764	S			R*	3000	6.5	0.2	0.1	8.0				
1N3765	S			R*	700	1.8	35	5.0	400				
1N3766	S			R*	800	1.8	35	4.0	400				
1N3767	S			R*	900	1.8	35	3.0	400				
1N3768	S			R*	1000	1.8	35	2.0	400				
1N3769	G			DS	90	0.5	25M	5.0*					
1N3770		Varactor Diode, see Table on Page 1-94											
1N3771 / 1N3772		4-Layer Diodes, see Table on Page 1-106											
1N3773	G			DS	25	0.35	2.0M	4.0*	40				
1N3774	S			DZ							1.15*	2.0	0.34W
1N3775	S			R*	1500	2.2	3.3	0.1	15				
1N3776	S			DZ							10*		6.0W
1N3777	S			DS	40	1.1	10M	0.1*	4.0				
1N3778	S	Microwave C-X-band Detector											
1N3779	S	1N821A	1N821	DR						0.015	6.7	-55	25
1N3780	S	1N821A	1N821	DR						0.001	6.7	-55	25
1N3781	S	1N823A	1N821	DR						0.005	6.7	-55	25
1N3782	S	1N825A	1N821	DR						0.002	6.7	-55	25
1N3783	S	1N827A	1N821	DR						0.001	6.7	-55	25
1N3784	S	1N829A	1N821	DR						0.0005	6.7	-55	25
1N3785	S		1N3785	DZ							6.8*	20	1.5W
1N3785A	S		1N3785	DZ							6.8*	10	1.5W
1N3785B	S		1N3785	DZ							6.8*	5.0	1.5W
1N3786	S		1N3785	DZ							7.5*	20	1.5W
1N3786A	S		1N3785	DZ							7.5*	10	1.5W
1N3786B	S		1N3785	DZ							7.5*	5.0	1.5W
1N3787	S		1N3785	DZ							8.2*	20	1.5W
1N3787A	S		1N3785	DZ							8.2*	10	1.5W
1N3787B	S		1N3785	DZ							8.2*	5.0	1.5W
1N3788	S		1N3785	DZ							9.1*	20	1.5W
1N3788A	S		1N3785	DZ							9.1*	10	1.5W
1N3788B	S		1N3785	DZ							9.1*	5.0	1.5W
1N3789	S		1N3785	DZ							10*	20	1.5W
1N3789A	S		1N3785	DZ							10*	10	1.5W
1N3789B	S		1N3785	DZ							10*	5.0	1.5W
1N3790	S		1N3785	DZ							11*	20	1.5W
1N3790A	S		1N3785	DZ							11*	10	1.5W
1N3790B	S		1N3785	DZ							11*	5.0	1.5W
1N3791	S		1N3785	DZ							12*	20	1.5W
1N3791A	S		1N3785	DZ							12*	10	1.5W
1N3791B	S		1N3785	DZ							12*	5.0	1.5W
1N3792	S		1N3785	DZ							13*	20	1.5W
1N3792A	S		1N3785	DZ							13*	10	1.5W
1N3792B	S		1N3785	DZ							13*	5.0	1.5W
1N3793	S		1N3785	DZ							15*	20	1.5W
1N3793A	S		1N3785	DZ							15*	10	1.5W
1N3793B	S		1N3785	DZ							15*	5.0	1.5W
1N3794	S		1N3785	DZ							16*	20	1.5W
1N3794A	S		1N3785	DZ							16*	10	1.5W
1N3794B	S		1N3785	DZ							16*	5.0	1.5W
1N3795	S		1N3785	DZ							18*	20	1.5W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3795A	S		1N3785	DZ							18*	10	1.5W
1N3795B	S		1N3785	DZ							18*	5.0	1.5W
1N3796	S		1N3785	DZ							20*	20	1.5W
1N3796A	S		1N3785	DZ							20*	10	1.5W
1N3796B	S		1N3785	DZ							20*	5.0	1.5W
1N3797	S		1N3785	DZ							22*	20	1.5W
1N3797A	S		1N3785	DZ							22*	10	1.5W
1N3797B	S		1N3785	DZ							22*	5.0	1.5W
1N3798	S		1N3785	DZ							24*	20	1.5W
1N3798A	S		1N3785	DZ							24*	10	1.5W
1N3798B	S		1N3785	DZ							24*	5.0	1.5W
1N3799	S		1N3785	DZ							27*	20	1.5W
1N3799A	S		1N3785	DZ							27*	10	1.5W
1N3799B	S		1N3785	DZ							27*	5.0	1.5W
1N3800	S		1N3785	DZ							30*	20	1.5W
1N3800A	S		1N3785	DZ							30*	10	1.5W
1N3800B	S		1N3785	DZ							30*	5.0	1.5W
1N3801	S		1N3785	DZ							33*	20	1.5W
1N3801A	S		1N3785	DZ							33*	10	1.5W
1N3801B	S		1N3785	DZ							33*	5.0	1.5W
1N3802	S		1N3785	DZ							36*	20	1.5W
1N3802A	S		1N3785	DZ							36*	10	1.5W
1N3802B	S		1N3785	DZ							36*	5.0	1.5W
1N3803	S		1N3785	DZ							39*	20	1.5W
1N3803A	S		1N3785	DZ							39*	10	1.5W
1N3803B	S		1N3785	DZ							39*	5.0	1.5W
1N3804	S		1N3785	DZ							43*	20	1.5W
1N3804A	S		1N3785	DZ							43*	10	1.5W
1N3804B	S		1N3785	DZ							43*	5.0	1.5W
1N3805	S		1N3785	DZ							47*	20	1.5W
1N3805A	S		1N3785	DZ							47*	10	1.5W
1N3805B	S		1N3785	DZ							47*	5.0	1.5W
1N3806	S		1N3785	DZ							51*	20	1.5W
1N3806A	S		1N3785	DZ							51*	10	1.5W
1N3806B	S		1N3785	DZ							51*	5.0	1.5W
1N3807	S		1N3785	DZ							56*	20	1.5W
1N3807A	S		1N3785	DZ							56*	10	1.5W
1N3807B	S		1N3785	DZ							56*	5.0	1.5W
1N3808	S		1N3785	DZ							62*	20	1.5W
1N3808A	S		1N3785	DZ							62*	10	1.5W
1N3808B	S		1N3785	DZ							62*	5.0	1.5W
1N3809	S		1N3785	DZ							68*	20	1.5W
1N3809A	S		1N3785	DZ							68*	10	1.5W
1N3809B	S		1N3785	DZ							68*	5.0	1.5W
1N3810	S		1N3785	DZ							75*	20	1.5W
1N3810A	S		1N3785	DZ							75*	10	1.5W
1N3810B	S		1N3785	DZ							75*	5.0	1.5W
1N3811	S		1N3785	DZ							82*	20	1.5W
1N3811A	S		1N3785	DZ							82*	10	1.5W
1N3811B	S		1N3785	DZ							82*	5.0	1.5W
1N3812	S		1N3785	DZ							91*	20	1.5W
1N3812A	S		1N3785	DZ							91*	10	1.5W
1N3812B	S		1N3785	DZ							91*	5.0	1.5W
1N3813	S		1N3785	DZ							100*	20	1.5W
1N3813A	S		1N3785	DZ							100*	10	1.5W
1N3813B	S		1N3785	DZ							100*	5.0	1.5W
1N3814	S		1N3785	DZ							110*	20	1.5W
1N3814A	S		1N3785	DZ							110*	10	1.5W
1N3814B	S		1N3785	DZ							110*	5.0	1.5W
1N3815	S		1N3785	DZ							120*	20	1.5W
1N3815A	S		1N3785	DZ							120*	10	1.5W
1N3815B	S		1N3785	DZ							120*	5.0	1.5W
1N3816	S		1N3785	DZ							130*	20	1.5W
1N3816A	S		1N3785	DZ							130*	10	1.5W
1N3816B	S		1N3785	DZ							130*	5.0	1.5W
1N3817	S		1N3785	DZ							150*	20	1.5W
1N3817A	S		1N3785	DZ							150*	10	1.5W
1N3817B	S		1N3785	DZ							150*	5.0	1.5W
1N3818	S		1N3785	DZ							160*	20	1.5W
1N3818A	S		1N3785	DZ							160*	10	1.5W
1N3818B	S		1N3785	DZ							160*	5.0	1.5W
1N3819	S		1N3785	DZ							180*	20	1.5W
1N3819A	S		1N3785	DZ							180*	10	1.5W
1N3819B	S		1N3785	DZ							180*	5.0	1.5W
1N3820	S		1N3785	DZ							200*	20	1.5W
1N3820A	S		1N3785	DZ							200*	10	1.5W
1N3820B	S		1N3785	DZ							200*	5.0	1.5W
1N3821	S		1N3821	DZ							3.3*	10	1.0W
1N3821A	S		1N3821	DZ							3.3*	5.0	1.0W
1N3822	S		1N3821	DZ							3.6*	10	1.0W
1N3822A	S		1N3821	DZ							3.6*	5.0	1.0W
1N3823	S		1N3821	DZ							3.9*	10	1.0W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3823A	S		1N3821	DZ							3.9*	5.0	1.0W
1N3824	S		1N3821	DZ							4.3*	10	1.0W
1N3824A	S		1N3821	DZ							4.3*	5.0	1.0W
1N3825	S		1N3821	DZ							4.7*	10	1.0W
1N3825A	S		1N3821	DZ							4.7*	5.0	1.0W
1N3826	S		1N3821	DZ							5.1*	10	1.0W
1N3826A	S		1N3821	DZ							5.1*	5.0	1.0W
1N3827	S		1N3821	DZ							5.6*	10	1.0W
1N3827A	S		1N3821	DZ							5.6*	5.0	1.0W
1N3828	S		1N3821	DZ							6.2*	10	1.0W
1N3828A	S		1N3821	DZ							6.2*	5.0	1.0W
1N3829	S		1N3821	DZ							6.8*	10	1.0W
1N3829A	S		1N3821	DZ							6.8*	5.0	1.0W
1N3830	S		1N3821	DZ							7.5*	10	1.0W
1N3830A	S		1N3821	DZ							7.5*	5.0	1.0W
1N3831 thru 1N3846		4-Layer Diodes, see Table on Page 1-106											
1N3847 thru 1N3860		Tunnel Diodes, see Table on Page 1-102											
1N3861	G	Tunnel Rectifier											
1N3862	G	Tunnel Rectifier											
1N3863	G	Tunnel Rectifier											
1N3864	S			DS	125	1.5	200M	1.0N	0.9				
1N3865	G			DS	80		100M	15*	0.5				
1N3866	S			R*	200	1.5	1.0	0.05	25				
1N3867	S			R*	400	1.5	1.0	0.05	25				
1N3868	S			R*	600	1.5	1.0	0.05	25				
1N3869	S			R*	1000	3.0	0.5	0.05	10				
1N3870	S			R*	1500	3.0	0.5	0.05	10				
1N3871	S			R*	2500	6.0	0.25	0.05	5.0				
1N3872	S			DS	90	1.0	150M	0.1*	15				
1N3873	S			DS	50	1.14	0.2A	0.1*	4.0				
1N3874	S			R*	50	1.5	6.0	3.0	75				
1N3875	S			R*	100	1.5	6.0	3.0	75				
1N3876	S			R*	200	1.5	6.0	3.0	75				
1N3877	S			R*	300	1.5	6.0	3.0	75				
1N3878	S			R*	400	1.5	6.0	3.0	75				
1N3879	S		1N4933	R*	50	1.5	6.0	3.0	75				
1N3880	S		1N4933	R*	150	1.5	6.0	3.0	75				
1N3881	S		1N4933	R*	200	1.5	6.0	3.0	75				
1N3882	S		1N4933	R*	300	1.5	6.0	3.0	75				
1N3883	S		1N4933	R*	400	1.5	6.0	3.0	75				
1N3884	S			R*	50	1.5	12	3.0	150				
1N3885	S			R*	100	1.5	12	3.0	150				
1N3886	S			R*	200	1.5	12	3.0	150				
1N3887	S			R*	300	1.5	12	3.0	150				
1N3888	S			R*	400	1.5	12	3.0	150				
1N3889	S		1N4933	R*	50	1.5	12	3.0	150				
1N3890	S		1N4933	R*	100	1.5	12	3.0	150				
1N3891	S		1N4933	R*	200	1.5	12	3.0	150				
1N3892	S		1N4933	R*	300	1.5	12	3.0	150				
1N3893	S		1N4933	R*	400	1.5	12	3.0	150				
1N3894	S			DS	400	1.0	400M	0.2*					
1N3895	S			DS	350	1.0	200M	0.5*					
1N3896	S			DZ							0.77*	5.0	250M
1N3897	S			DZ							1.5*	5.0	250M
1N3898	S	1N5221B	1N5221	DZ							2.1*	5.0	250M
1N3899	S		1N4933	R*	50	1.5	20	6.0	225				
1N3900	S		1N4933	R*	100	1.5	20	6.0	225				
1N3901	S		1N4933	R*	200	1.5	20	6.0	225				
1N3902	S		1N4933	R*	300	1.5	20	6.0	225				
1N3903	S		1N4933	R*	400	1.5	20	6.0	225				
1N3904	S			R*	50	1.5	20	6.0	225				
1N3905	S			R*	100	1.5	20	6.0	225				
1N3906	S			R*	200	1.5	20	6.0	225				
1N3907	S			R*	300	1.5	20	6.0	225				
1N3908	S			R*	400	1.5	20	6.0	225				
1N3909	S		1N4933	R*	50	1.5	30	10	300				
1N3910	S		1N4933	R*	100	1.5	30	10	300				
1N3911	S		1N4933	R*	200	1.5	30	10	300				
1N3912	S		1N4933	R*	300	1.5	30	10	300				
1N3913	S		1N4933	R*	400	1.5	30	10	300				
1N3914	S			R*	50	1.5	30	10	300				
1N3915	S			R*	100	1.5	30	10	300				
1N3916	S			R*	200	1.5	30	10	300				
1N3917	S			R*	300	1.5	30	10	300				
1N3918	S			R*	400	1.5	30	10	300				
1N3919	S			R*	1000	2.0	5.0	0.5	100				
1N3920	S			R*	1500	2.0	5.0	0.5	100				
1N3921	S			R*	2000	2.0	5.0	0.5	100				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F (volts) @ I_F		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3922	S			R*	2500	2.0	5.0	0.5	100				
1N3923	S			R*	3000	2.0	5.0	0.5	100				
1N3924	S			R*	1000	2.0	10	0.5	100				
1N3925	S			R*	1500	2.0	10	0.5	100				
1N3926	S			R*	2000	2.0	10	0.5	100				
1N3927	S			R*	2500	2.0	10	0.5	100				
1N3928	S			R*	3000	2.0	10	0.5	100				
1N3929	S			DS	1000	2.0	1.0A	10*					
1N3930	S			DS	1500	2.0	1.0A	10*					
1N3931	S			DS	2000	2.0	1.0A	10*					
1N3932	S			DS	1500	2.0	1.0A	10*					
1N3933	S			DS	3000	2.0	1.0A	10*					
1N3934	S			R*	1200	2.5	1.0	0.4	50				
1N3935 thru 1N3937		4-Layer Diodes, see Table on Page 1-106											
1N3938	S			R*	200	1.1	2.0	0.4	30				
1N3939	S			R*	400	1.1	2.0	0.2	30				
1N3940	S			R*	600	1.1	2.0	0.2	30				
1N3941	S			R*	800	1.5	2.0	0.2	30				
1N3942	S			R*	1000	1.5	2.0	0.2	30				
1N3943	S			DS	3.0	2.5	300M	100*					
1N3944	G			DS	15	0.75	10M	2.5*	12				
1N3945 thru 1N3947		Varactor Diodes, see Table on Page 1-94											
1N3948		Tunnel Diode, see Table on Page 1-102											
1N3949	S	1N2984B	1N2970	DZ							20*	5.0	10W
1N3950	S	1N3796B	1N3785	DZ							20*	5.0	1.5W
1N3951	S	1.5M25Z5		DZ							25*	5.0	1.5W
1N3952	S			DS	130	0.74	10M	25N					
1N3953	G			DS	40	0.5	35M	50*	300				
1N3954	S			DS	50	1.0	200M	0.1*	4.0				
1N3955	S			R*	100	1.3	70	15	1200				
1N3956	S			DS	40	0.55	100*	0.05*	2.0				
1N3957	S			DS	1000	1.0	400M	10*					
1N3958	S	1N3880	1N4933	R*	100	1.3	3.5	0.4	35				
1N3959	S	1N3881	1N4933	R*	200	1.3	3.5	0.4	35				
1N3960	S	1N3882	1N4933	R*	300	1.3	3.5	0.4	35				
1N3961	S	1N3883	1N4933	R*	400	1.3	3.5	0.4	35				
1N3962	S	MR1366	1N4933	R*	500	1.3	3.5	0.4	35				
1N3963	S	MR1366	1N4933	R*	600	1.3	3.5	0.4	35				
1N3964	S			R*	200	1.6	22	1.0	200				
1N3965	S			R*	400	1.6	22	1.0	200				
1N3966	S			R*	600	1.6	22	1.0	200				
1N3967	S			R*	800	1.6	22	1.0	200				
1N3968	S			R*	200	1.6	50	2.0	600				
1N3969	S			R*	400	1.6	50	2.0	600				
1N3970	S			R*	600	1.6	50	2.0	600				
1N3971	S			R*	800	1.6	50	2.0	600				
1N3972	S			R*	200	1.5	104	5.0	1500				
1N3973	S			R*	400	1.5	104	5.0	1500				
1N3974	S			R*	600	1.5	104	5.0	1500				
1N3975	S			R*	800	1.5	104	5.0	1500				
1N3976	S			R*	200	1.5	250	10	4000				
1N3977	S			R*	400	1.5	250	10	4000				
1N3978	S			R*	600	1.5	250	10	4000				
1N3979	S			R*	800	1.5	250	10	4000				
1N3981	S			DS	200	1.0	900M	0.01M					
1N3982	S			DS	400	1.0	900M	0.01M					
1N3983	S			DS	600	1.0	900M	0.01M					
1N3984	S	1N3997A	1N3993	DZ							5.5*	5.0	10W
1N3985	S	1N3998A	1N3993	DZ							6.0*	5.0	10W
1N3986	S	1N3998A	1N3993	DZ							6.2*	5.0	10W
1N3987	S			R*	700	1.4	6.0	0.9	150				
1N3988	S	MR1128	MR1120	R*	800	1.4	6.0	0.8	150				
1N3989	S	MR1130	MR1120	R*	900	1.4	6.0	0.7	150				
1N3990	S	MR1130	MR1120	R*	1000	1.4	6.0	0.6	150				
1N3991	G			DS	35	0.55	30M	1.0M	1.0				
1N3992	S			DS	4000	5.0	250M	5.0*					
1N3993	S		1N3993	DZ							3.9*	10	10W
1N3993A	S		1N3993	DZ							3.9*	5.0	10W
1N3994	S		1N3993	DZ							4.3*	10	10W
1N3994A	S		1N3993	DZ							4.3*	5.0	10W
1N3995	S		1N3993	DZ							4.7*	10	10W
1N3995A	S		1N3993	DZ							4.7*	5.0	10W
1N3996	S		1N3993	DZ							5.1*	10	10W
1N3996A	S		1N3993	DZ							5.1*	5.0	10W
1N3997	S		1N3993	DZ							5.6*	10	10W
1N3997A	S		1N3993	DZ							5.6*	5.0	10W
1N3998	S		1N3993	DZ							6.2*	10	10W
1N3998A	S		1N3993	DZ							6.2*	5.0	10W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N3999	S		1N3993	DZ							6.8*	10	10W
1N3999A	S		1N3993	DZ							6.8*	5.0	10W
1N4000	S		1N3993	DZ							7.5*	10	10W
1N4000A	S		1N3993	DZ							7.5*	5.0	10W
1N4001	S		1N4001	R*	50	1.6	1.0	0.03	30				
1N4002	S		1N4001	R*	100	1.6	1.0	0.03	30				
1N4003	S		1N4001	R*	200	1.6	1.0	0.03	30				
1N4004	S		1N4001	R*	400	1.6	1.0	0.03	30				
1N4005	S		1N4001	R*	600	1.6	1.0	0.03	30				
1N4006	S		1N4001	R*	800	1.6	1.0	0.03	30				
1N4007	S		1N4001	R*	1000	1.6	1.0	0.03	30				
1N4008	G			DS	12	0.5	10M	0.1M	70				
1N4009	S			DS	25	1.0	30M	0.1M	4.0				
1N4010	S	1N829	1N821	DR						0.0005	6.2	25	100
1N4011	S			R*	1000	1.1	0.5	0.2	30				
1N4012	S			R*	700	1.3	12	1.0	200				
1N4013	S			R*	800	1.3	12	1.0	200				
1N4014	S			R*	900	1.3	12	1.0	200				
1N4015	S			R*	1000	1.3	12	1.0	200				
1N4016	S	1N2972	1N2970	DZ							8.2*	20	5.0W
1N4016A	S	1N2972A	1N2970	DZ							8.2*	10	5.0W
1N4016B	S	1N2972B	1N2970	DZ							8.2*	5.0	5.0W
1N4017	S	1N2973	1N2970	DZ							9.1*	20	5.0W
1N4017A	S	1N2973A	1N2970	DZ							9.1*	10	5.0W
1N4017B	S	1N2973B	1N2970	DZ							9.1*	5.0	5.0W
1N4018	S	1N2974	1N2970	DZ							10*	20	5.0W
1N4018A	S	1N2974A	1N2970	DZ							10*	10	5.0W
1N4018B	S	1N2974B	1N2970	DZ							10*	5.0	5.0W
1N4019	S	1N2975	1N2970	DZ							11*	20	5.0W
1N4019A	S	1N2975A	1N2970	DZ							11*	10	5.0W
1N4019B	S	1N2975B	1N2970	DZ							11*	5.0	5.0W
1N4020	S	1N2976	1N2970	DZ							12*	20	5.0W
1N4020A	S	1N2976A	1N2970	DZ							12*	10	5.0W
1N4020B	S	1N2976B	1N2970	DZ							12*	5.0	5.0W
1N4021	S	1N2977	1N2970	DZ							13*	20	5.0W
1N4021A	S	1N2977A	1N2970	DZ							13*	10	5.0W
1N4021B	S	1N2977B	1N2970	DZ							13*	5.0	5.0W
1N4022	S	1N2979	1N2970	DZ							15*	20	5.0W
1N4022A	S	1N2979A	1N2970	DZ							15*	10	5.0W
1N4022B	S	1N2979B	1N2970	DZ							15*	5.0	5.0W
1N4023	S	1N2980	1N2970	DZ							16*	20	5.0W
1N4023A	S	1N2980A	1N2970	DZ							16*	10	5.0W
1N4023B	S	1N2980B	1N2970	DZ							16*	5.0	5.0W
1N4024	S	1N2982	1N2970	DZ							18*	20	5.0W
1N4024A	S	1N2982A	1N2970	DZ							18*	10	5.0W
1N4024B	S	1N2982B	1N2970	DZ							18*	5.0	5.0W
1N4025	S	1N2984	1N2970	DZ							20*	20	5.0W
1N4025A	S	1N2984A	1N2970	DZ							20*	10	5.0W
1N4025B	S	1N2984B	1N2970	DZ							20*	5.0	5.0W
1N4026	S	1N2985	1N2970	DZ							22*	20	5.0W
1N4026A	S	1N2985A	1N2970	DZ							22*	10	5.0W
1N4026B	S	1N2985B	1N2970	DZ							22*	5.0	5.0W
1N4027	S	1N2986	1N2970	DZ							24*	20	5.0W
1N4027A	S	1N2986A	1N2970	DZ							24*	10	5.0W
1N4027B	S	1N2986B	1N2970	DZ							24*	5.0	5.0W
1N4028	S	1N2988	1N2970	DZ							27*	20	5.0W
1N4028A	S	1N2988A	1N2970	DZ							27*	10	5.0W
1N4028B	S	1N2988B	1N2970	DZ							27*	5.0	5.0W
1N4029	S	1N2989	1N2970	DZ							30*	20	5.0W
1N4029A	S	1N2989A	1N2970	DZ							30*	10	5.0W
1N4029B	S	1N2989B	1N2970	DZ							30*	5.0	5.0W
1N4030	S	1N2990	1N2970	DZ							33*	20	5.0W
1N4030A	S	1N2990A	1N2970	DZ							33*	10	5.0W
1N4030B	S	1N2990B	1N2970	DZ							33*	5.0	5.0W
1N4031	S	1N2991	1N2970	DZ							36*	20	5.0W
1N4031A	S	1N2991A	1N2970	DZ							36*	10	5.0W
1N4031B	S	1N2992B	1N2970	DZ							36*	5.0	5.0W
1N4032	S	1N2992	1N2970	DZ							39*	20	5.0W
1N4032A	S	1N2992A	1N2970	DZ							39*	10	5.0W
1N4032B	S	1N2992B	1N2970	DZ							39*	5.0	5.0W
1N4033	S	1N2993	1N2970	DZ							43*	20	5.0W
1N4033A	S	1N2993A	1N2970	DZ							43*	10	5.0W
1N4033B	S	1N2993B	1N2970	DZ							43*	5.0	5.0W
1N4034	S	1N2995	1N2970	DZ							47*	20	5.0W
1N4034A	S	1N2995A	1N2970	DZ							47*	10	5.0W
1N4034B	S	1N2995B	1N2970	DZ							47*	5.0	5.0W
1N4035	S	1N2997	1N2970	DZ							51*	20	5.0W
1N4035A	S	1N2997A	1N2970	DZ							51*	10	5.0W
1N4035B	S	1N2997B	1N2970	DZ							51*	5.0	5.0W
1N4036	S	1N2999	1N2970	DZ							56*	20	5.0W
1N4036A	S	1N2999A	1N2970	DZ							56*	10	5.0W
1N4036B	S	1N2999B	1N2970	DZ							56*	5.0	5.0W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4037	S	1N3000	1N2970	DZ							62*	20	5.0W
1N4037A	S	1N3000A	1N2970	DZ							62*	10	5.0W
1N4037B	S	1N3000B	1N2970	DZ							62*	5.0	5.0W
1N4038	S	1N3001	1N2970	DZ							68*	20	5.0W
1N4038A	S	1N3001A	1N2970	DZ							68*	10	5.0W
1N4038B	S	1N3001B	1N2970	DZ							68*	5.0	5.0W
1N4039	S	1N3002	1N2970	DZ							75*	20	5.0W
1N4039A	S	1N3002A	1N2970	DZ							75*	10	5.0W
1N4039B	S	1N3002B	1N2970	DZ							75*	5.0	5.0W
1N4040	S	1N3003	1N2970	DZ							82*	20	5.0W
1N4040A	S	1N3003A	1N2970	DZ							82*	10	5.0W
1N4040B	S	1N3003B	1N2970	DZ							82*	5.0	5.0W
1N4041	S	1N3004	1N2970	DZ							91*	20	5.0W
1N4041A	S	1N3004A	1N2970	DZ							91*	10	5.0W
1N4041B	S	1N3004B	1N2970	DZ							91*	5.0	5.0W
1N4042	S	1N3005	1N2970	DZ							100*	20	5.0W
1N4042A	S	1N3005A	1N2970	DZ							100*	10	5.0W
1N4042B	S	1N3005B	1N2970	DZ							100*	5.0	5.0W
1N4043	S			DS	25	1.0	275	0.1*	2.0				
1N4044	S	MR1230SB	MR1230	R*	50	1.35	275	15	5000				
1N4045	S	MR1231SB	MR1230	R*	100	1.35	275	15	5000				
1N4046	S	MR1232SB	MR1230	R*	150	1.35	275	15	5000				
1N4047	S	MR1233SB	MR1230	R*	200	1.35	275	15	5000				
1N4048	S	MR1234SB	MR1230	R*	250	1.35	275	15	5000				
1N4049	S	MR1235SB	MR1230	R*	300	1.35	275	15	5000				
1N4050	S	MR1237SB	MR1230	R*	400	1.35	275	15	5000				
1N4051	S	MR1238SB	MR1230	R*	500	1.35	275	15	5000				
1N4052	S	MR1239SB	MR1230	R*	600	1.35	275	15	5000				
1N4053	S			R*	700	1.35	275	15	5000				
1N4054	S			R*	800	1.35	275	15	5000				
1N4055	S			R*	900	1.35	275	15	5000				
1N4056	S			R*	1000	1.35	275	15	5000				
1N4057	S		1N429	DR						0.005	12.4	-55	100
1N4057A	S		1N429	DR						0.002	12.4	-55	100
1N4058	S		1N429	DR						0.005	14.6	-55	100
1N4058A	S		1N429	DR						0.002	14.6	-55	100
1N4059	S		1N429	DR						0.005	16.8	-55	100
1N4059A	S		1N429	DR						0.002	16.8	-55	100
1N4060	S		1N429	DR						0.005	18.5	-55	100
1N4060A	S		1N429	DR						0.002	18.5	-55	100
1N4061	S		1N429	DR						0.005	21	-55	100
1N4061A	S		1N429	DR						0.002	21	-55	100
1N4062	S		1N429	DR						0.005	23	-55	100
1N4062A	S		1N429	DR						0.002	23	-55	100
1N4063	S		1N429	DR						0.005	27	-55	100
1N4063A	S		1N429	DR						0.002	27	-55	100
1N4064	S		1N429	DR						0.005	30	-55	100
1N4064A	S		1N429	DR						0.002	30	-55	100
1N4065	S		1N429	DR						0.005	33	-55	100
1N4065A	S		1N429	DR						0.002	33	-55	100
1N4066	S		1N429	DR						0.005	37	-55	100
1N4066A	S		1N429	DR						0.002	37	-55	100
1N4067	S		1N429	DR						5.0	43	-55	100
1N4067A	S		1N429	DR						2.0	43	-55	100
1N4068	S		1N429	DR						5.0	47	-55	100
1N4068A	S		1N429	DR						2.0	47	-55	100
1N4069	S		1N429	DR						5.0	51	-55	100
1N4069A	S		1N429	DR						2.0	51	-55	100
1N4070	S		1N429	DR						5.0	56	-55	100
1N4070A	S		1N429	DR						2.0	56	-55	100
1N4071	S		1N429	DR						5.0	62	-55	100
1N4071A	S		1N429	DR						2.0	62	-55	100
1N4072	S		1N429	DR						5.0	68	-55	100
1N4072A	S		1N429	DR						2.0	68	-55	100
1N4073	S		1N429	DR						5.0	75	-55	100
1N4073A	S		1N429	DR						2.0	75	-55	100
1N4074	S		1N429	DR						5.0	82	-55	100
1N4074A	S		1N429	DR						2.0	82	-55	100
1N4075	S		1N429	DR						0.005	87	-55	100
1N4075A	S		1N429	DR						0.002	87	-55	100
1N4076	S		1N429	DR						0.005	91	-55	100
1N4076A	S		1N429	DR						0.002	91	-55	100
1N4077	S		1N429	DR						0.002	100	-55	100
1N4077A	S		1N429	DR						0.002	100	-55	100
1N4078	S		1N429	DR						0.005	105	-55	100
1N4078A	S		1N429	DR						0.002	105	-55	100
1N4079	S		1N429	DR						0.005	110	-55	100
1N4079A	S		1N429	DR						0.002	110	-55	100
1N4080	S		1N429	DR						0.005	120	-55	100
1N4080A	S		1N429	DR						0.002	120	-55	100
1N4081	S		1N429	DR						0.005	130	-55	100
1N4081A	S		1N429	DR						0.002	130	-55	100

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C	
1N4082	S		1N429	DR						0.005	140	-55	100	
1N4082A	S		1N429	DR						0.002	140	-55	100	
1N4083	S		1N429	DR						0.005	150	-55	100	
1N4083A	S		1N429	DR						0.002	150	-55	100	
1N4084	S		1N429	DR						0.005	175	-55	100	
1N4084A	S		1N429	DR						0.002	175	-55	100	
1N4085	S		1N429	DR						0.005	200	-55	100	
1N4085A	S		1N429	DR						0.002	200	-55	100	
1N4086	S			DS	70	1.0	200M	0.25M	200					
1N4087	S			DS	50	0.975	30M	90N	2.5					
1N4088	G			DS	30	1.0	100M	0.2M						
1N4089	S			R*	400	1.2	400	0.2	75					
1N4090	G	Backward Diode												
1N4091		Varactor Diode, see Table on Page 1-94												
1N4092	S			DS		1.0	5.0M	1.0*						
1N4093	S			DS	50	1.0	5.0M	1.0						
1N4094	S	1N2624B	1N2620	DR							2.6			
1N4095	S	1N5231A	1N5221	DZ							5.0*	10	275M	
1N4096	S	1N4763A	1N4728	DZ							90*	5.0	3.0W	
1N4097	S	1N4764A	1N4728	DZ							100*	5.0	3.0W	
1N4098	S	1M150ZS5	1N4728	DZ							150*	5.0	3.0W	
1N4099	S		1N4099	DZ						6.46	7.14		250M	
1N4100	S		1N4099	DZ						7.125	7.875		250M	
1N4101	S		1N4099	DZ						7.79	8.61		250M	
1N4102	S		1N4099	DZ						8.265	9.135		250M	
1N4103	S		1N4099	DZ						8.645	9.555		250M	
1N4104	S		1N4099	DZ						9.5	10.5		250M	
1N4105	S		1N4099	DZ						10.45	11.55		250M	
1N4106	S		1N4099	DZ						11.4	12.6		250M	
1N4107	S		1N4099	DZ						12.35	13.65		250M	
1N4108	S		1N4099	DZ						13.3	14.7		250M	
1N4109	S		1N4099	DZ						14.25	15.75		250M	
1N4110	S		1N4099	DZ						15.2	16.8		250M	
1N4111	S		1N4099	DZ						16.15	17.85		250M	
1N4112	S		1N4099	DZ						17.1	18.9		250M	
1N4113	S		1N4099	DZ						18.05	19.95		250M	
1N4114	S		1N4099	DZ						19	21		250M	
1N4115	S		1N4099	DZ						20.9	23.1		250M	
1N4116	S		1N4099	DZ						22.8	25.2		250M	
1N4117	S		1N4099	DZ						23.75	26.25		250M	
1N4118	S		1N4099	DZ						25.65	28.35		250M	
1N4119	S		1N4099	DZ						26.6	29.4		250M	
1N4120	S		1N4099	DZ						28.5	31.5		250M	
1N4121	S		1N4099	DZ						31.35	34.65		250M	
1N4122	S		1N4099	DZ						34.2	37.8		250M	
1N4123	S		1N4099	DZ						37.05	40.95		250M	
1N4124	S		1N4099	DZ						40.85	45.15		250M	
1N4125	S		1N4099	DZ						44.65	49.35		250M	
1N4126	S		1N4099	DZ						48.45	53.55		250M	
1N4127	S		1N4099	DZ						53.2	58.8		250M	
1N4128	S		1N4099	DZ						57	63		250M	
1N4129	S		1N4099	DZ						58.9	65.1		250M	
1N4130	S		1N4099	DZ						64.6	71.4		250M	
1N4131	S		1N4099	DZ						71.25	78.75		250M	
1N4132	S		1N4099	DZ						77.9	86.1		250M	
1N4133	S		1N4099	DZ						82.65	91.35		250M	
1N4134	S		1N4099	DZ						86.45	95.55		250M	
1N4135	S		1N4099	DZ						95	105		250M	
1N4136	S			R*	200	1.6	70	16	750					
1N4137	S			R*	400	1.6	70	12	750					
1N4138	S			R*	600	1.6	70	8.0	750					
1N4139	S	1N4719	1N4719	R*	50	1.0	3.0	0.1	300					
1N4140	S	1N4720	1N4719	R*	100	1.0	3.0	0.1	300					
1N4141	S	1N4721	1N4719	R*	200	1.0	3.0	0.1	300					
1N4142	S	1N4722	1N4719	R*	400	1.0	3.0	0.1	300					
1N4143	S	1N4723	1N4719	R*	600	1.0	3.0	0.1	300					
1N4144	S	1N4724	1N4719	R*	800	1.0	3.0	0.1	300					
1N4145	S	1N4725	1N4719	R*	1000	1.0	3.0	0.1	300					
1N4146	S			R*	1200	1.0	3.0	0.1	300					
1N4147	S			DS	30	1.0	30M	0.1*	10					
1N4148	S			DS	75	1.0	10M	25N	4.0					
1N4149	S			DS	75	1.0	10M	25N	4.0					
1N4150	S			DS	50	1.0	200M	0.1*	6.0					
1N4151	S			DS	50	1.0	50M	50N	2.0					
1N4152	S			DS	30	0.88	20M	50N	2.0					
1N4153	S			DS	50	0.88	20M	50N	2.0					
1N4154	S			DS	25	1.0	30M	0.1*	4.0					
1N4155	S			DS	400	1.0	100M	0.1*	10					
1N4156	S			DS	20	1.84	0.1A	50N						
1N4157	S			DS	20	2.66	0.1A	50N						
1N4158	S	1N4736	1N4728	DZ							6.8*	20	1.0W	
1N4158A	S	1N4736	1N4728	DZ							6.8*	10	1.0W	

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4158B	S	1N4736A	1N4728	DZ							6.8*	5.0	1.0W
1N4159	S	1N4737	1N4728	DZ							7.5*	20	1.0W
1N4159A	S	1N4737	1N4728	DZ							7.5*	10	1.0W
1N4159B	S	1N4737A	1N4728	DZ							7.5*	5.0	1.0W
1N4160	S	1N4738	1N4728	DZ							8.2*	20	1.0W
1N4160A	S	1N4738	1N4728	DZ							8.2*	10	1.0W
1N4160B	S	1N4738A	1N4728	DZ							8.2*	5.0	1.0W
1N4161	S	1N4739	1N4728	DZ							9.1*	20	1.0W
1N4161A	S	1N4739	1N4728	DZ							9.1*	10	1.0W
1N4161B	S	1N4739A	1N4728	DZ							9.1*	5.0	1.0W
1N4162	S	1N4740	1N4728	DZ							10*	20	1.0W
1N4162A	S	1N4740	1N4728	DZ							10*	10	1.0W
1N4162B	S	1N4740A	1N4728	DZ							10*	5.0	1.0W
1N4163	S	1N4741	1N4728	DZ							11*	20	1.0W
1N4163A	S	1N4741	1N4728	DZ							11*	10	1.0W
1N4163B	S	1N4741A	1N4728	DZ							11*	5.0	1.0W
1N4164	S	1N4742	1N4728	DZ							12*	20	1.0W
1N4164A	S	1N4742	1N4728	DZ							12*	10	1.0W
1N4164B	S	1N4742A	1N4728	DZ							12*	5.0	1.0W
1N4165	S	1N4743	1N4728	DZ							13*	20	1.0W
1N4165A	S	1N4743	1N4728	DZ							13*	10	1.0W
1N4165B	S	1N4743A	1N4728	DZ							13*	5.0	1.0W
1N4166	S	1N4744	1N4728	DZ							15*	20	1.0W
1N4166A	S	1N4744	1N4728	DZ							15*	10	1.0W
1N4166B	S	1N4744A	1N4728	DZ							15*	5.0	1.0W
1N4167	S	1N4745	1N4728	DZ							16*	20	1.0W
1N4167A	S	1N4745	1N4728	DZ							16*	10	1.0W
1N4167B	S	1N4745A	1N4728	DZ							16*	5.0	1.0W
1N4168	S	1N4746	1N4728	DZ							18*	20	1.0W
1N4168A	S	1N4746	1N4728	DZ							18*	10	1.0W
1N4168B	S	1N4746A	1N4728	DZ							18*	5.0	1.0W
1N4169	S	1N4747	1N4728	DZ							20*	20	1.0W
1N4169A	S	1N4747	1N4728	DZ							20*	10	1.0W
1N4169B	S	1N4747A	1N4728	DZ							20*	5.0	1.0W
1N4170	S	1N4748	1N4728	DZ							22*	20	1.0W
1N4170A	S	1N4748	1N4728	DZ							22*	10	1.0W
1N4170B	S	1N4748A	1N4728	DZ							22*	5.0	1.0W
1N4171	S	1N4749	1N4728	DZ							24*	20	1.0W
1N4171A	S	1N4749	1N4728	DZ							24*	10	1.0W
1N4171B	S	1N4749A	1N4728	DZ							24*	5.0	1.0W
1N4172	S	1N4750	1N4728	DZ							27*	20	1.0W
1N4172A	S	1N4750	1N4728	DZ							27*	10	1.0W
1N4172B	S	1N4750A	1N4728	DZ							27*	5.0	1.0W
1N4173	S	1N4751	1N4728	DZ							30*	20	1.0W
1N4173A	S	1N4751	1N4728	DZ							30*	10	1.0W
1N4173B	S	1N4751A	1N4728	DZ							30*	5.0	1.0W
1N4174	S	1N4752	1N4728	DZ							33*	20	1.0W
1N4174A	S	1N4752	1N4728	DZ							33*	10	1.0W
1N4174B	S	1N4752A	1N4728	DZ							33*	5.0	1.0W
1N4175	S	1N4753	1N4728	DZ							36*	20	1.0W
1N4175A	S	1N4753	1N4728	DZ							36*	10	1.0W
1N4175B	S	1N4753A	1N4728	DZ							36*	5.0	1.0W
1N4176	S	1N4754	1N4728	DZ							39*	20	1.0W
1N4176A	S	1N4754	1N4728	DZ							39*	10	1.0W
1N4176B	S	1N4754A	1N4728	DZ							39*	5.0	1.0W
1N4177	S	1N4755	1N4728	DZ							43*	20	1.0W
1N4177A	S	1N4755	1N4728	DZ							43*	10	1.0W
1N4177B	S	1N4755A	1N4728	DZ							43*	5.0	1.0W
1N4178	S	1N4756	1N4728	DZ							47*	20	1.0W
1N4178A	S	1N4756	1N4728	DZ							47*	10	1.0W
1N4178B	S	1N4756A	1N4728	DZ							47*	5.0	1.0W
1N4179	S	1N4757	1N4728	DZ							51*	20	1.0W
1N4179A	S	1N4757	1N4728	DZ							51*	10	1.0W
1N4179B	S	1N4757A	1N4728	DZ							51*	5.0	1.0W
1N4180	S	1N4758	1N4728	DZ							56*	20	1.0W
1N4180A	S	1N4758	1N4728	DZ							56*	10	1.0W
1N4180B	S	1N4758A	1N4728	DZ							56*	5.0	1.0W
1N4181	S	1N4759	1N4728	DZ							62*	20	1.0W
1N4181A	S	1N4759	1N4728	DZ							62*	10	1.0W
1N4181B	S	1N4759A	1N4728	DZ							62*	5.0	1.0W
1N4182	S	1N4760	1N4728	DZ							68*	20	1.0W
1N4182A	S	1N4760	1N4728	DZ							68*	10	1.0W
1N4182B	S	1N4760A	1N4728	DZ							68*	5.0	1.0W
1N4183	S	1N4761	1N4728	DZ							75*	20	1.0W
1N4183A	S	1N4761	1N4728	DZ							75*	10	1.0W
1N4183B	S	1N4761A	1N4728	DZ							75*	5.0	1.0W
1N4184	S	1N4762	1N4728	DZ							82*	20	1.0W
1N4184A	S	1N4762	1N4728	DZ							82*	10	1.0W
1N4184B	S	1N4762A	1N4728	DZ							82*	5.0	1.0W
1N4185	S	1N4763	1N4728	DZ							91*	20	1.0W
1N4185A	S	1N4763	1N4728	DZ							91*	10	1.0W
1N4185B	S	1N4763A	1N4728	DZ							91*	5.0	1.0W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4186	S	1N4764	1N4728	DZ							100*	20	1.0W
1N4186A	S	1N4764	1N4728	DZ							100*	10	1.0W
1N4186B	S	1N4764A	1N4728	DZ							100*	5.0	1.0W
1N4187	S	1M110ZS10	1N4728	DZ							110*	20	1.0W
1N4187A	S	1M110ZS10	1N4728	DZ							110*	10	1.0W
1N4187B	S	1M110ZS5	1N4728	DZ							110*	5.0	1.0W
1N4188	S	1M120ZS10	1N4728	DZ							120*	20	1.0W
1N4188A	S	1M120ZS10	1N4728	DZ							120*	10	1.0W
1N4188B	S	1M120ZS5	1N4728	DZ							120*	5.0	1.0W
1N4189	S	1M130ZS10	1N4728	DZ							130*	20	1.0W
1N4189A	S	1M130ZS10	1N4728	DZ							130*	10	1.0W
1N4189B	S	1M130ZS5	1N4728	DZ							130*	5.0	1.0W
1N4190	S	1M150ZS10	1N4728	DZ							150*	20	1.0W
1N4190A	S	1M150ZS10	1N4728	DZ							150*	10	1.0W
1N4190B	S	1M150ZS5	1N4728	DZ							150*	5.0	1.0W
1N4191	S	1M160ZS10	1N4728	DZ							160*	20	1.0W
1N4191A	S	1M160ZS10	1N4728	DZ							160*	10	1.0W
1N4191B	S	1M160ZS5	1N4728	DZ							160*	5.0	1.0W
1N4192	S	1M180ZS10	1N4728	DZ							180*	20	1.0W
1N4192A	S	1M180ZS10	1N4728	DZ							180*	10	1.0W
1N4192B	S	1M180ZS5	1N4728	DZ							180*	5.0	1.0W
1N4193	S	1M200ZS10	1N4728	DZ							200*	20	1.0W
1N4193A	S	1M200ZS10	1N4728	DZ							200*	10	1.0W
1N4193B	S	1M200ZS5	1N4728	DZ							200*	5.0	1.0W
1N4194	S	1N2970	1N2970	DZ							6.8*	20	10W
1N4194A	S	1N2970A	1N2970	DZ							6.8*	10	10W
1N4194B	S	1N2970B	1N2970	DZ							6.8*	5.0	10W
1N4195	S	1N2971	1N2970	DZ							7.5*	20	10W
1N4195A	S	1N2971A	1N2970	DZ							7.5*	10	10W
1N4195B	S	1N2971B	1N2970	DZ							7.5*	5.0	10W
1N4196	S	1N2972	1N2970	DZ							8.2*	20	10W
1N4196A	S	1N2972A	1N2970	DZ							8.2*	10	10W
1N4196B	S	1N2972B	1N2970	DZ							8.2*	5.0	10W
1N4197	S	1N2973	1N2970	DZ							9.1*	20	10W
1N4197A	S	1N2973A	1N2970	DZ							9.1*	10	10W
1N4197B	S	1N2973B	1N2970	DZ							9.1*	5.0	10W
1N4198	S	1N2974	1N2970	DZ							10*	20	10W
1N4198A	S	1N2974A	1N2970	DZ							10*	10	10W
1N4198B	S	1N2974B	1N2970	DZ							10*	5.0	10W
1N4199	S	1N2975	1N2970	DZ							11*	20	10W
1N4199A	S	1N2975A	1N2970	DZ							11*	10	10W
1N4199B	S	1N2975B	1N2970	DZ							11*	5.0	10W
1N4200	S	1N2976	1N2970	DZ							12*	20	10W
1N4200A	S	1N2976A	1N2970	DZ							12*	10	10W
1N4200B	S	1N2976B	1N2970	DZ							12*	5.0	10W
1N4201	S	1N2977	1N2970	DZ							13*	20	10W
1N4201A	S	1N2977A	1N2970	DZ							13*	10	10W
1N4201B	S	1N2977B	1N2970	DZ							13*	5.0	10W
1N4202	S	1N2978	1N2970	DZ							14*	20	10W
1N4202A	S	1N2978A	1N2970	DZ							14*	10	10W
1N4202B	S	1N2978B	1N2970	DZ							14*	5.0	10W
1N4203	S	1N2979	1N2970	DZ							15*	20	10W
1N4203A	S	1N2979A	1N2970	DZ							15*	10	10W
1N4203B	S	1N2979B	1N2970	DZ							15*	5.0	10W
1N4204	S	1N2980	1N2970	DZ							16*	20	10W
1N4204A	S	1N2980A	1N2970	DZ							16*	10	10W
1N4204B	S	1N2980B	1N2970	DZ							16*	5.0	10W
1N4205	S	1N2981	1N2970	DZ							17*	20	10W
1N4205A	S	1N2981A	1N2970	DZ							17*	10	10W
1N4205B	S	1N2981B	1N2970	DZ							17*	5.0	10W
1N4206	S	1N2982	1N2970	DZ							18*	20	10W
1N4206A	S	1N2982A	1N2970	DZ							18*	10	10W
1N4206B	S	1N2982B	1N2970	DZ							18*	5.0	10W
1N4207	S	1N2983	1N2970	DZ							19*	20	10W
1N4207A	S	1N2983A	1N2970	DZ							19*	10	10W
1N4207B	S	1N2983B	1N2970	DZ							19*	5.0	10W
1N4208	S	1N2984	1N2970	DZ							20*	20	10W
1N4208A	S	1N2984A	1N2970	DZ							20*	10	10W
1N4208B	S	1N2984B	1N2970	DZ							20*	5.0	10W
1N4209	S	1N2985	1N2970	DZ							22*	20	10W
1N4209A	S	1N2985A	1N2970	DZ							22*	10	10W
1N4209B	S	1N2985B	1N2970	DZ							22*	5.0	10W
1N4210	S	1N2986	1N2970	DZ							24*	20	10W
1N4210A	S	1N2986A	1N2970	DZ							24*	10	10W
1N4210B	S	1N2986B	1N2970	DZ							24*	5.0	10W
1N4211	S	1N2987	1N2970	DZ							25*	20	10W
1N4211A	S	1N2987A	1N2970	DZ							25*	10	10W
1N4211B	S	1N2987B	1N2970	DZ							25*	5.0	10W
1N4212	S	1N2988	1N2970	DZ							27*	20	10W
1N4212A	S	1N2988A	1N2970	DZ							27*	10	10W
1N4212B	S	1N2988B	1N2970	DZ							27*	5.0	10W
1N4213	S	1N2989	1N2970	DZ							30*	20	10W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4213A	S	1N2989A	1N2970	DZ							30*	10	10W
1N4213B	S	1N2989B	1N2970	DZ							30*	5.0	10W
1N4214	S	1N2990	1N2970	DZ							33*	20	10W
1N4214A	S	1N2990A	1N2970	DZ							33*	10	10W
1N4214B	S	1N2990B	1N2970	DZ							33*	5.0	10W
1N4215	S	1N2991	1N2970	DZ							36*	20	10W
1N4215A	S	1N2991A	1N2970	DZ							36*	10	10W
1N4215B	S	1N2991B	1N2970	DZ							36*	5.0	10W
1N4216	S	1N2992	1N2970	DZ							39*	20	10W
1N4216A	S	1N2992A	1N2970	DZ							39*	10	10W
1N4216B	S	1N2992B	1N2970	DZ							39*	5.0	10W
1N4217	S	1N2993	1N2970	DZ							43*	20	10W
1N4217A	S	1N2993A	1N2970	DZ							43*	10	10W
1N4217B	S	1N2993B	1N2970	DZ							43*	5.0	10W
1N4218	S	1N2994	1N2970	DZ							45*	20	10W
1N4218A	S	1N2994A	1N2970	DZ							45*	10	10W
1N4218B	S	1N2994B	1N2970	DZ							45*	5.0	10W
1N4219	S	1N2995	1N2970	DZ							47*	20	10W
1N4219A	S	1N2995A	1N2970	DZ							47*	10	10W
1N4219B	S	1N2995B	1N2970	DZ							47*	5.0	10W
1N4220	S	1N2996	1N2970	DZ							50*	20	10W
1N4220A	S	1N2996A	1N2970	DZ							50*	10	10W
1N4220B	S	1N2996B	1N2970	DZ							50*	5.0	10W
1N4221	S	1N2997	1N2970	DZ							51*	20	10W
1N4221A	S	1N2997A	1N2970	DZ							51*	10	10W
1N4221B	S	1N2997B	1N2970	DZ							51*	5.0	10W
1N4222	S	1N2998	1N2970	DZ							52*	20	10W
1N4222A	S	1N2998A	1N2970	DZ							52*	10	10W
1N4222B	S	1N2998B	1N2970	DZ							52*	5.0	10W
1N4223	S	1N2999	1N2970	DZ							56*	20	10W
1N4223A	S	1N2999A	1N2970	DZ							56*	10	10W
1N4223B	S	1N2999B	1N2970	DZ							56*	5.0	10W
1N4224	S	1N3000	1N2970	DZ							62*	20	10W
1N4224A	S	1N3000A	1N2970	DZ							62*	10	10W
1N4224B	S	1N3000B	1N2970	DZ							62*	5.0	10W
1N4225	S	1N3001	1N2970	DZ							68*	20	10W
1N4225A	S	1N3001A	1N2970	DZ							68*	10	10W
1N4225B	S	1N3001B	1N2970	DZ							68*	5.0	10W
1N4226	S	1N3002	1N2970	DZ							75*	20	10W
1N4226A	S	1N3002A	1N2970	DZ							75*	10	10W
1N4226B	S	1N3002B	1N2970	DZ							75*	5.0	10W
1N4227	S	1N3003	1N2970	DZ							82*	20	10W
1N4227A	S	1N3003A	1N2970	DZ							82*	10	10W
1N4227B	S	1N3003B	1N2970	DZ							82*	5.0	10W
1N4228	S	1N3004	1N2970	DZ							91*	20	10W
1N4228A	S	1N3004A	1N2970	DZ							91*	10	10W
1N4228B	S	1N3004B	1N2970	DZ							91*	5.0	10W
1N4229	S	1N3005	1N2970	DZ							100*	20	10W
1N4229A	S	1N3005A	1N2970	DZ							100*	10	10W
1N4229B	S	1N3005B	1N2970	DZ							100*	5.0	10W
1N4230	S	1N3006	1N2970	DZ							105*	20	10W
1N4230A	S	1N3006A	1N2970	DZ							105*	10	10W
1N4230B	S	1N3006B	1N2970	DZ							105*	5.0	10W
1N4231	S	1N3007	1N2970	DZ							110*	20	10W
1N4231A	S	1N3007A	1N2970	DZ							110*	10	10W
1N4231B	S	1N3007B	1N2970	DZ							110*	5.0	10W
1N4232	S	1N3008	1N2970	DZ							120*	20	10W
1N4232A	S	1N3008A	1N2970	DZ							120*	10	10W
1N4232B	S	1N3008B	1N2970	DZ							120*	5.0	10W
1N4233	S	1N3009	1N2970	DZ							130*	20	10W
1N4233A	S	1N3009A	1N2970	DZ							130*	10	10W
1N4233B	S	1N3009B	1N2970	DZ							130*	5.0	10W
1N4234	S	1N3010	1N2970	DZ							140*	20	10W
1N4234A	S	1N3010A	1N2970	DZ							140*	10	10W
1N4234B	S	1N3010B	1N2970	DZ							140*	5.0	10W
1N4235	S	1N3011	1N2970	DZ							150*	20	10W
1N4235A	S	1N3011A	1N2970	DZ							150*	10	10W
1N4235B	S	1N3011B	1N2970	DZ							150*	5.0	10W
1N4236	S	1N3012	1N2970	DZ							160*	20	10W
1N4236A	S	1N3012A	1N2970	DZ							160*	10	10W
1N4236B	S	1N3012B	1N2970	DZ							160*	5.0	10W
1N4237	S	1N3013	1N2970	DZ							175*	20	10W
1N4237A	S	1N3013A	1N2970	DZ							175*	10	10W
1N4237B	S	1N3013B	1N2970	DZ							175*	5.0	10W
1N4238	S	1N3014	1N2970	DZ							180*	20	10W
1N4238A	S	1N3014A	1N2970	DZ							180*	10	10W
1N4238B	S	1N3014B	1N2970	DZ							180*	5.0	10W
1N4239	S	1N3015	1N2970	DZ							200*	20	10W
1N4239A	S	1N3015A	1N2970	DZ							200*	10	10W
1N4239B	S	1N3015B	1N2970	DZ							200*	5.0	10W
1N4240	S	10M5.0AZ2		DZ						4.9	5.1	2.0	10W
1N4241	S	10M6.0AZ1		DZ						5.9	6.1	2.0	10W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4242	S			DS	40	1.0	20M	0.1N	2.0				
1N4243	S			DS	40	1.0	10M	0.1N	2.0				
1N4244	S			DS	10	1.0	20M	0.1*	0.75				
1N4245	S	1N4003	1N4001	R*	200	1.64	1.0	0.05	25				
1N4246	S	1N4004	1N4001	R*	400	1.64	1.0	0.05	25				
1N4247	S	1N4005	1N4001	R*	600	1.64	1.0	0.05	25				
1N4248	S	1N4006	1N4001	R*	800	1.64	1.0	0.05	25				
1N4249	S	1N4007	1N4001	R*	1000	1.64	1.0	0.05	25				
1N4250	S	1N4006	1N4001	R*	800		0.5	0.05	10				
1N4251	S	1N4007	1N4001	R*	1000		0.5	0.05	10				
1N4252	S			R*	1200		0.5	0.05	10				
1N4253	S			R*	1500		0.5	0.05	10				
1N4254	S	MR991A	MR990A	R*	1500	4.8	0.25	0.05	6.25				
1N4255	S	MR992A	MR990A	R*	2000	4.8	0.25	0.05	6.25				
1N4256	S	MR993A	MR990A	R*	2500	4.8	0.25	0.05	6.25				
1N4257	S	MR994A	MR990A	R*	3000	4.8	0.25	0.05	6.25				
1N4258	S	1N2970	1N2970	DZ							6.8*	20	10W
1N4258A	S	1N2970A	1N2970	DZ							6.8*	10	10W
1N4258B	S	1N2970B	1N2970	DZ							6.8*	5.0	10W
1N4259	S	1N2971	1N2970	DZ							7.5*	20	10W
1N4259A	S	1N2971A	1N2970	DZ							7.5*	10	10W
1N4259B	S	1N2971B	1N2970	DZ							7.5*	5.0	10W
1N4260	S	1N2972	1N2970	DZ							8.2*	20	10W
1N4260A	S	1N2972A	1N2970	DZ							8.2*	10	10W
1N4260B	S	1N2972B	1N2970	DZ							8.2*	5.0	10W
1N4261	S	1N2973	1N2970	DZ							9.1*	20	10W
1N4261A	S	1N2973A	1N2970	DZ							9.1*	10	10W
1N4261B	S	1N2973B	1N2970	DZ							9.1*	5.0	10W
1N4262	S	1N2974	1N2970	DZ							10*	20	10W
1N4262A	S	1N2974A	1N2970	DZ							10*	10	10W
1N4262B	S	1N2974B	1N2970	DZ							10*	5.0	10W
1N4263	S	1N2975	1N2970	DZ							11*	20	10W
1N4263A	S	1N2975A	1N2970	DZ							11*	10	10W
1N4263B	S	1N2975B	1N2970	DZ							11*	5.0	10W
1N4264	S	1N2976	1N2970	DZ							12*	20	10W
1N4264A	S	1N2976A	1N2970	DZ							12*	10	10W
1N4264B	S	1N2976B	1N2970	DZ							12*	5.0	10W
1N4265	S	1N2977	1N2970	DZ							13*	20	10W
1N4265A	S	1N2977A	1N2970	DZ							13*	10	10W
1N4265B	S	1N2977B	1N2970	DZ							13*	5.0	10W
1N4266	S	1N2979	1N2970	DZ							15*	20	10W
1N4266A	S	1N2979A	1N2970	DZ							15*	10	10W
1N4266B	S	1N2979B	1N2970	DZ							15*	5.0	10W
1N4267	S	1N2980	1N2970	DZ							16*	20	10W
1N4267A	S	1N2980A	1N2970	DZ							16*	10	10W
1N4267B	S	1N2980B	1N2970	DZ							16*	5.0	10W
1N4268	S	1N2982	1N2970	DZ							18*	20	10W
1N4268A	S	1N2982A	1N2970	DZ							18*	10	10W
1N4268B	S	1N2982B	1N2970	DZ							18*	5.0	10W
1N4269	S	1N2984	1N2970	DZ							20*	20	10W
1N4269A	S	1N2984A	1N2970	DZ							20*	10	10W
1N4269B	S	1N2984B	1N2970	DZ							20*	5.0	10W
1N4270	S	1N2985	1N2979	DZ							22*	20	10W
1N4270A	S	1N2985A	1N2970	DZ							22*	10	10W
1N4270B	S	1N2985B	1N2970	DZ							22*	5.0	10W
1N4271	S	1N2986	1N2970	DZ							24*	20	10W
1N4271A	S	1N2986A	1N2970	DZ							24*	10	10W
1N4271B	S	1N2986B	1N2970	DZ							24*	5.0	10W
1N4272	S	1N2988	1N2970	DZ							27*	20	10W
1N4272A	S	1N2988A	1N2970	DZ							27*	10	10W
1N4272B	S	1N2988B	1N2970	DZ							27*	5.0	10W
1N4273	S	1N2989	1N2970	DZ							30*	20	10W
1N4273A	S	1N2989A	1N2970	DZ							30*	10	10W
1N4273B	S	1N2989B	1N2970	DZ							30*	5.0	10W
1N4274	S	1N2990	1N2970	DZ							33*	20	10W
1N4274A	S	1N2990A	1N2970	DZ							33*	10	10W
1N4274B	S	1N2990B	1N2970	DZ							33*	5.0	10W
1N4275	S	1N2991	1N2970	DZ							36*	20	10W
1N4275A	S	1N2991A	1N2970	DZ							36*	10	10W
1N4275B	S	1N2991B	1N2970	DZ							36*	5.0	10W
1N4276	S	1N2992	1N2970	DZ							39*	20	10W
1N4276A	S	1N2992A	1N2970	DZ							39*	10	10W
1N4276B	S	1N2992B	1N2970	DZ							39*	5.0	10W
1N4277	S	1N2993	1N2970	DZ							43*	20	10W
1N4277A	S	1N2993A	1N2970	DZ							43*	10	10W
1N4277B	S	1N2993B	1N2970	DZ							43*	5.0	10W
1N4278	S	1N2995	1N2970	DZ							47*	20	10W
1N4278A	S	1N2995A	1N2970	DZ							47*	10	10W
1N4278B	S	1N2995B	1N2970	DZ							47*	5.0	10W
1N4279	S	1N2997	1N2970	DZ							51*	20	10W
1N4279A	S	1N2997A	1N2970	DZ							51*	10	10W
1N4279B	S	1N2997B	1N2970	DZ							51*	5.0	10W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4280	S	1N2999	1N2970	DZ							56*	20	10W
1N4280A	S	1N2999A	1N2970	DZ							56*	10	10W
1N4280B	S	1N2999B	1N2970	DZ							56*	5.0	10W
1N4281	S	1N3000	1N2970	DZ							62*	20	10W
1N4281A	S	1N3000A	1N2970	DZ							62*	10	10W
1N4281B	S	1N3000B	1N2970	DZ							62*	5.0	10W
1N4282	S	1N3001	1N2970	DZ							68*	20	10W
1N4282A	S	1N3001A	1N2970	DZ							68*	10	10W
1N4282B	S	1N3001B	1N2970	DZ							68*	5.0	10W
1N4283	S	1N3002	1N2970	DZ							75*	20	10W
1N4283A	S	1N3002A	1N2970	DZ							75*	10	10W
1N4283B	S	1N3002B	1N2970	DZ							75*	5.0	10W
1N4284	S	1N3003	1N2970	DZ							82*	20	10W
1N4284A	S	1N3003A	1N2970	DZ							82*	10	10W
1N4284B	S	1N3003B	1N2970	DZ							82*	5.0	10W
1N4285	S	1N3004	1N2970	DZ							91*	20	10W
1N4285A	S	1N3004A	1N2970	DZ							91*	10	10W
1N4285B	S	1N3004B	1N2970	DZ							91*	5.0	10W
1N4286	S	1N3005	1N2970	DZ							100*	20	10W
1N4286A	S	1N3005A	1N2970	DZ							100*	10	10W
1N4286B	S	1N3005B	1N2970	DZ							100*	5.0	10W
1N4287	S	1N3007	1N2970	DZ							110*	20	10W
1N4287A	S	1N3007A	1N2970	DZ							110*	10	10W
1N4287B	S	1N3007B	1N2970	DZ							110*	5.0	10W
1N4288	S	1N3008	1N2970	DZ							120*	20	10W
1N4288A	S	1N3008A	1N2970	DZ							120*	10	10W
1N4288B	S	1N3008B	1N2970	DZ							120*	5.0	10W
1N4289	S	1N3009	1N2970	DZ							130*	20	10W
1N4289A	S	1N3009A	1N2970	DZ							130*	10	10W
1N4289B	S	1N3009B	1N2970	DZ							130*	5.0	10W
1N4290	S	1N3011	1N2970	DZ							150*	20	10W
1N4290A	S	1N3011A	1N2970	DZ							150*	10	10W
1N4290B	S	1N3011B	1N2970	DZ							150*	5.0	10W
1N4291	S	1N3012	1N2970	DZ							160*	20	10W
1N4291A	S	1N3012A	1N2970	DZ							160*	10	10W
1N4291B	S	1N3012B	1N2970	DZ							160*	5.0	10W
1N4292	S	1N3014	1N2970	DZ							180*	20	10W
1N4292A	S	1N3014A	1N2970	DZ							180*	10	10W
1N4292B	S	1N3014B	1N2970	DZ							180*	5.0	10W
1N4293	S	1N3015	1N2970	DZ							200*	20	10W
1N4293A	S	1N3015A	1N2970	DZ							200*	10	10W
1N4293B	S	1N3015B	1N2970	DZ							200*	5.0	10W
1N4294	S	Microwave S-band Mixer											
1N4295	S			DR						0.012	10	-55	150
1N4295A	S			DR						0.012	10	-55	150
1N4296	S			DR						0.0005	9.3*	-55	150
1N4296A	S			DR						0.0005	9.3*	-55	150
1N4297	S			DR						0.01	8.8	0	75
1N4297A	S			DR						0.01	8.8	-55	100
1N4297B	S			DR						0.01	8.8	-55	150
1N4298	S			DR						0.005	8.8	0	75
1N4298A	S			DR						0.005	8.8	-55	100
1N4298B	S			DR						0.005	8.8	-55	150
1N4299	S			DR						0.01	11.3	0	75
1N4299A	S			DR						0.01	11.3	-55	100
1N4299B	S			DR						0.01	11.3	-55	150
1N4300	S			DR						0.005	11.3	0	75
1N4300A	S			DR						0.005	11.3	-55	100
1N4300B	S			DR						0.005	11.3	-55	150
1N4301	S			DR						0.01	8.8	0	75
1N4301A	S			DR						0.01	8.8	-55	100
1N4301B	S			DR						0.01	8.8	-55	150
1N4302	S			DR						0.005	8.8	0	75
1N4302A	S			DR						0.005	8.8	-55	100
1N4302B	S			DR						0.005	8.8	-55	150
1N4303	S			DR						0.01	11.3	0	75
1N4303A	S			DR						0.01	11.3	-55	100
1N4303B	S			DR						0.01	11.3	-55	150
1N4304	S			DR						0.005	11.3	0	75
1N4304A	S			DR						0.005	11.3	-55	100
1N4304B	S			DR						0.005	11.3	-55	150
1N4305				DS	75	0.575	0.25M	0.1*	2.0				
1N4306	S			DS	50	1.0	50M	50N	2.0				
1N4307	S			DS	50	1.0	50M	50N	2.0				
1N4308	S			DS	80	1.0	200M	0.1*	2.0				
1N4309	S			DS	40	1.0	400M	0.1*	2.0				
1N4310	S			DS	60	1.0	400M	0.1*	2.0				
1N4311	S			DS	80	1.0	300M	0.1*	2.0				
1N4312	S			DS	120	1.0	200M	0.1*	2.0				
1N4313	S			DS	80	1.0	100M	0.1*	4.0				
1N4314	S			DS	80	1.0	200M	0.1*	2.0				
1N4315	S			DS	40	1.0	400M	0.1*	2.0				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4316	S			DS	60	1.0	400M	0.1*	2.0				
1N4317	S			DS	80	1.0	300M	0.1*	2.0				
1N4318	S			DS	120	1.0	200M	0.1*	2.0				
1N4319	S			DS	80	1.0	100M	0.1*	4.0				
1N4320	S			DS	640			1.0*					
1N4321	S	1M50ZS10	1N4728	DZ							50*	10	3.0W
1N4322	S			DS	50	1.0	0.2A	0.1*	6.0				
1N4323	S	1N4736	1N4728	DZ							6.8*	20	1.0W
1N4323A	S	1N4736	1N4728	DZ							6.8*	10	1.0W
1N4323B	S	1N4736A	1N4728	DZ							6.8*	5.0	1.0W
1N4324	S	1N4737	1N4728	DZ							7.5*	20	1.0W
1N4324A	S	1N4737	1N4728	DZ							7.5*	10	1.0W
1N4324B	S	1N4737A	1N4728	DZ							7.5*	5.0	1.0W
1N4325	S	1N4738	1N4728	DZ							8.2*	20	1.0W
1N4325A	S	1N4738	1N4728	DZ							8.2*	10	1.0W
1N4325B	S	1N4738A	1N4728	DZ							8.2*	5.0	1.0W
1N4326	S	1N4739	1N4728	DZ							9.1*	20	1.0W
1N4326A	S	1N4739	1N4728	DZ							9.1*	10	1.0W
1N4326B	S	1N4739A	1N4782	DZ							9.1*	5.0	1.0W
1N4327	S	1N4740	1N4728	DZ							10*	20	1.0W
1N4327A	S	1N4740	1N4728	DZ							10*	10	1.0W
1N4327B	S	1N4740A	1N4728	DZ							10*	5.0	1.0W
1N4328	S	1N4741	1N4728	DZ							11*	20	1.0W
1N4328A	S	1N4741	1N4728	DZ							11*	10	1.0W
1N4328B	S	1N4741A	1N4728	DZ							11*	5.0	1.0W
1N4329	S	1N4742	1N4728	DZ							12*	20	1.0W
1N4329A	S	1N4742	1N4728	DZ							12*	10	1.0W
1N4329B	S	1N4742A	1N4728	DZ							12*	5.0	1.0W
1N4330	S	1N4743	1N4728	DZ							13*	20	1.0W
1N4330A	S	1N4743	1N4728	DZ							13*	10	1.0W
1N4330B	S	1N4743A	1N4728	DZ							13*	5.0	1.0W
1N4331	S	1N4744	1N4728	DZ							15*	20	1.0W
1N4331A	S	1N4744	1N4728	DZ							15*	10	1.0W
1N4331B	S	1N4744A	1N4728	DZ							15*	5.0	1.0W
1N4332	S	1N4745	1N4728	DZ							16*	20	1.0W
1N4332A	S	1N4745	1N4728	DZ							16*	10	1.0W
1N4332B	S	1N4745A	1N4728	DZ							16*	5.0	1.0W
1N4333	S	1N4746	1N4728	DZ							18*	20	1.0W
1N4333A	S	1N4746	1N4728	DZ							18*	10	1.0W
1N4333B	S	1N4746A	1N4728	DZ							18*	5.0	1.0W
1N4334	S	1N4747	1N4728	DZ							20*	20	1.0W
1N4334A	S	1N4747	1N4728	DZ							20*	10	1.0W
1N4334B	S	1N4747A	1N4728	DZ							20*	5.0	1.0W
1N4335	S	1N4748	1N4728	DZ							22*	20	1.0W
1N4335A	S	1N4748	1N4728	DZ							22*	10	1.0W
1N4335B	S	1N4748A	1N4728	DZ							22*	5.0	1.0W
1N4336	S	1N4749	1N4728	DZ							24*	20	1.0W
1N4336A	S	1N4749	1N4728	DZ							24*	10	1.0W
1N4336B	S	1N4749A	1N4728	DZ							24*	5.0	1.0W
1N4337	S	1N4750	1N4728	DZ							27*	20	1.0W
1N4337A	S	1N4750	1N4728	DZ							27*	10	1.0W
1N4337B	S	1N4750A	1N4728	DZ							27*	5.0	1.0W
1N4338	S	1N4751	1N4728	DZ							30*	20	1.0W
1N4338A	S	1N4751	1N4728	DZ							30*	10	1.0W
1N4338B	S	1N4751A	1N4728	DZ							30*	5.0	1.0W
1N4339	S	1N4752	1N4728	DZ							33*	20	1.0W
1N4339A	S	1N4752	1N4728	DZ							33*	10	1.0W
1N4339B	S	1N4752A	1N4728	DZ							33*	5.0	1.0W
1N4340	S	1N4753	1N4728	DZ							36*	20	1.0W
1N4340A	S	1N4753	1N4728	DZ							36*	10	1.0W
1N4340B	S	1N4753A	1N4728	DZ							36*	5.0	1.0W
1N4341	S	1N4754	1N4728	DZ							39*	20	1.0W
1N4341A	S	1N4754	1N4728	DZ							39*	10	1.0W
1N4341B	S	1N4754A	1N4728	DZ							39*	5.0	1.0W
1N4342	S	1N4755	1N4728	DZ							43*	20	1.0W
1N4342A	S	1N4755	1N4728	DZ							43*	10	1.0W
1N4342B	S	1N4755A	1N4728	DZ							43*	5.0	1.0W
1N4343	S	1N4756	1N4728	DZ							47*	20	1.0W
1N4343A	S	1N4756	1N4728	DZ							47*	10	1.0W
1N4343B	S	1N4756A	1N4728	DZ							47*	5.0	1.0W
1N4344	S	1N4757	1N4728	DZ							51*	20	1.0W
1N4344A	S	1N4757	1N4728	DZ							51*	10	1.0W
1N4344B	S	1N4757A	1N4728	DZ							51*	5.0	1.0W
1N4345	S	1N4758	1N4728	DZ							56*	20	1.0W
1N4345A	S	1N4758	1N4728	DZ							56*	10	1.0W
1N4345B	S	1N4758A	1N4728	DZ							56*	5.0	1.0W
1N4346	S	1N4759	1N4728	DZ							62*	20	1.0W
1N4346A	S	1N4759	1N4728	DZ							62*	10	1.0W
1N4346B	S	1N4759A	1N4728	DZ							62*	5.0	1.0W
1N4347	S	1N4760	1N4728	DZ							68*	20	1.0W
1N4347A	S	1N4760	1N4728	DZ							68*	10	1.0W
1N4347B	S	1N4760A	1N4728	DZ							68*	5.0	1.0W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4348	S	1N4761	1N4728	DZ							75*	20	1.0W
1N4348A	S	1N4761	1N4728	DZ							75*	10	1.0W
1N4348B	S	1N4761A	1N4728	DZ							75*	5.0	1.0W
1N4349	S	1N4762	1N4728	DZ							82*	20	1.0W
1N4349A	S	1N4762	1N4728	DZ							82*	10	1.0W
1N4349B	S	1N4762A	1N4728	DZ							82*	5.0	1.0W
1N4350	S	1N4763	1N4728	DZ							91*	20	1.0W
1N4350A	S	1N4763	1N4728	DZ							91*	10	1.0W
1N4350B	S	1N4763A	1N4728	DZ							91*	5.0	1.0W
1N4351	S	1N4764	1N4728	DZ							100*	20	1.0W
1N4351A	S	1N4764	1N4728	DZ							100*	10	1.0W
1N4351B	S	1N4764A	1N4728	DZ							100*	5.0	1.0W
1N4352	S	1M110ZS10	1N4728	DZ							110*	20	1.0W
1N4352A	S	1M110ZS10	1N4728	DZ							110*	10	1.0W
1N4352B	S	1M110ZS5	1N4728	DZ							110*	5.0	1.0W
1N4353	S	1M120ZS10	1N4728	DZ							120*	20	1.0W
1N4353A	S	1M120ZS10	1N4728	DZ							120*	10	1.0W
1N4343B	S	1M120ZS5	1N4728	DZ							120*	5.0	1.0W
1N4354	S	1M130ZS10	1N4728	DZ							130*	20	1.0W
1N4354A	S	1M130ZS10	1N4728	DZ							130*	10	1.0W
1N4354B	S	1M130ZS5	1N4728	DZ							130*	5.0	1.0W
1N4355	S	1M150ZS10	1N4728	DZ							150*	20	1.0W
1N4355A	S	1M150ZS10	1N4728	DZ							150*	10	1.0W
1N4355B	S	1M150ZS5	1N4728	DZ							150*	5.0	1.0W
1N4356	S	1M160ZS10	1N4728	DZ							160*	20	1.0W
1N4356A	S	1M160ZS10	1N4728	DZ							160*	10	1.0W
1N4356B	S	1M160ZS5	1N4728	DZ							160*	5.0	1.0W
1N4357	S	1M180ZS10	1N4728	DZ							180*	20	1.0W
1N4357A	S	1M180ZS10	1N4728	DZ							180*	10	1.0W
1N4357B	S	1M180ZS5	1N4728	DZ							180*	5.0	1.0W
1N4358	S	1M200ZS10	1N4728	DZ							200*	20	1.0W
1N4358A	S	1M200ZS10	1N4728	DZ							200*	10	1.0W
1N4358B	S	1M200ZS5	1N4728	DZ							200*	5.0	1.0W
1N4359	S			DS	200								
1N4360	S	1N4370A*	1N746	DZ						2.28	2.52	5.0	0.25W
1N4361	S	1N4007	1N4001	R*	900	1.3	0.5	0.5	20				
1N4362	S			DS	100	0.9	0.1A	10N					
1N4363	S			DS	120	1.0	0.2A	0.1*	40				
1N4364	S	1N4002	1N4001	R*	100	1.5	0.75	0.1	20				
1N4365	S	1N4003	1N4001	R*	200	1.5	0.75	0.1	20				
1N4366	S	1N4004	1N4001	R*	300	1.5	0.75	0.1	20				
1N4367	S	1N4004	1N4001	R*	400	1.5	0.75	0.1	20				
1N4368	S	1N4005	1N4001	R*	500	1.5	0.75	0.1	20				
1N4369	S	1N4005	1N4001	R*	600	1.5	0.75	0.1	20				
1N4370	S		1N746	DZ							2.4*	10	0.4W
1N4370A	S		1N746	DZ							2.4*	5.0	0.4W
1N4371	S		1N746	DZ							2.7*	10	0.4W
1N4371A	S		1N746	DZ							2.7*	5.0	0.4W
1N4372	S		1N746	DZ							3.0*	10	0.4W
1N4372A	S		1N746	DZ							3.0*	5.0	0.4W
1N4373	S			DS	80	1.0	10M	5.0*	4.0				
1N4374	S	MR991A	MR990A	R*	1500	1.75	0.75	0.1	15				
1N4375	S			DS	50	1.0	20M	10N	6.0				
1N4376	S			DS	10	1.1	50M	0.1*	0.75				
1N4377	S			R*	25K	30	0.75	0.1	50				
1N4378	S	Photosensitive Device; I(dark) = 10 nA, Sensitivity = 9.0 mA @ V_{CE} = 5.0 V, H = 9.0 mW/cm^2											
1N4379	S	Microwave S-band Detector											
1N4380	S			DS	50	1.4	570M	50N	1.8				
1N4381	G			DS	25	0.35	2.0M	0.1M	0.1				
1N4382	S			DS	55	1.0	0.3A	0.1*	6.5				
1N4383	S	1N4003	1N4001	R*	200	1.3	1.0	0.275	50				
1N4384	S	1N4004	1N4001	R*	400	1.3	1.0	0.25	50				
1N4385	S	1N4005	1N4001	R*	600	1.3	1.0	0.225	50				
1N4387, 1N4388		Varactor Diodes, see Table on Page 1-94											
1N4389	S			DS	5.0	1.0	2.0M	0.1M					
1N4390	S			DS	20	1.0	5.0M	0.2*	0.5				
1N4391	S			DS	20	1.0	2.0M	0.2*	0.5				
1N4392	S			DS	15	1.0	2.0M	1.0*	0.5				
1N4393, A,B thru 1N4399, A,B		Tunnel Diodes, see Table on Page 1-102											
1N4400	S	1N4736	1N4728	DZ							6.8*	20	1.0W
1N4401	S	1N4737	1N4728	DZ							7.5*	20	1.0W
1N4402	S	1N4738	1N4728	DZ							8.2*	20	1.0W
1N4403	S	1N4739	1N4728	DZ							9.1*	20	1.0W
1N4404	S	1N4740	1N4728	DZ							10*	20	1.0W
1N4405	S	1N4741	1N4728	DZ							11*	20	1.0W

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4406	S	1N4742	1N4728	DZ							12*	20	1.0W
1N4407	S	1N4743	1N4728	DZ							13*	20	1.0W
1N4408	S	1N4744	1N4728	DZ							15*	20	1.0W
1N4409	S	1N4745	1N4728	DZ							16*	20	1.0W
1N4410	S	1N4746	1N4728	DZ							18*	20	1.0W
1N4411	S	1N4747	1N4728	DZ							20*	20	1.0W
1N4412	S	1N4748	1N4728	DZ							22*	20	1.0W
1N4413	S	1N4749	1N4728	DZ							24*	20	1.0W
1N4414	S	1N4750	1N4728	DZ							27*	20	1.0W
1N4415	S	1N4751	1N4728	DZ							30*	20	1.0W
1N4416	S	1N4752	1N4728	DZ							33*	20	1.0W
1N4417	S	1N4753	1N4728	DZ							36*	20	1.0W
1N4418	S	1N4754	1N4728	DZ							39*	20	1.0W
1N4419	S	1N4755	1N4728	DZ							43*	20	1.0W
1N4420	S	1N4756	1N4728	DZ							47*	20	1.0W
1N4421	S	1N4757	1N4728	DZ							51*	20	1.0W
1N4422	S	1N4758	1N4728	DZ							56*	20	1.0W
1N4423	S	1N4759	1N4728	DZ							62*	20	1.0W
1N4424	S	1N4760	1N4728	DZ							68*	20	1.0W
1N4425	S	1N4761	1N4728	DZ							75*	20	1.0W
1N4426	S	1N4762	1N4728	DZ							82*	20	1.0W
1N4427	S	1N4763	1N4728	DZ							91*	20	1.0W
1N4428	S	1N4764	1N4728	DZ							100*	20	1.0W
1N4429	S	1M110ZS10	1N4728	DZ							110*	20	1.0W
1N4430	S	1M120ZS10	1N4728	DZ							120*	20	1.0W
1N4431	S	1M130ZS10	1N4728	DZ							130*	20	1.0W
1N4432	S	1M150ZS10	1N4728	DZ							150*	20	1.0W
1N4433	S	1M160ZS10	1N4728	DZ							160*	20	1.0W
1N4434	S	1M180ZS10	1N4728	DZ							180*	20	1.0W
1N4435	S	1M200ZS10	1N4728	DZ							200*	20	1.0W
1N4436	S			R*	200	1.2	10	1.0	100				
1N4437	S			R*	400	1.2	10	1.0	100				
1N4438	S			R*	600	1.0	10	1.0	100				
1N4439	S			R*	800	1.2	10	1.0	100				
1N4440	S			R*	1000	1.2	10	1.0	100				
1N4441	S			R*	1500	4.0	0.025	0.001	3.0				
1N4442	S			DS	30	1.0	0.1A	1.0N	1.0				
1N4443	S			DS	50	1.0	0.1A	2.0N	0.6				
1N4444	S			DS	50	1.0	0.1A	50N	7.0				
1N4445	S			DS	100	1.0	0.1A	50N	4.0				
1N4446	S			DS	75	1.0	20M	25N	4.0				
1N4447	S			DS	75	1.0	20M	25N	4.0				
1N4448	S			DS	75	0.72	5.0M	25N	4.0				
1N4449	S			DS	75	0.73	5.0M	25N	4.0				
1N4450	S			DS	30	0.92	0.1A	50N	4.0				
1N4451	S			DS	30	0.875	0.1A	50N	10				
1N4452	S			DS	30	1.2	1.0A	50N	50				
1N4453	S			DS	20	0.92	0.1A	50N					
1N4454	S			DS	75	1.0	10M	0.1*	2.0				
1N4455	S			DS	50	0.7	5.0M	0.1*					
1N4456	S			DS	35	1.0	0.15A	0.2*	1.5				
1N4457	S			DS	50	1.0	0.2A	0.2*	1.5				
1N4458	S			R*	800	1.5	5.0	0.5	150				
1N4459	S			R*	1000	1.5	5.0	0.5	150				
1N4460	S	1N4735A	1N4728	DZ							6.2*	5.0	1.5W
1N4461	S	1N4736A	1N4728	DZ							6.8*	5.0	1.5W
1N4462	S	1N4737A	1N4728	DZ							7.5*	5.0	1.5W
1N4463	S	1N4738A	1N4728	DZ							8.2*	5.0	1.5W
1N4464	S	1N4739A	1N4728	DZ							9.1*	5.0	1.5W
1N4465	S	1N4740A	1N4728	DZ							10*	5.0	1.5W
1N4466	S	1N4741A	1N4728	DZ							11*	5.0	1.5W
1N4467	S	1N4742A	1N4728	DZ							12*	5.0	1.5W
1N4468	S	1N4743A	1N4728	DZ							13*	5.0	1.5W
1N4469	S	1N4744A	1N4728	DZ							15*	5.0	1.5W
1N4470	S	1N4745A	1N4728	DZ							16*	5.0	1.5W
1N4471	S	1N4746A	1N4728	DZ							18*	5.0	1.5W
1N4472	S	1N4747A	1N4728	DZ							20*	5.0	1.5W
1N4473	S	1N4748A	1N4728	DZ							22*	5.0	1.5W
1N4474	S	1N4749A	1N4728	DZ							24*	5.0	1.5W
1N4475	S	1N4750A	1N4728	DZ							27*	5.0	1.5W
1N4476	S	1N4751A	1N4728	DZ							30*	5.0	1.5W
1N4477	S	1N4752A	1N4728	DZ							33*	5.0	1.5W
1N4478	S	1N4753A	1N4728	DZ							36*	5.0	1.5W
1N4479	S	1N4754A	1N4728	DZ							39*	5.0	1.5W
1N4480	S	1N4755A	1N4728	DZ							43*	5.0	1.5W
1N4481	S	1N4756A	1N4728	DZ							47*	5.0	1.5W
1N4482	S	1N4757A	1N4728	DZ							51*	5.0	1.5W
1N4483	S	1N4758A	1N4728	DZ							56*	5.0	1.5W
1N4484	S	1N4759A	1N4728	DZ							62*	5.0	1.5W
1N4485	S	1N4760A	1N4728	DZ							68*	5.0	1.5W
1N4486	S	1N4761A	1N4728	DZ							75*	5.0	1.5W
1N4487	S	1N4762A	1N4728	DZ							82*	5.0	1.5W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4488	S	1N4763A	1N4728	DZ							91*	5.0	1.5W
1N4489	S	1N4764A	1N4728	DZ							100*	5.0	1.5W
1N4490	S	1M110ZS5	1N4728	DZ							110*	5.0	1.5W
1N4491	S	1M120ZS5	1N4728	DZ							120*	5.0	1.5W
1N4492	S	1M130ZS5	1N4728	DZ							130*	5.0	1.5W
1N4493	S	1M150ZS5	1N4728	DZ							150*	5.0	1.5W
1N4494	S	1M160ZS5	1N4728	DZ							160*	5.0	1.5W
1N4495	S	1M180ZS5	1N4728	DZ							180*	5.0	1.5W
1N4496	S	1M200ZS5	1N4728	DZ							200*	5.0	1.5W
1N4497	S			R*	1600	3.0	0.75	0.1	35				
1N4498	S			R*	3000	5.0	0.75	0.1	35				
1N4499	S	1N4735A	1N4728	DZ							6.2*	5.0	1.0W
1N4500	S			DS	80	1.0	0.3A	0.1*	4.0				
1N4501	S			DR						0.01	7.4	-55	100
1N4502	G			DS	20	0.3	3.0M	10*					
1N4503	S	1N4752	1N4728	DZ							33*	10	3.0W
1N4504	S	1N5388A	1N5333	DZ							200*	10	3.0W
1N4505	S			R*	6000	8.5	0.1	0.1	20				
1N4506	S			R*	200	1.4	12	2.5	240				
1N4507	S			R*	400	1.4	12	2.5	240				
1N4508	S			R*	600	1.4	12	2.5	240				
1N4509	S			R*	800	1.4	12	2.0	240				
1N4510	S			R*	1000	1.4	12	1.75	240				
1N4511	S			R*	1200	1.4	12	1.5	240				
1N4512	S			DS	10	0.777	5.0M	10N					
1N4513	S			R*	2000	4.5	0.25	0.1	20				
1N4514	S			R*	800	1.0	1.1	0.1	50				
1N4517	S			R*	200	1.2	2.0	0.1	100				
1N4523	G			DS	15	1.0	0.1A	30*	8.0				
1N4524	G			DS	10	0.65	10M	12*	3.0				
1N4525	S			R*	200	1.4	35	3.5	500				
1N4526	S			R*	400	1.4	35	3.5	500				
1N4527	S			R*	600	1.4	35	3.5	500				
1N4528	S			R*	800	1.4	35	3.0	500				
1N4529	S			R*	1000	1.4	35	2.5	500				
1N4530	S			R*	1200	1.4	35	2.0	500				
1N4531	S			DS	75	1.0	10M	25N	4.0				
1N4532	S			DS	75	1.0	10M	0.1*	2.0				
1N4533	S			DS	40	0.88	20M	50N	2.0				
1N4534	S			DS	50	0.88	20M	50N	2.0				
1N4535	S	.5M3.4ZZS5		DZ							3.45*	5.0	0.5W
1N4536	S			DS	25	1.0	30M	0.1*	2.0				
1N4537	S			R*	1500	1.85	3.0	0.3	15				
1N4538	S			R*	2000	1.85	3.0	0.3	15				
1N4539	S			R*	2500	1.85	3.0	0.3	15				
1N4540	S			R*	3000	1.85	3.0	0.3	15				
1N4541	S			DS	225	1.0	0.4A	20N					
1N4542	S			DS	400	1.0	0.4A	20N					
1N4543	S			DS	600	1.0	0.4A	20N					
1N4544	S			DS	800	1.0	0.4A	20N					
1N4545	S			DS	1000	1.0	400M	0.02*					
1N4546	S			R*	25K	30	1.0	0.1	50				
1N4547	S			DS	25	1.0	25M	10N					
1N4548	S			DS	25	1.0	30M	0.1*	4.0				
1N4549	S		1N2804	DZ							3.9*	20	50W
1N4549A	S		1N2804	DZ							3.9*	10	50W
1N4549B	S		1N2804	DZ							3.9*	5.0	50W
1N4550	S		1N2804	DZ							4.3*	20	50W
1N4550A	S		1N2804	DZ							4.3*	10	50W
1N4550B	S		1N2804	DZ							4.3*	5.0	50W
1N4551	S		1N2804	DZ							4.7*	20	50W
1N4551A	S		1N2804	DZ							4.7*	10	50W
1N4551B	S		1N2804	DZ							4.7*	5.0	50W
1N4552	S		1N2804	DZ							5.1*	20	50W
1N4552A	S		1N2804	DZ							5.1*	10	50W
1N4552B	S		1N2804	DZ							5.1*	5.0	50W
1N4553	S		1N2804	DZ							5.6*	20	50W
1N4553A	S		1N2804	DZ							5.6*	10	50W
1N4553B	S		1N2804	DZ							5.6*	5.0	50W
1N4554	S		1N2804	DZ							6.2*	20	50W
1N4554A	S		1N2804	DZ							6.2*	10	50W
1N4554B	S		1N2804	DZ							6.2*	5.0	50W
1N4555	S		1N2804	DZ							6.8*	20	50W
1N4555A	S		1N2804	DZ							6.8*	10	50W
1N4555B	S		1N2804	DZ							6.8*	5.0	50W
1N4556	S		1N2804	DZ							7.5*	20	50W
1N4556A	S		1N2804	DZ							7.5*	10	50W
1N4556B	S		1N2804	DZ							7.5*	5.0	50W
1N4557	S		1N2804	DZ							3.9*	20	50W
1N4557A	S		1N2804	DZ							3.9*	10	50W
1N4557B	S		1N2804	DZ							3.9*	5.0	50W
1N4558	S		1N2804	DZ							4.3*	20	50W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4558A	S		1N2804	DZ							4.3*	10	50W
1N4558B	S		1N2804	DZ							4.3*	5.0	50W
1N4559	S		1N2804	DZ							4.7*	20	50W
1N4559A	S		1N2804	DZ							4.7*	10	50W
1N4559B	S		1N2804	DZ							4.7*	5.0	50W
1N4560	S		1N2804	DZ							5.1*	20	50W
1N4560A	S		1N2804	DZ							5.1*	10	50W
1N4560B	S		1N2804	DZ							5.1*	5.0	50W
1N4561	S		1N2804	DZ							5.6*	20	50W
1N4561A	S		1N2804	DZ							5.6*	10	50W
1N4561B	S		1N2804	DZ							5.6*	5.0	50W
1N4562	S		1N2804	DZ							6.2*	20	50W
1N4562A	S		1N2804	DZ							6.2*	10	50W
1N4562B	S		1N2804	DZ							6.2*	5.0	50W
1N4563	S		1N2804	DZ							6.8*	20	50W
1N4563A	S		1N2804	DZ							6.8*	10	50W
1N4563B	S		1N2804	DZ							6.8*	5.0	50W
1N4564	S		1N2804	DZ							7.5*	20	50W
1N4564A	S		1N2804	DZ							7.5*	10	50W
1N4564B	S		1N2804	DZ							7.5*	5.0	50W
1N4565	S		1N4549	DR						0.01	6.4	0	75
1N4565A	S		1N4549	DR						0.01	6.4	-55	100
1N4566	S		1N4549	DR						0.005	6.4	0	75
1N4566A	S		1N4549	DR						0.005	6.4	-55	100
1N4567	S		1N4549	DR						0.002	6.4	0	75
1N4567A	S		1N4549	DR						0.002	6.4	-55	100
1N4568	S		1N4549	DR						0.001	6.4	0	75
1N4568A	S		1N4549	DR						0.001	6.4	-55	100
1N4569	S		1N4549	DR						0.0005	6.4	0	75
1N4569A	S		1N4549	DR						0.0005	6.4	-55	100
1N4570	S		1N4549	DR						0.01	6.4	0	75
1N4570A	S		1N4549	DR						0.01	6.4	-55	100
1N4571	S		1N4549	DR						0.005	6.4	0	75
1N4571A	S		1N4549	DR						0.005	6.4	-55	100
1N4572	S		1N4549	DR						0.002	6.4	0	75
1N4572A	S		1N4549	DR						0.002	6.4	-55	100
1N4573	S		1N4549	DR						0.001	6.4	0	75
1N4573A	S		1N4549	DR						0.001	6.4	-55	100
1N4574	S		1N4549	DR						0.0005	6.4	0	75
1N4574A	S		1N4549	DR						0.0005	6.4	-55	100
1N4575	S			DR						0.01	6.4	0	75
1N4575A	S			DR						0.01	6.4	-55	100
1N4576	S			DR						0.005	6.4	0	75
1N4576A	S			DR						0.005	6.4	-55	100
1N4577	S			DR						0.002	6.4	0	75
1N4577A	S			DR						0.002	6.4	-55	100
1N4578	S			DR						0.001	6.4	0	75
1N4578A	S			DR						0.001	6.4	-55	100
1N4579	S			DR						0.0005	6.4	0	75
1N4579A	S			DR						0.0005	6.4	-55	100
1N4580	S			DR						0.01	6.4	0	75
1N4580A	S			DR						0.01	6.4	-55	100
1N4581	S			DR						0.005	6.4	0	75
1N4581A	S			DR						0.005	6.4	-55	100
1N4582	S			DR						0.002	6.4	0	75
1N4582A	S			DR						0.002	6.4	-55	100
1N4583	S			DR						0.0001	6.4	0	75
1N4583A	S			DR						0.0001	6.4	-55	100
1N4584	S			DR						0.0005	6.4	0	75
1N4584A	S			DR						0.0005	6.4	-55	100
1N4585	S			R*	800	1.3	1.0	0.2	50				
1N4586	S			R*	1000	1.3	1.0	0.2	50				
1N4587	S	MR1221SB	MR1220	R*	100	1.35	150	9.5	3000				
1N4588	S	MR1223SB	MR1220	R*	200	1.35	150	9.5	3000				
1N4589	S	MR1225SB	MR1220	R*	300	1.35	150	9.0	3000				
1N4590	S	MR1227SB	MR1220	R*	400	1.35	150	9.0	3000				
1N4591	S	MR1228SB	MR1220	R*	500	1.35	150	8.0	3000				
1N4592	S	MR1229SB	MR1220	R*	600	1.35	150	6.5	3000				
1N4593	S			R*	800	1.35	150	5.5	3000				
1N4594	S			R*	1000	1.35	150	4.5	3000				
1N4595	S			R*	1200	1.35	150	4.0	3000				
1N4596	S			R*	1400	1.35	150	3.5	3000				
1N4597	S			R*	5000	5.0	0.025		1.0				
1N4598 } 1N4599 }		Varactor Diodes, see Table on Page 1-94											
1N4600	S	Microwave Mixer: f = 13,300 MHz, NF = 9.5 dB											
1N4601	S	Microwave Mixer: f = 13,300 MHz, NF = 8.8 dB											
1N4602	S	Microwave Mixer: f = 13,300 MHz, NF = 8.0 dB											
1N4603	S	Microwave Mixer: f = 16,000 MHz, NF = 9.5 dB											
1N4604	S	Microwave Mixer: f = 16,000 MHz, NF = 8.8 dB											
1N4605	S	Microwave Mixer: f = 16,000 MHz, NF = 8.0 dB											

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4606	S			DS	70	1.0	0.2A	0.25*	6.0				
1N4607	S			DS	70	0.95	250M	0.25*	10				
1N4608	S			DS	70	0.96	350M	0.25*	10				
1N4609	S	Varactor Diode, see Table on Page 1-94											
1N4610	S			DS	55	1.1	0.3A	0.1*	2.0				
1N4611	S	1N4576A *	1N4549	DR						0.005	6.6	-50	100
1N4611A	S	1N4577A *	1N4549	DR						0.002	6.6	-50	100
1N4611B	S	1N4578A *	1N4549	DR						0.001	6.6	-50	100
1N4611C	S	1N4579A *	1N4549	DR						0.0005	6.6	-50	100
1N4612	S	1N4581A *	1N4549	DR						0.005	6.6	-50	100
1N4612A	S	1N4582A *	1N4549	DR						0.002	6.6	-50	100
1N4612B	S	1N4583A *	1N4549	DR						0.001	6.6	-50	100
1N4612C	S	1N4584A *	1N4549	DR						0.0005	6.6	-50	100
1N4613	S	1N4581A *	1N4549	DR						0.005	6.6	-50	100
1N4613A	S	1N4582A *	1N4549	DR						0.002	6.6	-50	100
1N4613B	S	1N4583A *	1N4549	DR						0.001	6.6	-50	100
1N4613C	S	1N4584A *	1N4549	DR						0.0005	6.6	-50	100
1N4614	S	MZ4614	1N4099	DZ							1.8*		0.25W
1N4615	S	MZ4615	1N4099	DZ							2.0*		0.25W
1N4616	S	MZ4616	1N4099	DZ							2.2*		0.25W
1N4617	S	MZ4617	1N4099	DZ							2.4*		0.25W
1N4618	S	MZ4618	1N4099	DZ							2.7*		0.25W
1N4619	S	MZ4619	1N4099	DZ							3.0*		0.25W
1N4620	S	MZ4620	1N4099	DZ							3.3*		0.25W
1N4621	S	MZ4621	1N4099	DZ							3.6*		0.25W
1N4622	S	MZ4622	1N4099	DZ							3.9*		0.25W
1N4623	S	MZ4623	1N4099	DZ							4.3*		0.25W
1N4624	S	MZ4624	1N4099	DZ							4.7*		0.25W
1N4625	S	MZ4625	1N4099	DZ							5.1*		0.25W
1N4626	S	MZ4626	1N4099	DZ							5.6*		0.25W
1N4627	S	MZ4627	1N4099	DZ							6.2*		0.25W
1N4628	S	1N4736A	1N4728	DZ							6.8*		0.6W
1N4629	S	1N4737A	1N4728	DZ							7.5*		0.6W
1N4630	S	1N4738A	1N4728	DZ							8.2*		0.6W
1N4631	S	1N4739A	1N4728	DZ							9.1*		0.6W
1N4632	S	1N4740A	1N4728	DZ							10*		0.6W
1N4633	S	1N4741A	1N4728	DZ							11*		0.6W
1N4634	S	1N4742A	1N4728	DZ							12*		0.6W
1N4635	S	1N4743A	1N4728	DZ							13*		0.6W
1N4636	S	1N4744A	1N4728	DZ							15*		0.6W
1N4637	S	1N4745A	1N4728	DZ							16*		0.6W
1N4638	S	1N4746A	1N4728	DZ							18*		0.6W
1N4639	S	1N4747A	1N4728	DZ							20*		0.6W
1N4640	S	1N4748A	1N4728	DZ							22*		0.6W
1N4641	S	1N4749A	1N4728	DZ							24*		0.6W
1N4642	S	1N4750A	1N4728	DZ							27*		0.6W
1N4643	S	1N4751A	1N4728	DZ							30*		0.6W
1N4644	S	1N4752A	1N4728	DZ							33*		0.6W
1N4645	S	1N4753A	1N4728	DZ							36*		0.6W
1N4646	S	1N4754A	1N4728	DZ							39*		0.6W
1N4647	S	1N4755A	1N4728	DZ							43*		0.6W
1N4648	S	1N4756A	1N4728	DZ							47*		0.6W
1N4649	S	1N4728A	1N4728	DZ							3.3*		1.0W
1N4650	S	1N4729A	1N4728	DZ							3.6*		1.0W
1N4651	S	1N4730A	1N4728	DZ							3.9*		1.0W
1N4652	S	1N4731A	1N4728	DZ							4.3*		1.0W
1N4653	S	1N4732A	1N4728	DZ							4.7*		1.0W
1N4654	S	1N4733A	1N4728	DZ							5.1*		1.0W
1N4655	S	1N4734A	1N4728	DZ							5.6*		1.0W
1N4656	S	1N4735A	1N4728	DZ							6.2*		1.0W
1N4657	S	1N4736A	1N4728	DZ							6.8*		1.0W
1N4658	S	1N4737A	1N4728	DZ							7.5*		1.0W
1N4659	S	1N4738A	1N4728	DZ							8.2*		1.0W
1N4660	S	1N4739A	1N4728	DZ							9.1*		1.0W
1N4661	S	1N4740A	1N4728	DZ							10*		1.0W
1N4662	S	1N4741A	1N4728	DZ							11*		1.0W
1N4663	S	1N4742A	1N4728	DZ							12*		1.0W
1N4664	S	1N4743A	1N4728	DZ							13*		1.0W
1N4665	S	1N4744A	1N4728	DZ							15*		1.0W
1N4666	S	1N4745A	1N4728	DZ							16*		1.0W
1N4667	S	1N4746A	1N4728	DZ							18*		1.0W
1N4668	S	1N4747A	1N4728	DZ							20*		1.0W
1N4669	S	1N4748A	1N4728	DZ							22*		1.0W
1N4670	S	1N4749A	1N4728	DZ							24*		1.0W
1N4671	S	1N4750A	1N4728	DZ							27*		1.0W
1N4672	S	1N4751A	1N4728	DZ							30*		1.0W
1N4673	S	1N4752A	1N4728	DZ							33*		1.0W
1N4674	S	1N4753A	1N4728	DZ							36*		1.0W
1N4675	S	1N4754A	1N4728	DZ							39*		1.0W
1N4676	S	1N4755A	1N4728	DZ							43*		1.0W
1N4677	S	1N4756A	1N4728	DZ							47*		1.0W

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts) (Amps)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4678	S	MZ4678		DZ						1.710	1.890		250
1N4679	S	MZ4679		DZ						1.900	2.100		250
1N4680	S	MZ4680		DZ						2.090	2.310		250
1N4681	S	MZ4681		DZ						2.280	2.520		250
1N4682	S	MZ4682		DZ						2.565	2.835		250
1N4683	S	MZ4683		DZ						2.850	3.150		250
1N4684	S	MZ4684		DZ						3.135	3.465		250
1N4685	S	MZ4685		DZ						3.420	3.780		250
1N4686	S	MZ4686		DZ						3.705	4.095		250
1N4687	S	MZ4687		DZ						4.085	4.515		250
1N4688	S	MZ4688		DZ						4.465	4.935		250
1N4689	S	MZ4689		DZ						4.845	5.355		250
1N4690	S	MZ4690		DZ						5.320	5.880		250
1N4691	S	MZ4691		DZ						5.890	6.510		250
1N4692	S	MZ4692		DZ						6.460	7.140		250
1N4693	S	MZ4693		DZ						7.125	7.875		250
1N4694	S	MZ4694		DZ						7.790	8.610		250
1N4695	S	MZ4695		DZ						8.265	9.135		250
1N4696	S	MZ4696		DZ						8.645	9.555		250
1N4697	S	MZ4697		DZ						9.500	10.50		250
1N4698	S	MZ4698		DZ						10.45	11.55		250
1N4699	S	MZ4699		DZ						11.40	12.60		250
1N4700	S	MZ4700		DZ						12.35	13.65		250
1N4701	S	MZ4701		DZ						13.30	14.70		250
1N4702	S	MZ4702		DZ						14.25	15.75		250
1N4703	S	MZ4703		DZ						15.20	16.80		250
1N4704	S	MZ4704		DZ						16.15	17.85		250
1N4705	S	MZ4705		DZ						17.10	18.90		250
1N4706	S	MZ4706		DZ						18.05	19.95		250
1N4707	S	MZ4707		DZ						19.00	21.00		250
1N4708	S	MZ4708		DZ						20.90	23.10		250
1N4709	S	MZ4709		DZ						22.80	25.20		250
1N4710	S	MZ4710		DZ						23.75	26.25		250
1N4711	S	MZ4711		DZ						25.65	28.35		250
1N4712	S	MZ4712		DZ						26.60	29.40		250
1N4713	S	MZ4713		DZ						28.50	31.50		250
1N4714	S	MZ4714		DZ						31.35	34.65		250
1N4715	S	MZ4715		DZ						34.20	37.80		250
1N4716	S	MZ4716		DZ						37.05	40.95		250
1N4717	S	MZ4717		DZ						40.85	45.15		250
1N4718	S			DS	50	1.2	0.75A	50*	180				
1N4719	S			R*	50	1.0	3.0	1.5	300				
1N4720	S			R*	100	1.0	3.0	1.5	300				
1N4721	S			R*	200	1.0	3.0	1.5	300				
1N4722	S			R*	400	1.0	3.0	1.5	300				
1N4723	S			R*	600	1.0	3.0	1.5	300				
1N4724	S			R*	800	1.0	3.0	1.5	300				
1N4725	S			R*	1000	1.0	3.0	1.5	300				
1N4726	S			DS	20	0.85	10M	0.1*					
1N4727	S			DS	20	0.85	10M	0.1*					
1N4728	S		1N4728	DZ							3.3*	10	1.0W
1N4728A	S		1N4728	DZ							3.3*	5.0	1.0W
1N4729	S		1N4728	DZ							3.6*	10	1.0W
1N4729A	S		1N4728	DZ							3.6*	5.0	1.0W
1N4730	S		1N4728	DZ							3.9*	10	1.0W
1N4730A	S		1N4728	DZ							3.9*	5.0	1.0W
1N4731	S		1N4728	DZ							4.3*	10	1.0W
1N4731A	S		1N4728	DZ							4.3*	5.0	1.0W
1N4732	S		1N4728	DZ							4.7*	10	1.0W
1N4732A	S		1N4728	DZ							4.7*	5.0	1.0W
1N4733	S		1N4728	DZ							5.1*	10	1.0W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4733A	S		1N4728	DZ							5.1*	5.0	1.0W
1N4734	S		1N4728	DZ							5.6*	10	1.0W
1N4734A	S		1N4728	DZ							5.6*	5.0	1.0W
1N4735	S		1N4728	DZ							6.2*	10	1.0W
1N4735A	S		1N4728	DZ							6.2*	5.0	1.0W
1N4736	S		1N4728	DZ							6.8*	10	1.0W
1N4736A	S		1N4728	DZ							6.8*	5.0	1.0W
1N4737	S		1N4728	DZ							7.5*	10	1.0W
1N4737A	S		1N4728	DZ							7.5*	5.0	1.0W
1N4738	S		1N4728	DZ							8.2*	10	1.0W
1N4738A	S		1N4728	DZ							8.2*	5.0	1.0W
1N4739	S		1N4728	DZ							9.1*	10	1.0W
1N4739A	S		1N4728	DZ							9.1*	5.0	1.0W
1N4740	S		1N4728	DZ							10*	10	1.0W
1N4740A	S		1N4728	DZ							10*	5.0	1.0W
1N4741	S		1N4728	DZ							11*	10	1.0W
1N4741A	S		1N4728	DZ							11*	5.0	1.0W
1N4742	S		1N4728	DZ							12*	10	1.0W
1N4742A	S		1N4728	DZ							12*	5.0	1.0W
1N4743	S		1N4728	DZ							13*	10	1.0W
1N4743A	S		1N4728	DZ							13*	5.0	1.0W
1N4744	S		1N4728	DZ							15*	10	1.0W
1N4744A	S		1N4728	DZ							15*	5.0	1.0W
1N4745	S		1N4728	DZ							16*	10	1.0W
1N4745A	S		1N4728	DZ							16*	5.0	1.0W
1N4746	S		1N4728	DZ							18*	10	1.0W
1N4746A	S		1N4728	DZ							18*	5.0	1.0W
1N4747	S		1N4728	DZ							20*	10	1.0W
1N4747A	S		1N4728	DZ							20*	5.0	1.0W
1N4748	S		1N4728	DZ							22*	10	1.0W
1N4748A	S		1N4728	DZ							22*	5.0	1.0W
1N4749	S		1N4728	DZ							24*	10	1.0W
1N4749A	S		1N4728	DZ							24*	5.0	1.0W
1N4750	S		1N4728	DZ							27*	10	1.0W
1N4750A	S		1N4728	DZ							27*	5.0	1.0W
1N4751	S		1N4728	DZ							30*	10	1.0W
1N4751A	S		1N4728	DZ							30*	5.0	1.0W
1N4752	S		1N4728	DZ							33*	10	1.0W
1N4752A	S		1N4728	DZ							33*	5.0	1.0W
1N4753	S		1N4728	DZ							36*	10	1.0W
1N4753A	S		1N4728	DZ							36*	5.0	1.0W
1N4754	S		1N4728	DZ							39*	10	1.0W
1N4754A	S		1N4728	DZ							39*	5.0	1.0W
1N4755	S		1N4728	DZ							43*	10	1.0W
1N4755A	S		1N4728	DZ							43*	5.0	1.0W
1N4756	S		1N4728	DZ							47*	10	1.0W
1N4756A	S		1N4728	DZ							47*	5.0	1.0W
1N4757	S		1N4728	DZ							51*	10	1.0W
1N4757A	S		1N4728	DZ							51*	5.0	1.0W
1N4758	S		1N4728	DZ							56*	10	1.0W
1N4758A	S		1N4728	DZ							56*	5.0	1.0W
1N4759	S		1N4728	DZ							62*	10	1.0W
1N4759A	S		1N4728	DZ							62*	5.0	1.0W
1N4760	S		1N4728	DZ							68*	10	1.0W
1N4760A	S		1N4728	DZ							68*	5.0	1.0W
1N4761	S		1N4728	DZ							75*	10	1.0W
1N4761A	S		1N4728	DZ							75*	5.0	1.0W
1N4762	S		1N4728	DZ							82*	10	1.0W
1N4762A	S		1N4728	DZ							82*	5.0	1.0W
1N4763	S		1N4728	DZ							91*	10	1.0W
1N4763A	S		1N4728	DZ							91*	5.0	1.0W
1N4764	S		1N4728	DZ							100*	10	1.0W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4764A	S		1N4728	DZ							100*	5.0	1.0W
1N4765	S		1N4549	DR						0.01	9.1	0	75
1N4765A	S		1N4549	DR						0.01	9.1	-55	100
1N4766	S		1N4549	DR						0.005	9.1	0	75
1N4766A	S		1N4549	DR						0.005	9.1	-55	100
1N4767	S		1N4549	DR						0.002	9.1	0	75
1N4767A	S		1N4549	DR						0.002	9.1	-55	100
1N4768	S		1N4549	DR						0.001	9.1	0	75
1N4768A	S		1N4549	DR						0.001	9.1	-55	100
1N4769	S		1N4549	DR						0.0005	9.1	0	75
1N4769A	S		1N4549	DR						0.0005	9.1	-55	100
1N4770	S		1N4549	DR						0.01	9.1	0	75
1N4770A	S		1N4549	DR						0.01	9.1	-55	100
1N4771	S		1N4549	DR						0.005	9.1	0	75
1N4771A	S		1N4549	DR						0.005	9.1	-55	100
1N4772	S		1N4549	DR						0.002	9.1	0	75
1N4772A	S		1N4549	DR						0.002	9.1	-55	100
1N4773	S		1N4549	DR						0.001	9.1	0	75
1N4773A	S		1N4549	DR						0.001	9.1	-55	100
1N4774	S		1N4549	DR						0.0005	9.1	0	75
1N4774A	S		1N4549	DR						0.0005	9.1	-55	100
1N4775	S		1N4549	DR						0.01	8.5	0	75
1N4775A	S		1N4549	DR						0.01	8.5	-55	100
1N4776	S		1N4549	DR						0.005	8.5	0	75
1N4776A	S		1N4549	DR						0.005	8.5	-55	100
1N4777	S		1N4549	DR						0.002	8.5	0	75
1N4777A	S		1N4549	DR						0.002	8.5	-55	100
1N4778	S		1N4549	DR						0.001	8.5	0	75
1N4778A	S		1N4549	DR						0.001	8.5	-55	100
1N4779	S		1N4549	DR						0.0005	8.5	0	75
1N4779A	S		1N4549	DR						0.0005	8.5	-55	100
1N4780	S		1N4549	DR						0.01	8.5	0	75
1N4780A	S		1N4549	DR						0.01	8.5	-55	100
1N4781	S		1N4549	DR						0.005	8.5	0	75
1N4781A	S		1N4549	DR						0.005	8.5	-55	100
1N4782	S		1N4549	DR						0.002	8.5	0	75
1N4782A	S		1N4549	DR						0.002	8.5	-55	100
1N4783	S		1N4549	DR						0.001	8.5	0	75
1N4783A	S		1N4549	DR						0.001	8.5	-55	100
1N4784	S		1N4549	DR						0.0005	8.5	0	75
1N4784A	S		1N4549	DR						0.0005	8.5	-55	100
1N4786 thru 1N4815		Varactor Diodes, see Table on Page 1-94											
1N4816	S	1N4001	1N4001	R*	50	1.3	1.5	0.25	50				
1N4817	S	1N4002	1N4001	R*	100	1.3	1.5	0.25	50				
1N4818	S	1N4003	1N4001	R*	200	1.3	1.5	0.25	50				
1N4819	S	1N4004	1N4001	R*	300	1.3	1.5	0.25	50				
1N4820	S	1N4004	1N4001	R*	400	1.3	1.5	0.25	50				
1N4821	S	1N4005	1N4001	R*	500	1.3	1.5	0.25	50				
1N4822	S	1N4005	1N4001	R*	600	1.3	1.5	0.25	50				
1N4823	S			R*	100	1.25	1.0	1.0	35				
1N4824	S			R*	200	1.25	1.0	1.0	35				
1N4825	S			R*	400	1.25	1.0	1.0	35				
1N4826	S			R*	600	1.25	1.0	1.0	35				
1N4827	G			DS	30	1.0	40M	15*	0.2				
1N4828	S			DS	20	1.1	0.1A	0.1*					
1N4829	S			DS	20	1.87	0.1A	0.1*					
1N4830	S			DS	20	2.69	0.1A	0.1*					
1N4831	S	1N4739	1N4728	DZ							9.1*	20	1.2W
1N4831A	S	1N4739	1N4728	DZ							9.1*	10	1.2W
1N4831B	S	1N4739A	1N4728	DZ							9.1*	5.0	1.2W
1N4832	S	1N4740	1N4728	DZ							10*	20	1.2W
1N4832A	S	1N4740	1N4728	DZ							10*	10	1.2W
1N4832B	S	1N4740A	1N4728	DZ							10*	5.0	1.2W
1N4833	S	1N4741	1N4728	DZ							11*	20	1.2W
1N4833A	S	1N4741	1N4728	DZ							11*	10	1.2W
1N4833B	S	1N4741A	1N4728	DZ							11*	5.0	1.2W
1N4834	S	1N4742	1N4728	DZ							12*	20	1.2W
1N4834A	S	1N4742	1N4728	DZ							12*	10	1.2W
1N4834B	S	1N4742A	1N4728	DZ							12*	5.0	1.2W
1N4835	S	1N4743	1N4728	DZ							13*	20	1.2W
1N4835A	S	1N4743	1N4728	DZ							13*	10	1.2W
1N4835B	S	1N4743A	1N4728	DZ							13*	5.0	1.2W
1N4836	S	1N4744	1N4728	DZ							15*	20	1.2W
1N4836A	S	1N4744	1N4728	DZ							15*	10	1.2W
1N4836B	S	1N4744A	1N4728	DZ							15*	5.0	1.2W
1N4837	S	1N4745	1N4728	DZ							16*	20	1.2W
1N4837A	S	1N4745	1N4728	DZ							16*	10	1.2W
1N4837B	S	1N4745A	1N4728	DZ							16*	5.0	1.2W
1N4838	S	1N4746	1N4728	DZ							18*	20	1.2W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4838A	S	1N4746	1N4728	DZ							18*	10	1.2W
1N4838B	S	1N4746A	1N4728	DZ							18*	5.0	1.2W
1N4839	S	1N4747	1N4728	DZ							20*	20	1.2W
1N4839A	S	1N4747	1N4728	DZ							20*	10	1.2W
1N4839B	S	1N4747A	1N4728	DZ							20*	5.0	1.2W
1N4840	S	1N4748	1N4728	DZ							22*	20	1.2W
1N4840A	S	1N4748	1N4728	DZ							22*	10	1.2W
1N4840B	S	1N4748A	1N4728	DZ							22*	5.0	1.2W
1N4841	S	1N4749	1N4728	DZ							24*	20	1.2W
1N4841A	S	1N4749	1N4728	DZ							24*	10	1.2W
1N4841B	S	1N4749A	1N4728	DZ							24*	5.0	1.2W
1N4842	S	1N4750	1N4728	DZ							27*	20	1.2W
1N4842A	S	1N4750	1N4728	DZ							27*	10	1.2W
1N4842B	S	1N4750A	1N4728	DZ							27*	5.0	1.2W
1N4843	S	1N4751	1N4728	DZ							30*	20	1.2W
1N4843A	S	1N4751	1N4728	DZ							30*	10	1.2W
1N4843B	S	1N4751A	1N4728	DZ							30*	5.0	1.2W
1N4844	S	1N4752	1N4728	DZ							33*	20	1.2W
1N4844A	S	1N4752	1N4728	DZ							33*	10	1.2W
1N4844B	S	1N4752A	1N4728	DZ							33*	5.0	1.2W
1N4845	S	1N4753	1N4728	DZ							36*	20	1.2W
1N4845A	S	1N4753	1N4728	DZ							36*	10	1.2W
1N4845B	S	1N4753A	1N4728	DZ							36*	5.0	1.2W
1N4846	S	1N4754	1N4728	DZ							39*	20	1.2W
1N4846A	S	1N4754	1N4728	DZ							39*	10	1.2W
1N4846B	S	1N4754A	1N4728	DZ							39*	5.0	1.2W
1N4847	S	1N4755	1N4728	DZ							43*	20	1.2W
1N4847A	S	1N4755	1N4728	DZ							43*	10	1.2W
1N4847B	S	1N4755A	1N4728	DZ							43*	5.0	1.2W
1N4848	S	1N4756	1N4728	DZ							47*	20	1.2W
1N4848A	S	1N4756	1N4728	DZ							47*	10	1.2W
1N4848B	S	1N4756A	1N4728	DZ							47*	5.0	1.2W
1N4849	S	1N4757	1N4728	DZ							51*	20	1.2W
1N4849A	S	1N4757	1N4728	DZ							51*	10	1.2W
1N4849B	S	1N4757A	1N4728	DZ							51*	5.0	1.2W
1N4850	S	1N4758	1N4728	DZ							56*	20	1.2W
1N4850A	S	1N4758	1N4728	DZ							56*	10	1.2W
1N4850B	S	1N4758A	1N4728	DZ							56*	5.0	1.2W
1N4851	S	1N4759	1N4728	DZ							62*	20	1.2W
1N4851A	S	1N4759	1N4728	DZ							62*	10	1.2W
1N4851B	S	1N4759A	1N4728	DZ							62*	5.0	1.2W
1N4852	S	1N4760	1N4728	DZ							68*	20	1.2W
1N4852A	S	1N4760	1N4728	DZ							68*	10	1.2W
1N4852B	S	1N4760A	1N4728	DZ							68*	5.0	1.2W
1N4853	S	1N4761	1N4728	DZ							75*	20	1.2W
1N4853A	S	1N4761	1N4728	DZ							75*	10	1.2W
1N4853B	S	1N4761A	1N4728	DZ							75*	5.0	1.2W
1N4854	S	1N4762	1N4728	DZ							82*	20	1.2W
1N4854A	S	1N4762	1N4728	DZ							82*	10	1.2W
1N4854B	S	1N4762A	1N4728	DZ							82*	5.0	1.2W
1N4855	S	1N4763	1N4728	DZ							91*	20	1.2W
1N4855A	S	1N4763	1N4728	DZ							91*	10	1.2W
1N4855B	S	1N5763A	1N4728	DZ							91*	5.0	1.2W
1N4856	S	1N5764	1N4728	DZ							100*	20	1.2W
1N4856A	S	1N5764	1N4728	DZ							100*	10	1.2W
1N4856B	S	1N5764A	1N4728	DZ							100*	5.0	1.2W
1N4857	S	1M110ZS10	1N4728	DZ							110*	20	1.2W
1N4857A	S	1M110ZS10	1N4728	DZ							110*	10	1.2W
1N4857B	S	1M110ZS5	1N4728	DZ							110*	5.0	1.2W
1N4858	S	1M120ZS10	1N4728	DZ							120*	20	1.2W
1N4858A	S	1M120ZS10	1N4728	DZ							120*	10	1.2W
1N4858B	S	1M120ZS5	1N4728	DZ							120*	5.0	1.2W
1N4859	S	1M130ZS10	1N4728	DZ							130*	20	1.2W
1N4859A	S	1M130ZS10	1N4728	DZ							130*	10	1.2W
1N4859B	S	1M130ZS5	1N4728	DZ							130*	5.0	1.2W
1N4860	S	1M150ZS10	1N4728	DZ							150*	20	1.2W
1N4860A	S	1M150ZS10	1N4728	DZ							150*	10	1.2W
1N4860B	S	1M150ZS5	1N4728	DZ							150*	5.0	1.2W
1N4861	S			DS	50	1.2	0.1A	2.0N	1.0				
1N4862	S			DS	50	1.1	0.1A	5.0N	1.0				
1N4863	S			DS	50	1.2	0.1A	50N	7.0				
1N4864	S			DS	80	1.1	0.1A	0.1*	9.0				
1N4865	S			R*	1500	2.4	1.25	0.6	150				
1N4866	S			R*	2500	3.6	1.25	0.6	150				
1N4867	S			R*	3000	4.8	1.25	0.6	150				
1N4868	S			R*	5000	8.4	1.25	0.6	150				
1N4869	S			R*	7500	12	1.25	0.6	150				
1N4870	S			R*	10K	16	1.25	0.6	150				
1N4871	S			R*	12K	18	1.25	0.6	150				
1N4872	S			R*	15K	23	1.25	0.6	150				
1N4873	S			R*	20K	30	1.25	0.6	150				
1N4874	S			R*	25K	38	1.25	0.6	150				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4875	S			R*	30K	46	1.25	0.6	150				
1N4876	S			R*	40K	60	1.25	0.6	150				
1N4877	S			R*	50K	76	1.25	0.6	150				
1N4878	S			R*	100	1.3	100	5.0	1500				
1N4879	S	MR1221SB	MR1220	R*	100	1.3	160	10	2200				
1N4880	S			R*	100	1.2	250	10	4000				
1N4881	S	1N4747	1N4728	DZ							20*	10	3.0W
1N4882	S	1N4753	1N4728	DZ							36*	10	3.0W
1N4883	S	1N4742A	1N4728	DZ							12*	5.0	3.0W
1N4884	S	1N4747A	1N4728	DZ							20*	5.0	3.0W
1N4885 } 1N4886 }		Varactor Diodes, see Table on Page 1-94											
1N4887	S			R*	75K	115	1.25	0.6	150				
1N4888	S			DS	12	1.0	20M	50N					
1N4889	S	1N3000B	1N2970	DZ							62*	5.0	5.0W
1N4890	S	MZ640*	MZ600	DR						0.001	6.35	25	100
1N4890A	S	MZ640*	MZ600	DR						0.001	6.35	-55	100
1N4891	S	MZ640*	MZ600	DR						0.0005	6.35	25	100
1N4891A	S	MZ640*	MZ600	DR						0.0005	6.35	-55	100
1N4892	S	MZ620*	MZ600	DR						0.001	6.35	25	100
1N4892A	S	MZ620*	MZ600	DR						0.001	6.35	-55	100
1N4893	S	MZ620*	MZ600	DR						0.0005	6.35	25	100
1N4893A	S	MZ620*	MZ600	DR						0.0005	6.35	-55	100
1N4894	S	MZ610*	MZ600	DR						0.001	6.35	25	100
1N4894A	S	MZ610*	MZ600	DR						0.001	6.35	-55	100
1N4895	S	MZ610*	MZ600	DR						0.0005	6.35	25	100
1N4895A	S	MZ610*	MZ600	DR						0.0005	6.35	-55	100
1N4896	S		1N4765	DR						0.01	12.8	25	100
1N4896A	S		1N4765	DR						0.01	12.8	-55	100
1N4897	S		1N4765	DR						0.005	12.8	25	100
1N4897A	S		1N4765	DR						0.005	12.8	-55	100
1N4898	S		1N4765	DR						0.002	12.8	25	100
1N4898A	S		1N4765	DR						0.002	12.8	-55	100
1N4899	S		1N4765	DR						0.001	12.8	25	100
1N4899A	S		1N4765	DR						0.001	12.8	-55	100
1N4900	S		1N4765	DR						0.01	12.8	25	100
1N4900A	S		1N4765	DR						0.01	12.8	-55	100
1N4901	S		1N4765	DR						0.005	12.8	25	100
1N4901A	S		1N4765	DR						0.005	12.8	-55	100
1N4902	S		1N4765	DR						0.002	12.8	25	100
1N4902A	S		1N4765	DR						0.002	12.8	-55	100
1N4903	S		1N4765	DR						0.001	12.8	25	100
1N4903A	S		1N4765	DR						0.001	12.8	-55	100
1N4904	S		1N4765	DR						0.01	12.8	25	100
1N4904A	S		1N4765	DR						0.01	12.8	-55	100
1N4905	S		1N4765	DR						0.005	12.8	25	100
1N4905A	S		1N4765	DR						0.005	12.8	-55	100
1N4906	S		1N4765	DR						0.002	12.8	25	100
1N4906A	S		1N4765	DR						0.002	12.8	-55	100
1N4907	S		1N4765	DR						0.001	12.8	25	100
1N4907A	S		1N4765	DR						0.001	12.8	-55	100
1N4908	S		1N4765	DR						0.01	12.8	25	100
1N4908A	S		1N4765	DR						0.01	12.8	-55	100
1N4909	S		1N4765	DR						0.005	12.8	25	100
1N4909A	S		1N4765	DR						0.005	12.8	-55	100
1N4910	S		1N4765	DR						0.002	12.8	25	100
1N4910A	S		1N4765	DR						0.002	12.8	-55	100
1N4911	S		1N4765	DR						0.001	12.8	25	100
1N4911A	S		1N4765	DR						0.001	12.8	-55	100
1N4912	S		1N4765	DR						0.01	12.8	25	100
1N4912A	S		1N4765	DR						0.01	12.8	-55	100
1N4913	S		1N4765	DR						0.005	12.8	25	100
1N4913A	S		1N4765	DR						0.005	12.8	-55	100
1N4914	S		1N4765	DR						0.002	12.8	25	100
1N4914A	S		1N4765	DR						0.002	12.8	-55	100
1N4915	S		1N4765	DR						0.001	12.8	25	100
1N4915A	S		1N4765	DR						0.001	12.8	-55	100
1N4916	S		1N4765	DR						0.01	19.2	25	100
1N4916A	S		1N4765	DR						0.01	19.2	-55	100
1N4917	S		1N4765	DR						0.005	19.2	25	100
1N4917A	S		1N4765	DR						0.005	19.2	-55	100
1N4918	S		1N4765	DR						0.002	19.2	25	100
1N4918A	S		1N4765	DR						0.002	19.2	-55	100
1N4919	S		1N4765	DR						0.01	19.2	25	100
1N4919A	S		1N4765	DR						0.01	19.2	-55	100
1N4920	S		1N4765	DR						0.005	19.2	25	100
1N4920A	S		1N4765	DR						0.005	19.2	-55	100
1N4921	S		1N4765	DR						0.002	19.2	25	100
1N4921A	S		1N4765	DR						0.002	19.2	-55	100
1N4922	S		1N4765	DR						0.01	19.2	25	100
1N4922A	S		1N4765	DR						0.01	19.2	-55	100

Replacement * denotes exact device type replacement available on request.

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4923	S		1N4765	DR						0.005	19.2	25	100
1N4923A	S		1N4765	DR						0.005	19.2	-55	100
1N4924	S		1N4765	DR						0.002	19.2	25	100
1N4924A	S		1N4765	DR						0.002	19.2	-55	100
1N4925	S		1N4765	DR						0.01	19.2	25	100
1N4925A	S		1N4765	DR						0.01	19.2	-55	100
1N4926	S		1N4765	DR						0.005	19.2	25	100
1N4926A	S		1N4765	DR						0.005	19.2	-55	100
1N4927	S		1N4765	DR						0.002	19.2	25	100
1N4927A	S		1N4765	DR						0.002	19.2	-55	100
1N4928	S		1N4765	DR						0.001	19.2	25	100
1N4928A	S		1N4765	DR						0.001	19.2	-55	100
1N4929	S		1N4765	DR						0.01	19.2	25	100
1N4929A	S		1N4765	DR						0.01	19.2	-55	100
1N4930	S		1N4765	DR						0.005	19.2	25	100
1N4930A	S		1N4765	DR						0.005	19.2	-55	100
1N4931	S		1N4765	DR						0.002	19.2	25	100
1N4931A	S		1N4765	DR						0.002	19.2	-55	100
1N4932	S		1N4765	DR						0.001	19.2	25	100
1N4932A	S		1N4765	DR						0.001	19.2	-55	100
1N4933	S		1N4933	R*	50	1.2	1.0	0.3	30				
1N4934	S		1N4933	R*	100	1.2	1.0	0.3	30				
1N4935	S		1N4933	R*	200	1.2	1.0	0.3	30				
1N4936	S		1N4933	R*	400	1.2	1.0	0.3	30				
1N4937	S		1N4933	R*	600	1.2	1.0	0.3	30				
1N4938	S			DS	200	1.0	0.1A	0.1*	50				
1N4939	G	Microwave Ka-band Mixer, NF = 10.5 dB											
1N4940	G	Microwave Ka-band Mixer, f = 9,375 MHz, NF = 6.5 dB											
1N4941		Varactor Diode, see Table on Page 1-94											
1N4942	S			DS	200	2.5	2.0	0.5M	0.15				
1N4943	S			DS	300	2.5	2.0	0.5M	0.15				
1N4944	S			DS	400	2.5	2.0	0.5M	0.15				
1N4945	S			DS	500	2.5	2.0	0.5M	0.15				
1N4946	S			DS	600	2.5	2.0	0.5M	0.15				
1N4947	S			DS	800	2.5	2.0	0.5M	0.25				
1N4948	S			DS	1000	2.5	2.0	0.5M	0.5				
1N4950	S			DS	25	0.53	1.0M	0.1M					
1N4951	S			DS	20	0.85	1.0M	0.1*					
1N4952	S			DS	50	0.85	1.0M	0.1*					
1N4954	S	1N5342B	1N5333	DZ							6.8*	5.0	3.0W
1N4955	S	1N5343B	1N5333	DZ							7.5*	5.0	3.0W
1N4956	S	1N5344B	1N5333	DZ							8.2*	5.0	3.0W
1N4957	S	1N5346B	1N5333	DZ							9.1*	5.0	3.0W
1N4958	S	1N5347B	1N5333	DZ							10*	5.0	3.0W
1N4959	S	1N5348B	1N5333	DZ							11*	5.0	3.0W
1N4960	S	1N5349B	1N5333	DZ							12*	5.0	3.0W
1N4961	S	1N5350B	1N5333	DZ							13*	5.0	3.0W
1N4962	S	1N5352B	1N5333	DZ							15*	5.0	3.0W
1N4963	S	1N5353B	1N5333	DZ							16*	5.0	3.0W
1N4964	S	1N5355B	1N5333	DZ							18*	5.0	3.0W
1N4965	S	1N5357B	1N5333	DZ							20*	5.0	3.0W
1N4966	S	1N5358B	1N5333	DZ							22*	5.0	3.0W
1N4967	S	1N5359B	1N5333	DZ							24*	5.0	3.0W
1N4968	S	1N5361B	1N5333	DZ							27*	5.0	3.0W
1N4969	S	1N5363B	1N5333	DZ							30*	5.0	3.0W
1N4970	S	1N5364B	1N5333	DZ							33*	5.0	3.0W
1N4971	S	1N5365B	1N5333	DZ							36*	5.0	3.0W
1N4972	S	1N5366B	1N5333	DZ							39*	5.0	3.0W
1N4973	S	1N5367B	1N5333	DZ							43*	5.0	3.0W
1N4974	S	1N5368B	1N5333	DZ							47*	5.0	3.0W
1N4975	S	1N5369B	1N5333	DZ							51*	5.0	3.0W
1N4976	S	1N5370B	1N5333	DZ							56*	5.0	3.0W
1N4977	S	1N5372B	1N5333	DZ							62*	5.0	3.0W
1N4978	S	1N5373B	1N5333	DZ							68*	5.0	3.0W
1N4979	S	1N5374B	1N5333	DZ							75*	5.0	3.0W
1N4980	S	1N5375B	1N5333	DZ							82*	5.0	3.0W
1N4981	S	1N5377B	1N5333	DZ							91*	5.0	3.0W
1N4982	S	1N5378B	1N5333	DZ							100*	5.0	3.0W
1N4983	S	1N5379B	1N5333	DZ							110*	5.0	3.0W
1N4984	S	1N5380B	1N5333	DZ							120*	5.0	3.0W
1N4985	S	1N5381B	1N5333	DZ							130*	5.0	3.0W
1N4986	S	1N5383B	1N5333	DZ							150*	5.0	3.0W
1N4987	S	1N5384B	1N5333	DZ							160*	5.0	3.0W
1N4988	S	1N5386B	1N5333	DZ							180*	5.0	3.0W
1N4989	S	1N5388B	1N5333	DZ							200*	5.0	3.0W
1N4990	S	5M110ZSB5		DZ							220*	5.0	3.0W
1N4991	S	5M180ZSB5		DZ							240*	5.0	3.0W
1N4992	S	5M135ZSB5		DZ							270*	5.0	3.0W
1N4993	S	5M150ZSB5		DZ							300*	5.0	3.0W
1N4994	S	5M165ZSB5		DZ							330*	5.0	3.0W
1N4995	S	5M180ZSB5		DZ							360*	5.0	3.0W
1N4996	S	5M195ZSB5		DZ							390*	5.0	3.0W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N4997	S		1N4719	R*	50	1.0	3.0	2.0	300				
1N4998	S		1N4719	R*	100	1.0	3.0	2.0	300				
1N4999	S		1N4719	R*	200	1.0	3.0	2.0	300				
1N5000	S		1N4719	R*	400	1.0	3.0	2.0	300				
1N5001	S		1N4719	R*	600	1.0	3.0	1.0	300				
1N5002	S		1N4719	R*	800	1.0	3.0	1.0	300				
1N5003	S		1N4719	R*	1000	1.0	3.0	1.0	300				
1N5004	S			R*	100	1.3	1.0	1.0	35				
1N5005	S			R*	200	1.3	1.0	1.0	35				
1N5006	S			R*	400	1.3	1.0	1.0	35				
1N5007	S			R*	600	1.3	1.0	1.0	35				
1N5008	S	1N4728	1N4728	DZ							3.3*	10	2.5W
1N5008A	S	1N4728A	1N4728	DZ							3.3*	5.0	2.5W
1N5009	S	1N4729	1N4728	DZ							3.6*	10	2.5W
1N5009A	S	1N4729A	1N4728	DZ							3.6*	5.0	2.5W
1N5010	S	1N4730	1N4728	DZ							3.9*	10	2.5W
1N5010A	S	1N4730A	1N4728	DZ							3.9*	5.0	2.5W
1N5011	S	1N4731	1N4728	DZ							4.3*	10	2.5W
1N5011A	S	1N4731A	1N4728	DZ							4.3*	5.0	2.5W
1N5012	S	1N4732	1N4728	DZ							4.7*	10	2.5W
1N5012A	S	1N4732A	1N4728	DZ							4.7*	5.0	2.5W
1N5013	S	1N4733	1N4728	DZ							5.1*	10	2.5W
1N5013A	S	1N4733A	1N4728	DZ							5.1*	5.0	2.5W
1N5014	S	1N4734	1N4728	DZ							5.6*	10	2.5W
1N5014A	S	1N4734A	1N4728	DZ							5.6*	5.0	2.5W
1N5015	S	1N4735	1N4728	DZ							6.2*	10	2.5W
1N5015A	S	1N4735A	1N4728	DZ							6.2*	5.0	2.5W
1N5016	S	1N4736	1N4728	DZ							6.8*	10	2.5W
1N5016A	S	1N4736A	1N4728	DZ							6.8*	5.0	2.5W
1N5017	S	1N4737	1N4728	DZ							7.5*	10	2.5W
1N5017A	S	1N4737A	1N4728	DZ							7.5*	5.0	2.5W
1N5018	S	1N4738	1N4728	DZ							8.2*	10	2.5W
1N5018A	S	1N4738A	1N4728	DZ							8.2*	5.0	2.5W
1N5019	S	1N4739	1N4728	DZ							9.1*	10	2.5W
1N5019A	S	1N4739A	1N4728	DZ							9.1*	5.0	2.5W
1N5020	S	1N4740	1N4728	DZ							10*	10	2.5W
1N5020A	S	1N4740A	1N4728	DZ							10*	5.0	2.5W
1N5021	S	1N4741	1N4728	DZ							11*	10	2.5W
1N5021A	S	1N4741A	1N4728	DZ							11*	5.0	2.5W
1N5022	S	1N4742	1N4728	DZ							12*	10	2.5W
1N5022A	S	1N4742A	1N4728	DZ							12*	5.0	2.5W
1N5023	S	1N4743	1N4728	DZ							13*	10	2.5W
1N5023A	S	1N4743A	1N4728	DZ							13*	5.0	2.5W
1N5024	S	1M14ZS10		DZ							14*	10	2.5W
1N5024A	S	1M14ZS5		DZ							14*	5.0	2.5W
1N5025	S	1N4744	1N4728	DZ							15*	10	2.5W
1N5025A	S	1N4744A	1N4728	DZ							15*	5.0	2.5W
1N5026	S	1N4745	1N4728	DZ							16*	10	2.5W
1N5026A	S	1N4745A	1N4728	DZ							16*	5.0	2.5W
1N5027	S	1M17ZS10		DZ							17*	10	2.5W
1N5027A	S	1M17ZS5		DZ							17*	5.0	2.5W
1N5028	S	1N4746	1N4728	DZ							18*	10	2.5W
1N5028A	S	1N4746A	1N4728	DZ							18*	5.0	2.5W
1N5029	S	1M19ZS10		DZ							19*	10	2.5W
1N5029A	S	1M19ZS5		DZ							19*	5.0	2.5W
1N5030	S	1N4747	1N4728	DZ							20*	10	2.5W
1N5030A	S	1N4747A	1N4728	DZ							20*	5.0	2.5W
1N5031	S	1N4748	1N4728	DZ							22*	10	2.5W
1N5031A	S	1N4748A	1N4728	DZ							22*	5.0	2.5W
1N5032	S	1N4749	1N4728	DZ							24*	10	2.5W
1N5032A	S	1N4749A	1N4728	DZ							24*	5.0	2.5W
1N5033	S	1M25ZS10		DZ							25*	10	2.5W
1N5033A	S	1M25ZS5		DZ							25*	5.0	2.5W
1N5034	S	1N4750	1N4728	DZ							27*	10	2.5W
1N5034A	S	1N4750A	1N4728	DZ							27*	5.0	2.5W
1N5035	S	1N4751	1N4728	DZ							30*	10	2.5W
1N5035A	S	1N4751A	1N4728	DZ							30*	5.0	2.5W
1N5036	S	1N4752	1N4728	DZ							33*	10	2.5W
1N5036A	S	1N4752A	1N4728	DZ							33*	5.0	2.5W
1N5037	S	1N4753	1N4728	DZ							36*	10	2.5W
1N5037A	S	1N4753A	1N4728	DZ							36*	5.0	2.5W
1N5038	S	1N4754	1N4728	DZ							39*	10	2.5W
1N5038A	S	1N4754A	1N4728	DZ							39*	5.0	2.5W
1N5039	S	1N4755	1N4728	DZ							43*	10	2.5W
1N5039A	S	1N4755A	1N4728	DZ							43*	5.0	2.5W
1N5040	S	1M45ZS10		DZ							45*	10	2.5W
1N5040A	S	1M45ZS5		DZ							45*	5.0	2.5W
1N5041	S	1N4756	1N4728	DZ							47*	10	2.5W
1N5041A	S	1N4756A	1N4728	DZ							47*	5.0	2.5W
1N5042	S	1M50ZS10		DZ							50*	10	2.5W
1N5042A	S	1M50ZS5		DZ							50*	5.0	2.5W
1N5043	S	1N4757	1N4728	DZ							51*	10	2.5W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (Amps)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5043A	S	1N4757A	1N4728	DZ							51*	5.0	2.5W
1N5044	S	1M52ZS10	1N4728	DZ							52*	10	2.5W
1N5044A	S	1M52ZS5	1N4728	DZ							52*	5.0	2.5W
1N5045	S	1N4758	1N4728	DZ							56*	10	2.5W
1N5045A	S	1N4758A	1N4728	DZ							56*	5.0	2.5W
1N5046	S	1N4759	1N4728	DZ							62*	10	2.5W
1N5046A	S	1N4759A	1N4728	DZ							62*	5.0	2.5W
1N5047	S	1N4760	1N4728	DZ							68*	10	2.5W
1N5047A	S	1N4760A	1N4728	DZ							68*	5.0	2.5W
1N5048	S	1N4761	1N4728	DZ							75*	10	2.5W
1N5048A	S	1N4761A	1N4728	DZ							75*	5.0	2.5W
1N5049	S	1N4762	1N4728	DZ							82*	10	2.5W
1N5049A	S	1N4762A	1N4728	DZ							82*	5.0	2.5W
1N5050	S	1N4763	1N4728	DZ							91*	10	2.5W
1N5050A	S	1N4763A	1N4728	DZ							91*	5.0	2.5W
1N5051	S	1N4764	1N4728	DZ							100*	10	2.5W
1N5051A	S	1N4764A	1N4728	DZ							100*	5.0	2.5W
1N5052	S	1N4006	1N4001	R*	700	1.3	1.5	0.5	50				
1N5053	S	1N4006	1N4001	R*	800	1.3	1.5	0.5	50				
1N5054	S	1N4007	1N4001	R*	1000	1.3	1.5	0.5	50				
1N5055	S			R*	100	1.4	1.0	0.25	30				
1N5056	S			R*	200	1.4	1.0	0.25	30				
1N5057	S			R*	300	1.4	0.8	0.25	30				
1N5058	S			R*	400	1.4	0.8	0.25	30				
1N5059	S	1N4003	1N4001	R*	200	1.0	1.5	0.3	100				
1N5060	S	1N4004	1N4001	R*	400	1.0	1.5	0.3	100				
1N5061	S	1N4005	1N4001	R*	600	1.0	1.5	0.2	100				
1N5062	S	1N4006	1N4001	R*	800	1.0	1.25	0.2	100				
1N5063	S	1N4736A	1N4728	DZ							6.8*	5.0	1.0W
1N5064	S	1N4737A	1N4728	DZ							7.5*	5.0	1.0W
1N5065	S	1N4738A	1N4728	DZ							8.2*	5.0	1.0W
1N5066	S	1N4739A	1N4728	DZ							9.1*	5.0	1.0W
1N5067	S	1N4740A	1N4728	DZ							10*	5.0	1.0W
1N5068	S	1N4741A	1N4728	DZ							11*	5.0	1.0W
1N5069	S	1N4743A	1N4728	DZ							13*	5.0	1.0W
1N5070	S	1M14ZS5		DZ							14*	5.0	1.0W
1N5071	S	1N4744A	1N4728	DZ							15*	5.0	1.0W
1N5072	S	1N4745A	1N4728	DZ							16*	5.0	1.0W
1N5073	S	1N4746A	1N4728	DZ							18*	5.0	1.0W
1N5074	S	1N4748A	1N4728	DZ							22*	5.0	1.0W
1N5075	S	1N4749A	1N4728	DZ							24*	5.0	1.0W
1N5076	S	1N4750A	1N4728	DZ							27*	5.0	1.0W
1N5077	S	1N4751A	1N4728	DZ							30*	5.0	1.0W
1N5078	S	1N4752A	1N4728	DZ							33*	5.0	1.0W
1N5079	S	1N4753A	1N4728	DZ							36*	5.0	1.0W
1N5080	S	1N4754A	1N4728	DZ							39*	5.0	1.0W
1N5081	S	1M40ZS5		DZ							40*	5.0	1.0W
1N5082	S	1N4755A	1N4728	DZ							43*	5.0	1.0W
1N5083	S	1M45ZS5		DZ							45*	5.0	1.0W
1N5084	S	1N4756A	1N4728	DZ							47*	5.0	1.0W
1N5085	S	1M50ZS5		DZ							50*	5.0	1.0W
1N5086	S	1N4757A	1N4728	DZ							51*	5.0	1.0W
1N5087	S	1N4758A	1N4728	DZ							56*	5.0	1.0W
1N5088	S	1M60ZS5		DZ							60*	5.0	1.0W
1N5089	S	1N4759A	1N4728	DZ							62*	5.0	1.0W
1N5090	S	1N4760A		DZ							68*	5.0	1.0W
1N5091	S	1M70ZS5		DZ							70*	5.0	1.0W
1N5092	S	1N4761A	1N4728	DZ							75*	5.0	1.0W
1N5093	S	1M80ZS5		DZ							80*	5.0	1.0W
1N5094	S	1N4762A	1N4728	DZ							82*	5.0	1.0W
1N5095	S	1N4763A	1N4728	DZ							91*	5.0	1.0W
1N5096	S	1M110ZS5	1N4728	DZ							110*	5.0	1.0W
1N5097	S	1M120ZS5	1N4728	DZ							120*	5.0	1.0W
1N5098	S	1M130ZS5	1N4728	DZ							130*	5.0	1.0W
1N5099	S	1M140ZS5	1N4728	DZ							140*	5.0	1.0W
1N5100	S	1M160ZS5	1N4728	DZ							160*	5.0	1.0W
1N5101	S	1M170ZS5	1N4728	DZ							170*	5.0	1.0W
1N5102	S	1M180ZS5	1N4728	DZ							180*	5.0	1.0W
1N5103	S	1M190ZS5	1N4728	DZ							190*	5.0	1.0W
1N5104	S	1M200ZS5	1N4728	DZ							200*	5.0	1.0W
1N5105	S	1M110ZSB5	1N4728	DZ							220*	5.0	1.0W
1N5106	S	1M120ZSB5	1N4728	DZ							240*	5.0	1.0W
1N5107	S	1M130ZSB5	1N4728	DZ							260*	5.0	1.0W
1N5108	S	1M135ZSB5	1N4728	DZ							270*	5.0	1.0W
1N5109	S	1M140ZSB5	1N4728	DZ							280*	5.0	1.0W
1N5110	S	1M150ZSB5	1N4728	DZ							300*	5.0	1.0W
1N5111	S	1M160ZSB5	1N4728	DZ							320*	5.0	1.0W
1N5112	S	1M165ZSB5	1N4728	DZ							330*	5.0	1.0W
1N5113	S	1M170ZSB5	1N4728	DZ							340*	5.0	1.0W
1N5114	S	1M180ZSB5	1N4728	DZ							360*	5.0	1.0W
1N5115	S	1M190ZSB5	1N4728	DZ							380*	5.0	1.0W
1N5116	S	1M195ZSB5	1N4728	DZ							390*	5.0	1.0W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5117	S	1M200ZSB5		DZ							400*	5.0	1.0W
1N5118	S	1N5341B	1N5333	DZ							14*	5.0	3.0W
1N5119	S	5M40ZS5		DZ							40*	5.0	3.0W
1N5120	S	5M45ZS5		DZ							45*	5.0	3.0W
1N5121	S	5M50ZS5		DZ							50*	5.0	3.0W
1N5122	S	1N5371B	1N5333	DZ							60*	5.0	3.0W
1N5123	S	5M70ZS5		DZ							70*	5.0	3.0W
1N5124	S	5M80ZS5		DZ							80*	5.0	3.0W
1N5125	S	5M90ZS5		DZ							90*	5.0	3.0W
1N5126	S	1N5382B	1N5333	DZ							140*	5.0	3.0W
1N5127	S	1N5385B	1N5333	DZ							170*	5.0	3.0W
1N5128	S	1N5387B	1N5333	DZ							190*	5.0	3.0W
1N5129	S	5M130ZSB5		DZ							260*	5.0	3.0W
1N5130	S	5M140ZSB5		DZ							280*	5.0	3.0W
1N5131	S	5M160ZSB5		DZ							320*	5.0	3.0W
1N5132	S	5M170ZSB5		DZ							340*	5.0	3.0W
1N5133	S	5M190ZSB5		DZ							380*	5.0	3.0W
1N5134	S	5M200ZSB5		DZ							400*	5.0	3.0W
1N5136 thru 1N5148		Varactor Diodes, see Table on Page 1-94											
1N5136A thru 1N5148A		Varactor Diodes, see Table on Page 1-94											
1N5150A 1N5152A 1N5153A		Varactor Diodes, see Table on Page 1-94											
1N5155A 1N5156 thru 1N5157		Varactor Diodes, see Table on Page 1-94											
1N5158 thru 1N5160		4-Layer Diodes, see Table on Page 1-106											
1N5163	S	Harmonic Generator											
1N5164		Harmonic Generator											
1N5165,A thru 1N5167,A		Hot Carrier Diodes											
1N5168		Hot Carrier Diode											
1N5169		Hot Carrier Diode											
1N5170	S			R*	15	1.2	2.0	0.025	200				
1N5171	S			R*	50	1.2	2.0	0.025	200				
1N5172	S			R*	100	1.2	2.0	0.025	200				
1N5173	S			R*	300	1.2	2.0	0.025	200				
1N5174	S			R*	400	1.2	2.0	0.025	200				
1N5175	S			R*	500	1.2	2.0	0.025	200				
1N5176	S			R*	600	1.2	2.0	0.025	200				
1N5177	S			R*	800	1.2	2.0	0.025	200				
1N5178	S			R*	1000	1.2	2.0	0.025	200				
1N5179	S			DS		2.8	1.0	50	200				
1N5180	S			R*	100	1.25	4.0	100	100				
1N5181	S			R*	4000		0.6	0.02					
1N5182	S			R*	5000		0.6	0.02					
1N5183	S			R*	7500		0.6	0.02					
1N5184	S			R*	10000		0.6	0.02					
1N5185	S			R*	50	1.1	3.0	0.100	80				
1N5186	S			R*	100	1.1	3.0	0.100	80				
1N5187	S			R*	200	1.1	3.0	0.100	80				
1N5188	S			R*	400	1.1	3.0	0.100	80				

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (Amps)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5189	S			R*	500	1.1	3.0	0.100	80				
1N5190	S			R*	600	1.1	3.0	0.100	80				
1N5197	S			R*	50		2.0	0.1					
1N5198	S			R*	100		2.0	0.1					
1N5199	S			R*	200		2.0	0.1					
1N5200	S			R*	400		2.0	0.1					
1N5201	S			R*	600		2.0	0.1					
1N5206	S			R*	400	1.1	2.0	0.003	25				
1N5207	S			R*	400	1.25	4.0	0.005	100				
1N5211	S			R*	200	1.2	1.0	0.2	50				
1N5212	S			R*	400	1.2	1.0	0.2	50				
1N5213	S			R*	600	1.2	1.0	0.2	50				
1N5214	S			R*	800	1.2	0.75	0.2	50				
1N5215	S			R*	200	1.2	1.0	0.2	50				
1N5216	S			R*	400	1.2	1.0	0.2	50				
1N5217	S			R*	600	1.2	1.0	0.2	50				
1N5218	S			R*	800	1.2	0.75	0.2	50				
1N5219	S			DS	30	1.0	50	50	0.002				
1N5220	S			DS	30	1.2	50	50					
1N5221	S		1N5221	DZ							2.4*	10	500M
1N5221A	S		1N5221	DZ							2.4*	10	500M
1N5221B	S		1N5221	DZ							2.4*	5.0	500M
1N5222	S		1N5221	DZ							2.5*	10	500M
1N5222A	S		1N5221	DZ							2.5*	10	500M
1N5222B	S		1N5221	DZ							2.5*	5.0	500M
1N5223	S		1N5221	DZ							2.7*	10	500M
1N5223A	S		1N5221	DZ							2.7*	10	500M
1N5223B	S		1N5221	DZ							2.7*	5.0	500M
1N5224	S		1N5221	DZ							2.8*	10	500M
1N5224A	S		1N5221	DZ							2.8*	10	500M
1N5224B	S		1N5221	DZ							2.8*	5.0	500M
1N5225	S		1N5221	DZ							3.0*	10	500M
1N5225A	S		1N5221	DZ							3.0*	10	500M
1N5225B	S		1N5221	DZ							3.0*	5.0	500M
1N5226	S		1N5221	DZ							3.3*	10	500M
1N5226A	S		1N5221	DZ							3.3*	10	500M
1N5226B	S		1N5221	DZ							3.3*	5.0	500M
1N5227	S		1N5221	DZ							3.6*	10	500M
1N5227A	S		1N5221	DZ							3.6*	10	500M
1N5227B	S		1N5221	DZ							3.6*	5.0	500M
1N5228	S		1N5221	DZ							3.9*	10	500M
1N5228A	S		1N5221	DZ							3.9*	10	500M
1N5228B	S		1N5221	DZ							3.9*	5.0	500M
1N5229	S		1N5221	DZ							4.3*	10	500M
1N5229A	S		1N5221	DZ							4.3*	10	500M
1N5229B	S		1N5221	DZ							4.3*	5.0	500M
1N5230	S		1N5221	DZ							4.7*	10	500M
1N5230A	S		1N5221	DZ							4.7*	10	500M
1N5230B	S		1N5221	DZ							4.7*	5.0	500M
1N5231	S		1N5221	DZ							5.1*	10	500M
1N5231A	S		1N5221	DZ							5.1*	10	500M
1N5231B	S		1N5221	DZ							5.1*	5.0	500M
1N5232	S		1N5221	DZ							5.6*	10	500M
1N5232A	S		1N5221	DZ							5.6*	10	500M
1N5232B	S		1N5221	DZ							5.6*	5.0	500M
1N5233	S		1N5221	DZ							6.0*	10	500M
1N5233A	S		1N5221	DZ							6.0*	10	500M
1N5233B	S		1N5221	DZ							6.0*	5.0	500M
1N5234	S		1N5221	DZ							6.2*	10	500M
1N5234A	S		1N5221	DZ							6.2*	10	500M

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5234B	S		1N5221	DZ							6.2*	5.0	500M
1N5235	S		1N5221	DZ							6.8*	10	500M
1N5235A	S		1N5221	DZ							6.8*	10	500M
1N5235B	S		1N5221	DZ							6.8*	5.0	500M
1N5236	S		1N5221	DZ							7.5*	10	500M
1N5236A	S		1N5221	DZ							7.5*	10	500M
1N5236B	S		1N5221	DZ							7.5*	5.0	500M
1N5237	S		1N5221	DZ							8.2*	10	500M
1N5237A	S		1N5221	DZ							8.2*	10	500M
1N5237B	S		1N5221	DZ							8.2*	5.0	500M
1N5238	S		1N5221	DZ							8.7*	10	500M
1N5238A	S		1N5221	DZ							8.7*	10	500M
1N5238B	S		1N5221	DZ							8.7*	5.0	500M
1N5239	S		1N5221	DZ							9.1*	10	500M
1N5239A	S		1N5221	DZ							9.1*	10	500M
1N5239B	S		1N5221	DZ							9.1*	5.0	500M
1N5240	S		1N5221	DZ							10*	10	500M
1N5240A	S		1N5221	DZ							10*	10	500M
1N5240B	S		1N5221	DZ							10*	5.0	500M
1N5241	S		1N5221	DZ							11*	10	500M
1N5241A	S		1N5221	DZ							11*	10	500M
1N5241B	S		1N5221	DZ							11*	5.0	500M
1N5242	S		1N5221	DZ							12*	10	500M
1N5242A	S		1N5221	DZ							12*	10	500M
1N5242B	S		1N5221	DZ							12*	5.0	500M
1N5243	S		1N5221	DZ							13*	10	500M
1N5243A	S		1N5221	DZ							13*	10	500M
1N5243B	S		1N5221	DZ							13*	5.0	500M
1N5244	S		1N5221	DZ							14*	10	500M
1N5244A	S		1N5221	DZ							14*	10	500M
1N5244B	S		1N5221	DZ							14*	5.0	500M
1N5245	S		1N5221	DZ							15*	10	500M
1N5245A	S		1N5221	DZ							15*	10	500M
1N5245B	S		1N5221	DZ							15*	5.0	500M
1N5246	S		1N5221	DZ							16*	10	500M
1N5246A	S		1N5221	DZ							16*	10	500M
1N5246B	S		1N5221	DZ							16*	5.0	500M
1N5247	S		1N5221	DZ							17*	10	500M
1N5247A	S		1N5221	DZ							17*	10	500M
1N5247B	S		1N5221	DZ							17*	5.0	500M
1N5248	S		1N5221	DZ							18*	10	500M
1N5248A	S		1N5221	DZ							18*	10	500M
1N5248B	S		1N5221	DZ							18*	5.0	500M
1N5249	S		1N5221	DZ							19*	10	500M
1N5249A	S		1N5221	DZ							19*	10	500M
1N5249B	S		1N5221	DZ							19*	5.0	500M
1N5250	S		1N5221	DZ							20*	10	500M
1N5250A	S		1N5221	DZ							20*	10	500M
1N5250B	S		1N5221	DZ							20*	5.0	500M
1N5251	S		1N5221	DZ							22*	10	500M
1N5251A	S		1N5221	DZ							22*	10	500M
1N5251B	S		1N5221	DZ							22*	5.0	500M
1N5252	S		1N5221	DZ							24*	10	500M
1N5252A	S		1N5221	DZ							24*	10	500M
1N5252B	S		1N5221	DZ							24*	5.0	500M
1N5253	S		1N5221	DZ							25*	10	500M
1N5253A	S		1N5221	DZ							25*	10	500M
1N5253B	S		1N5221	DZ							25*	5.0	500M
1N5254	S		1N5221	DZ							27*	10	500M
1N5254A	S		1N5221	DZ							27*	10	500M
1N5254B	S		1N5221	DZ							27*	5.0	500M
1N5255	S		1N5221	DZ							28*	10	500M
1N5255A	S		1N5221	DZ							28*	10	500M
1N5255B	S		1N5221	DZ							28*	5.0	500M
1N5256	S		1N5221	DZ							30*	10	500M
1N5256A	S		1N5221	DZ							30*	10	500M
1N5256B	S		1N5221	DZ							30*	5.0	500M
1N5257	S		1N5221	DZ							33*	10	500M
1N5257A	S		1N5221	DZ							33*	10	500M
1N5257B	S		1N5221	DZ							33*	5.0	500M
1N5258	S		1N5221	DZ							36*	10	500M
1N5258A	S		1N5221	DZ							36*	10	500M
1N5258B	S		1N5221	DZ							36*	5.0	500M
1N5259	S		1N5221	DZ							39*	10	500M
1N5259A	S		1N5221	DZ							39*	10	500M
1N5259B	S		1N5221	DZ							39*	5.0	500M
1N5260	S		1N5221	DZ							43*	10	500M
1N5260A	S		1N5221	DZ							43*	10	500M
1N5260B	S		1N5221	DZ							43*	5.0	500M
1N5261	S		1N5221	DZ							47*	10	500M
1N5261A	S		1N5221	DZ							47*	10	500M
1N5261B	S		1N5221	DZ							47*	5.0	500M

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5262	S		1N5221	DZ							51*	10	500M
1N5262A	S		1N5221	DZ							51*	10	500M
1N5262B	S		1N5221	DZ							51*	5.0	500M
1N5263	S		1N5221	DZ							56*	10	500M
1N5263A	S		1N5221	DZ							56*	10	500M
1N5263B	S		1N5221	DZ							56*	5.0	500M
1N5264	S		1N5221	DZ							60*	10	500M
1N5264A	S		1N5221	DZ							60*	10	500M
1N5264B	S		1N5221	DZ							60*	5.0	500M
1N5265	S		1N5221	DZ							62*	10	500M
1N5265A	S		1N5221	DZ							62*	10	500M
1N5265B	S		1N5221	DZ							62*	5.0	500M
1N5266	S		1N5221	DZ							68*	10	500M
1N5266A	S		1N5221	DZ							68*	10	500M
1N5266B	S		1N5221	DZ							68*	5.0	500M
1N5267	S		1N5221	DZ							75*	10	500M
1N5267A	S		1N5221	DZ							75*	10	500M
1N5267B	S		1N5221	DZ							75*	5.0	500M
1N5268	S		1N5221	DZ							82*	10	500M
1N5268A	S		1N5221	DZ							82*	10	500M
1N5268B	S		1N5221	DZ							82*	5.0	500M
1N5269	S		1N5221	DZ							87*	10	500M
1N5269A	S		1N5221	DZ							87*	10	500M
1N5269B	S		1N5221	DZ							87*	5.0	500M
1N5270	S		1N5221	DZ							91*	10	500M
1N5270A	S		1N5221	DZ							91*	10	500M
1N5270B	S		1N5221	DZ							91*	5.0	500M
1N5271	S		1N5221	DZ							100*	10	500M
1N5271A	S		1N5221	DZ							100*	10	500M
1N5271B	S		1N5221	DZ							100*	5.0	500M
1N5272	S		1N5221	DZ							110*	10	500M
1N5272A	S		1N5221	DZ							110*	10	500M
1N5272B	S		1N5221	DZ							110*	5.0	500M
1N5273	S		1N5221	DZ							120*	10	500M
1N5273A	S		1N5221	DZ							120*	10	500M
1N5273B	S		1N5221	DZ							120*	5.0	500M
1N5274	S		1N5221	DZ							130*	10	500M
1N5274A	S		1N5221	DZ							130*	10	500M
1N5274B	S		1N5221	DZ							130*	5.0	500M
1N5275	S		1N5221	DZ							140*	10	500M
1N5275A	S		1N5221	DZ							140*	10	500M
1N5275B	S		1N5221	DZ							140*	5.0	500M
1N5276	S		1N5221	DZ							150*	10	500M
1N5276A	S		1N5221	DZ							150*	10	500M
1N5276B	S		1N5221	DZ							150*	5.0	500M
1N5277	S		1N5221	DZ							160*	10	500M
1N5277A	S		1N5221	DZ							160*	10	500M
1N5277B	S		1N5221	DZ							160*	5.0	500M
1N5278	S		1N5221	DZ							170*	10	500M
1N5278A	S		1N5221	DZ							170*	10	500M
1N5278B	S		1N5221	DZ							170*	5.0	500M
1N5279	S		1N5221	DZ							180*	10	500M
1N5279A	S		1N5221	DZ							180*	10	500M
1N5279B	S		1N5221	DZ							180*	5.0	500M
1N5280	S		1N5221	DZ							190*	10	500M
1N5280A	S		1N5221	DZ							190*	10	500M
1N5280B	S		1N5221	DZ							190*	5.0	500M
1N5281	S		1N5221	DZ							200*	10	500M
1N5281A	S		1N5221	DZ							200*	10	500M
1N5281B	S		1N5221	DZ							200*	5.0	500M
1N5282	S			DS	55	1.3	500M	0.1*	0.004				
1N5283 thru 1N5314		Current Regulator Diodes, See Data Sheet											
1N5315	S			DS	75	0.49	0.1M	0.05*	0.004				
1N5316	S			DS	75	0.49	0.1M	0.05*	0.004				
1N5317	S			DS	55	1.17	500M	0.1*	0.004				
1N5318	S			DS	50	0.87	200M	0.1*	0.004				
1N5319	S			DS	25	1.0	100M	100*	0.004				
1N5320	S			R*	100		1.0		20				
1N5324	S			R*	15000	24	0.010	0.025	0.75				
1N5326	S			R*	100		12		200				

1N5329-1N5355A

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D (W)
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (mA)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5329	S			R*	100		0.135	0.150	10				
1N5330	S			R*	100		0.540	0.150	15				
1N5331	S			R*	1200		12		240				
1N5332	S			R*	1200		35		500				
1N5333	S		1N5333	DZ							3.3	20	5.0
1N5333A	S		1N5333	DZ							3.3	10	5.0
1N5333B	S		1N5333	DZ							3.3	5	5.0
1N5334	S		1N5333	DZ							3.6	20	5.0
1N5334A	S		1N5333	DZ							3.6	10	5.0
1N5334B	S		1N5333	DZ							3.6	5	5.0
1N5335	S		1N5333	DZ							3.9	20	5.0
1N5335A	S		1N5333	DZ							3.9	10	5.0
1N5335B	S		1N5333	DZ							3.9	5	5.0
1N5336	S		1N5333	DZ							4.3	20	5.0
1N5336A	S		1N5333	DZ							4.3	10	5.0
1N5336B	S		1N5333	DZ							4.3	5	5.0
1N5337	S		1N5333	DZ							4.7	20	5.0
1N5337A	S		1N5333	DZ							4.7	10	5.0
1N5337B	S		1N5333	DZ							4.7	5	5.0
1N5338	S		1N5333	DZ							5.1	20	5.0
1N5338A	S		1N5333	DZ							5.1	10	5.0
1N5338B	S		1N5333	DZ							5.1	5	5.0
1N5339	S		1N5333	DZ							5.6	20	5.0
1N5339A	S		1N5333	DZ							5.6	10	5.0
1N5339B	S		1N5333	DZ							5.6	5	5.0
1N5340	S		1N5333	DZ							6.0	20	5.0
1N5340A	S		1N5333	DZ							6.0	10	5.0
1N5340B	S		1N5333	DZ							6.0	5	5.0
1N5341	S		1N5333	DZ							6.2	20	5.0
1N5341A	S		1N5333	DZ							6.2	10	5.0
1N5341B	S		1N5333	DZ							6.2	5	5.0
1N5342	S		1N5333	DZ							6.8	20	5.0
1N5342A	S		1N5333	DZ							6.8	10	5.0
1N5342B	S		1N5333	DZ							6.8	5	5.0
1N5343	S		1N5333	DZ							7.5	20	5.0
1N5343A	S		1N5333	DZ							7.5	10	5.0
1N5343B	S		1N5333	DZ							7.5	5	5.0
1N5344	S		1N5333	DZ							8.2	20	5.0
1N5344A	S		1N5333	DZ							8.2	10	5.0
1N5344B	S		1N5333	DZ							8.2	5	5.0
1N5345	S		1N5333	DZ							8.7	20	5.0
1N5345A	S		1N5333	DZ							8.7	10	5.0
1N5345B	S		1N5333	DZ							8.7	5	5.0
1N5346	S		1N5333	DZ							9.1	20	5.0
1N5346A	S		1N5333	DZ							9.1	10	5.0
1N5346B	S		1N5333	DZ							9.1	5	5.0
1N5347	S		1N5333	DZ							10	20	5.0
1N5347A	S		1N5333	DZ							10	10	5.0
1N5347B	S		1N5333	DZ							10	5	5.0
1N5348	S		1N5333	DZ							11	20	5.0
1N5348A	S		1N5333	DZ							11	10	5.0
1N5348B	S		1N5333	DZ							11	5	5.0
1N5349	S		1N5333	DZ							12	20	5.0
1N5349A	S		1N5333	DZ							12	10	5.0
1N5349B	S		1N5333	DZ							12	5	5.0
1N5350	S		1N5333	DZ							13	20	5.0
1N5350A	S		1N5333	DZ							13	10	5.0
1N5350B	S		1N5333	DZ							13	5	5.0
1N5351	S		1N5333	DZ							14	20	5.0
1N5351A	S		1N5333	DZ							14	10	5.0
1N5351B	S		1N5333	DZ							14	5	5.0
1N5352	S		1N5333	DZ							15	20	5.0
1N5352A	S		1N5333	DZ							15	10	5.0
1N5352B	S		1N5333	DZ							15	5	5.0
1N5353	S		1N5333	DZ							16	20	5.0
1N5353A	S		1N5333	DZ							16	10	5.0
1N5353B	S		1N5333	DZ							16	5	5.0
1N5354	S		1N5333	DZ							17	20	5.0
1N5354A	S		1N5333	DZ							17	10	5.0
1N5354B	S		1N5333	DZ							17	5	5.0
1N5355	S		1N5333	DZ							18	20	5.0
1N5355A	S		1N5333	DZ							18	10	5.0

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D (W)
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts) (mA)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5355B	S		1N5333	DZ							18	5	5.0
1N5356	S		1N5333	DZ							19	20	5.0
1N5356A	S		1N5333	DZ							19	10	5.0
1N5356B	S		1N5333	DZ							19	5	5.0
1N5357	S		1N5333	DZ							20	20	5.0
1N5357A	S		1N5333	DZ							20	10	5.0
1N5357B	S		1N5333	DZ							20	5	5.0
1N5358	S		1N5333	DZ							22	20	5.0
1N5358A	S		1N5333	DZ							22	10	5.0
1N5358B	S		1N5333	DZ							22	5	5.0
1N5359	S		1N5333	DZ							24	20	5.0
1N5359A	S		1N5333	DZ							24	10	5.0
1N5359B	S		1N5333	DZ							24	5	5.0
1N5360	S		1N5333	DZ							25	20	5.0
1N5360A	S		1N5333	DZ							25	10	5.0
1N5360B	S		1N5333	DZ							25	5	5.0
1N5361	S		1N5333	DZ							27	20	5.0
1N5361A	S		1N5333	DZ							27	10	5.0
1N5361B	S		1N5333	DZ							27	5	5.0
1N5362	S		1N5333	DZ							28	20	5.0
1N5362A	S		1N5333	DZ							28	10	5.0
1N5362B	S		1N5333	DZ							28	5	5.0
1N5363	S		1N5333	DZ							30	20	5.0
1N5363A	S		1N5333	DZ							30	10	5.0
1N5363B	S		1N5333	DZ							30	5	5.0
1N5364	S		1N5333	DZ							33	20	5.0
1N5364A	S		1N5333	DZ							33	10	5.0
1N5364B	S		1N5333	DZ							33	5	5.0
1N5365	S		1N5333	DZ							36	20	5.0
1N5365A	S		1N5333	DZ							36	10	5.0
1N5365B	S		1N5333	DZ							36	5	5.0
1N5366	S		1N5333	DZ							39	20	5.0
1N5366A	S		1N5333	DZ							39	10	5.0
1N5366B	S		1N5333	DZ							39	5	5.0
1N5367	S		1N5333	DZ							43	20	5.0
1N5367A	S		1N5333	DZ							43	10	5.0
1N5367B	S		1N5333	DZ							43	5	5.0
1N5368	S		1N5333	DZ							47	20	5.0
1N5368A	S		1N5333	DZ							47	10	5.0
1N5368B	S		1N5333	DZ							47	5	5.0
1N5369	S		1N5333	DZ							51	20	5.0
1N5369A	S		1N5333	DZ							51	10	5.0
1N5369B	S		1N5333	DZ							51	5	5.0
1N5370	S		1N5333	DZ							56	20	5.0
1N5370A	S		1N5333	DZ							56	10	5.0
1N5370B	S		1N5333	DZ							56	5	5.0
1N5371	S		1N5333	DZ							60	20	5.0
1N5371A	S		1N5333	DZ							60	10	5.0
1N5371B	S		1N5333	DZ							60	5	5.0
1N5372	S		1N5333	DZ							62	20	5.0
1N5372A	S		1N5333	DZ							62	10	5.0
1N5372B	S		1N5333	DZ							62	5	5.0
1N5373	S		1N5333	DZ							68	20	5.0
1N5373A	S		1N5333	DZ							68	10	5.0
1N5373B	S		1N5333	DZ							68	5	5.0
1N5374	S		1N5333	DZ							75	20	5.0
1N5374A	S		1N5333	DZ							75	10	5.0
1N5374B	S		1N5333	DZ							75	5	5.0
1N5375	S		1N5333	DZ							82	20	5.0
1N5375A	S		1N5333	DZ							82	10	5.0
1N5375B	S		1N5333	DZ							82	5	5.0
1N5376	S		1N5333	DZ							87	20	5.0
1N5376A	S		1N5333	DZ							87	10	5.0
1N5376B	S		1N5333	DZ							87	5	5.0
1N5377	S		1N5333	DZ							91	20	5.0
1N5377A	S		1N5333	DZ							91	10	5.0
1N5377B	S		1N5333	DZ							91	5	5.0
1N5378	S		1N5333	DZ							100	20	5.0
1N5378A	S		1N5333	DZ							100	10	5.0
1N5378B	S		1N5333	DZ							100	5	5.0
1N5379	S		1N5333	DZ							110	20	5.0
1N5379A	S		1N5333	DZ							110	10	5.0
1N5379B	S		1N5333	DZ							110	5	5.0
1N5380	S		1N5333	DZ							120	20	5.0
1N5380A	S		1N5333	DZ							120	10	5.0
1N5380B	S		1N5333	DZ							120	5	5.0
1N5381	S		1N5333	DZ							130	20	5.0
1N5381A	S		1N5333	DZ							130	10	5.0
1N5381B	S		1N5333	DZ							130	5	5.0
1N5382	S		1N5333	DZ							140	20	5.0
1N5382A	S		1N5333	DZ							140	10	5.0
1N5382B	S		1N5333	DZ							140	5	5.0

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom).* / V_Z (max)	Tol V_Z %	P_D (W)	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts) (mA)		I_R N = nA *µA	t_{rr} (µs)	TC %/°C	V_Z	T (min) °C	T (max) °C	
1N5383	S		1N5333	DZ							150	20	5.0	
1N5383A	S		1N5333	DZ							150	10	5.0	
1N5383B	S		1N5333	DZ							150	5	5.0	
1N5384	S		1N5333	DZ							160	20	5.0	
1N5384A	S		1N5333	DZ							160	10	5.0	
1N5384B	S		1N5333	DZ							160	5	5.0	
1N5385	S		1N5333	DZ							170	20	5.0	
1N5385A	S		1N5333	DZ							170	10	5.0	
1N5385B	S		1N5333	DZ							170	5	5.0	
1N5386	S		1N5333	DZ							180	20	5.0	
1N5386A	S		1N5333	DZ							180	10	5.0	
1N5386B	S		1N5333	DZ							180	5	5.0	
1N5387	S		1N5333	DZ							190	20	5.0	
1N5387A	S		1N5333	DZ							190	10	5.0	
1N5387B	S		1N5333	DZ							190	5	5.0	
1N5388	S		1N5333	DZ							200	20	5.0	
1N5388A	S		1N5333	DZ							200	10	5.0	
1N5388B	S		1N5333	DZ							200	5	5.0	
1N5389	S			R*	40,000	80	0.100	0.10	10					
1N5390		Hot Carrier Diode												
1N5391	S			R*	50		1.5		50					
1N5392	S			R*	100		1.5		50					
1N5393	S			R*	200		1.5		50					
1N5394	S			R*	300		1.5		50					
1N5395	S			R*	400		1.5		50					
1N5396	S			R*	500		1.5		50					
1N5397	S			R*	600		1.5		50					
1N5398	S			R*	800		1.5		50					
1N5399	S			R*	1000		1.5		50					
1N5400	S			R*	50		3.0		200					
1N5401	S			R*	100		3.0		200					
1N5402	S			R*	200		3.0		200					
1N5403	S			R*	300		3.0		200					
1N5404	S			R*	400		3.0		200					
1N5405	S			R*	500		3.0		200					
1N5406	S			R*	600		3.0		200					
1N5407	S			R*	800		3.0		200					
1N5408	S			R*	1000		3.0		200					
1N5409	S			R*	175		40		1000					
1N5410	S			R*	175		12		200					
1N5411	S	Diac (Trigger Diode)												
1N5412	S			DS	30	0.500	0.1M	100N	0.002					
1N5413	S			DS	55	0.500	0.1M	100N	0.002					
1N5414	S			DS	75	0.500	0.1M	100N	0.002					
1N5415	S			R*	50				200					
1N5416	S			R*	100				200					
1N5417	S			R*	200				200					
1N5418	S			R*	400				200					
1N5419	S			R*	500				200					
1N5420	S			R*	600				200					
1N5421 thru 1N5425		Varactor Diodes, see Table on Page 1-94												
1N5426	S			DS		1.0	40M	1.0*						
1N5427	S			DS		1.0	10M	0.10*	0.004					
1N5428	S			DS		1.0	100M	0.10*	0.050					
1N5429	S			DS		1.0	200M	0.005*						
1N5430	S			DS		1.0	200M	0.10*	0.004					
1N5431	S			DS		1.3	500M	0.10*	0.004					
1N5432	S			DS		1.3	50M	0.050*	0.75N					

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amp)	I_R (mA)	I_{surge} (Amp)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5433	S			R*	600		2.0		25				
1N5434	S			R*	600		2.0		60				
1N5435	S			R*	600		12		200				
1N5436	}	Microwave Mixers											
1N5437	}												
1N5438	}												
1N5439	}												
thru	Varactor Diodes, see Table on Page 1-94												
1N5476													
1N5477	S			R*	6000		0.6	0.350	80				
1N5478	S			R*	7200		0.6	0.350	80				
1N5479	S			R*	8400		0.6	0.350	80				
1N5480	S			R*	9600		0.6	0.350	80				
1N5481	S			R*	12000		0.6	0.350	80				
1N5482	S			R*	2400		1.0	0.350	80				
1N5483	S			R*	3600		1.0	0.350	80				
1N5484	S			R*	4800		1.0	0.350	80				
1N5485	S			R*	6000		1.0	0.350	80				
1N5518	S		1N5518	DZ							3.3*	20	400M
1N5518A	S		1N5518	DZ							3.3*	10	400M
1N5518B	S		1N5518	DZ							3.3*	5.0	400M
1N5518C	S			DZ							3.3*	2.0	400M
1N5518D	S			DZ							3.3*	1.0	400M
1N5519	S		1N5518	DZ							3.6*	20	400M
1N5519A	S		1N5518	DZ							3.6*	10	400M
1N5519B	S		1N5518	DZ							3.6*	5.0	400M
1N5519C	S			DZ							3.6*	2.0	400M
1N5519D	S			DZ							3.6*	1.0	400M
1N5520	S		1N5518	DZ							3.9*	20	400M
1N5520A	S		1N5518	DZ							3.9*	10	400M
1N5520B	S		1N5518	DZ							3.9*	5.0	400M
1N5520C	S			DZ							3.9*	2.0	400M
1N5520D	S			DZ							3.9*	1.0	400M
1N5521	S		1N5518	DZ							4.3*	20	400M
1N5521A	S		1N5518	DZ							4.3*	10	400M
1N5521B	S		1N5518	DZ							4.3*	5.0	400M
1N5521C	S			DZ							4.3*	2.0	400M
1N5521D	S			DZ							4.3*	1.0	400M
1N5522	S		1N5518	DZ							4.7*	20	400M
1N5522A	S		1N5518	DZ							4.7*	10	400M
1N5522B	S		1N5518	DZ							4.7*	5.0	400M
1N5522C	S			DZ							4.7*	2.0	400M
1N5522D	S			DZ							4.7*	1.0	400M
1N5523	S		1N5518	DZ							5.1*	20	400M
1N5523A	S		1N5518	DZ							5.1*	10	400M
1N5523B	S		1N5518	DZ							5.1*	5.0	400M
1N5523C	S			DZ							5.1*	2.0	400M
1N5523D	S			DZ							5.1*	1.0	400M
1N5524	S		1N5518	DZ							5.6*	20	400M
1N5524A	S		1N5518	DZ							5.6*	10	400M
1N5524B	S		1N5518	DZ							5.6*	5.0	400M
1N5524C	S			DZ							5.6*	2.0	400M
1N5524D	S			DZ							5.6*	1.0	400M
1N5525	S		1N5518	DZ							6.2*	20	400M
1N5525A	S		1N5518	DZ							6.2*	10	400M
1N5525B	S		1N5518	DZ							6.2*	5.0	400M
1N5525C	S			DZ							6.2*	2.0	400M
1N5525D	S			DZ							6.2*	1.0	400M
1N5526	S		1N5518	DZ							6.8*	20	400M
1N5526A	S		1N5518	DZ							6.8*	10	400M
1N5526B	S		1N5518	DZ							6.8*	5.0	400M
1N5526C	S			DZ							6.8*	2.0	400M
1N5526D	S			DZ							6.8*	1.0	400M
1N5527	S		1N5518	DZ							7.5*	20	400M
1N5527A	S		1N5518	DZ							7.5*	10	400M
1N5527B	S		1N5518	DZ							7.5*	5.0	400M
1N5527C	S			DZ							7.5*	2.0	400M
1N5527D	S			DZ							7.5*	1.0	400M
1N5528	S		1N5518	DZ							8.2*	20	400M
1N5528A	S		1N5518	DZ							8.2*	10	400M
1N5528B	S		1N5518	DZ							8.2*	5.0	400M
1N5528C	S			DZ							8.2*	2.0	400M
1N5528D	S			DZ							8.2*	1.0	400M
1N5529	S		1N5518	DZ							9.1*	20	400M
1N5529A	S		1N5518	DZ							9.1*	10	400M
1N5529B	S		1N5518	DZ							9.1*	5.0	400M

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amp)	I_R (mA)	I_{surge} (Amp)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5529C	S			DZ							9.1*	2.0	400M
1N5529D	S			DZ							9.1*	1.0	400M
1N5530	S		1N5518	DZ							10*	20	400M
1N5530A	S		1N5518	DZ							10*	10	400M
1N5530B	S		1N5518	DZ							10*	5.0	400M
1N5530C	S			DZ							10*	2.0	400M
1N5530D	S			DZ							10*	1.0	400M
1N5531	S		1N5518	DZ							11*	20	400M
1N5531A	S		1N5518	DZ							11*	10	400M
1N5531B	S		1N5518	DZ							11*	5.0	400M
1N5531C	S			DZ							11*	2.0	400M
1N5531D	S			DZ							11*	1.0	400M
1N5532	S		1N5518	DZ							12*	20	400M
1N5532A	S		1N5518	DZ							12*	10	400M
1N5532B	S		1N5518	DZ							12*	5.0	400M
1N5532C	S			DZ							12*	2.0	400M
1N5532D	S			DZ							12*	1.0	400M
1N5533	S		1N5518	DZ							13*	20	400M
1N5533A	S		1N5518	DZ							13*	10	400M
1N5533B	S		1N5518	DZ							13*	5.0	400M
1N5533C	S			DZ							13*	2.0	400M
1N5533D	S			DZ							13*	1.0	400M
1N5534	S		1N5518	DZ							14*	20	400M
1N5534A	S		1N5518	DZ							14*	10	400M
1N5534B	S		1N5518	DZ							14*	5.0	400M
1N5534C	S			DZ							14*	2.0	400M
1N5534D	S			DZ							14*	1.0	400M
1N5535	S		1N5518	DZ							15*	20	400M
1N5535A	S		1N5518	DZ							15*	10	400M
1N5535B	S		1N5518	DZ							15*	5.0	400M
1N5535C	S			DZ							15*	2.0	400M
1N5535D	S			DZ							15*	1.0	400M
1N5536	S		1N5518	DZ							16*	20	400M
1N5536A	S		1N5518	DZ							16*	10	400M
1N5536B	S		1N5518	DZ							16*	5.0	400M
1N5536C	S			DZ							16*	2.0	400M
1N5536D	S			DZ							16*	1.0	400M
1N5537	S		1N5518	DZ							17*	20	400M
1N5537A	S		1N5518	DZ							17*	10	400M
1N5537B	S		1N5518	DZ							17*	5.0	400M
1N5537C	S			DZ							17*	2.0	400M
1N5537D	S			DZ							17*	1.0	400M
1N5538	S		1N5518	DZ							18*	20	400M
1N5538A	S		1N5518	DZ							18*	10	400M
1N5538B	S		1N5518	DZ							18*	5.0	400M
1N5538C	S			DZ							18*	2.0	400M
1N5538D	S			DZ							18*	1.0	400M
1N5539	S		1N5518	DZ							19*	20	400M
1N5539A	S		1N5518	DZ							19*	10	400M
1N5539B	S		1N5518	DZ							19*	5.0	400M
1N5539C	S			DZ							19*	2.0	400M
1N5539D	S			DZ							19*	1.0	400M
1N5540	S		1N5518	DZ							20*	20	400M
1N5540A	S		1N5518	DZ							20*	10	400M
1N5540B	S		1N5518	DZ							20*	5.0	400M
1N5540C	S			DZ							20*	2.0	400M
1N5540D	S			DZ							20*	1.0	400M
1N5541	S		1N5518	DZ							22*	20	400M
1N5541A	S		1N5518	DZ							22*	10	400M
1N5541B	S		1N5518	DZ							22*	5.0	400M
1N5541C	S			DZ							22*	2.0	400M
1N5541D	S			DZ							22*	1.0	400M
1N5542	S		1N5518	DZ							24*	20	400M
1N5542A	S		1N5518	DZ							24*	10	400M
1N5542B	S		1N5518	DZ							24*	5.0	400M
1N5542C	S			DZ							24*	2.0	400M
1N5542D	S			DZ							24*	1.0	400M
1N5543	S		1N5518	DZ							25*	20	400M
1N5543A	S		1N5518	DZ							25*	10	400M
1N5543B	S		1N5518	DZ							25*	5.0	400M
1N5543C	S			DZ							25*	2.0	400M
1N5543D	S			DZ							25*	1.0	400M
1N5544	S		1N5518	DZ							28*	20	400M
1N5544A	S		1N5518	DZ							28*	10	400M
1N5544B	S		1N5518	DZ							28*	5.0	400M

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F (volts) @ I_F (Amps)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5544C	S			DZ							28*	2.0	400M
1N5544D	S			DZ							28*	1.0	400M
1N5545	S		1N5518	DZ							30*	20	400M
1N5545A	S		1N5518	DZ							30*	10	400M
1N5545B	S		1N5518	DZ							30*	5.0	400M
1N5545C	S			DZ							30*	2.0	400M
1N5545D	S			DZ							30*	1.0	400M
1N5546	S		1N5518	DZ							33*	20	400M
1N5546A	S		1N5518	DZ							33*	10	400M
1N5546B	S		1N5518	DZ							33*	5.0	400M
1N5546C	S			DZ							33*	2.0	400M
1N5546D	S			DZ							33*	1.0	400M
1N555C	S			R*	200	1.0	3.0	0.025	150				
1N5551	S			R*	400	1.0	3.0	0.025	150				
1N5552	S			R*	600	1.0	3.0	0.025	150				
1N5553	S			R*	800	1.1	3.0	0.025	150				
1N5554	S			R*	1000	1.1	3.0	0.025	150				
1N5555 thru 1N5558	Transient Suppressors, see Table on Page 1-108												
1N5559	S			DZ							6.8*	20	1.0W
1N5559A	S			DZ							6.8*	10	1.0W
1N5559B	S			DZ							6.8*	5.0	1.0W
1N5560	S			DZ							7.5*	20	1.0W
1N5560A	S			DZ							7.5*	10	1.0W
1N5560B	S			DZ							7.5*	5.0	1.0W
1N5561	S			DZ							8.2*	20	1.0W
1N5561A	S			DZ							8.2*	10	1.0W
1N5561B	S			DZ							8.2*	5.0	1.0W
1N5562	S			DZ							9.1*	20	1.0W
1N5562A	S			DZ							9.1*	10	1.0W
1N5562B	S			DZ							9.1*	5.0	1.0W
1N5563	S			DZ							10*	20	1.0W
1N5563A	S			DZ							10*	10	1.0W
1N5563B	S			DZ							10*	5.0	1.0W
1N5564	S			DZ							11*	20	1.0W
1N5564A	S			DZ							11*	10	1.0W
1N5564B	S			DZ							11*	5.0	1.0W
1N5565	S			DZ							12*	20	1.0W
1N5565A	S			DZ							12*	10	1.0W
1N5565B	S			DZ							12*	5.0	1.0W
1N5566	S			DZ							13*	20	1.0W
1N5566A	S			DZ							13*	10	1.0W
1N5566B	S			DZ							13*	5.0	1.0W
1N5567	S			DZ							15*	20	1.0W
1N5567A	S			DZ							15*	10	1.0W
1N5567B	S			DZ							15*	5.0	1.0W
1N5568	S			DZ							16*	20	1.0W
1N5568A	S			DZ							16*	10	1.0W
1N5568B	S			DZ							16*	5.0	1.0W
1N5569	S			DZ							18*	20	1.0W
1N5569A	S			DZ							18*	10	1.0W
1N5569B	S			DZ							18*	5.0	1.0W
1N5570	S			DZ							20*	20	1.0W
1N5570A	S			DZ							20*	10	1.0W
1N5570B	S			DZ							20*	5.0	1.0W
1N5571	S			DZ							22*	20	1.0W
1N5571A	S			DZ							22*	10	1.0W
1N5571B	S			DZ							22*	5.0	1.0W
1N5572	S			DZ							24*	20	1.0W
1N5572A	S			DZ							24*	10	1.0W
1N5572B	S			DZ							24*	5.0	1.0W
1N5573	S			DZ							27*	20	1.0W
1N5573A	S			DZ							27*	10	1.0W
1N5573B	S			DZ							27*	5.0	1.0W
1N5574	S			DZ							30*	20	1.0W
1N5574A	S			DZ							30*	10	1.0W
1N5574B	S			DZ							30*	5.0	1.0W
1N5575	S			DZ							33*	20	1.0W
1N5575A	S			DZ							33*	10	1.0W
1N5575B	S			DZ							33*	5.0	1.0W
1N5576	S			DZ							36*	20	1.0W
1N5576A	S			DZ							36*	10	1.0W
1N5576B	S			DZ							36*	5.0	1.0W
1N5577	S			DZ							39*	20	1.0W
1N5577A	S			DZ							39*	10	1.0W
1N5577B	S			DZ							39*	5.0	1.0W
1N5578	S			DZ							43*	20	1.0W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amp)	I_R (mA)	I_{surge} (Amp)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5578A	S			DZ							43*	10	1.0W
1N5578B	S			DZ							43*	5.0	1.0W
1N5579	S			DZ							47*	20	1.0W
1N5579A	S			DZ							47*	10	1.0W
1N5579B	S			DZ							47*	5.0	1.0W
1N5580	S			DZ							51*	20	1.0W
1N5580A	S			DZ							51*	10	1.0W
1N5580B	S			DZ							51*	5.0	1.0W
1N5581	S			DZ							56*	20	1.0W
1N5581A	S			DZ							56*	10	1.0W
1N5581B	S			DZ							56*	5.0	1.0W
1N5582	S			DZ							62*	20	1.0W
1N5582A	S			DZ							62*	10	1.0W
1N5582B	S			DZ							62*	5.0	1.0W
1N5583	S			DZ							68*	20	1.0W
1N5583A	S			DZ							68*	10	1.0W
1N5583B	S			DZ							68*	5.0	1.0W
1N5584	S			DZ							75*	20	1.0W
1N5584A	S			DZ							75*	10	1.0W
1N5584B	S			DZ							75*	5.0	1.0W
1N5585	S			DZ							82*	20	1.0W
1N5585A	S			DZ							82*	10	1.0W
1N5585B	S			DZ							82*	5.0	1.0W
1N5586	S			DZ							91*	20	1.0W
1N5586A	S			DZ							91*	10	1.0W
1N5586B	S			DZ							91*	5.0	1.0W
1N5587	S			DZ							100*	20	1.0W
1N5587A	S			DZ							100*	10	1.0W
1N5587B	S			DZ							100*	5.0	1.0W
1N5588	S			DZ							110*	20	1.0W
1N5588A	S			DZ							110*	10	1.0W
1N5588B	S			DZ							110*	5.0	1.0W
1N5589	S			DZ							120*	20	1.0W
1N5589A	S			DZ							120*	10	1.0W
1N5589B	S			DZ							120*	5.0	1.0W
1N5590	S			DZ							130*	20	1.0W
1N5590A	S			DZ							130*	10	1.0W
1N5590B	S			DZ							130*	5.0	1.0W
1N5591	S			DZ							150*	20	1.0W
1N5591A	S			DZ							150*	10	1.0W
1N5591B	S			DZ							150*	5.0	1.0W
1N5592	S			DZ							160*	20	1.0W
1N5592A	S			DZ							160*	10	1.0W
1N5592B	S			DZ							160*	5.0	1.0W
1N5593	S			DZ							180*	20	1.0W
1N5593A	S			DZ							180*	10	1.0W
1N5593B	S			DZ							180*	5.0	1.0W
1N5594	S			DZ							200*	20	1.0W
1N5594A	S			DZ							200*	10	1.0W
1N5594B	S			DZ							200*	5.0	1.0W
1N5605	S			DS	70	1.0	20M	25N					
1N5606	S			DS	150	1.0	7.0M	25N					
1N5607	S			DS	200	1.0	3.0M	25N					
1N5608	S			DS	120	1.0	100M	50N					
1N5609	S			DS	120	1.0	6.0M	5.0*					
1N5610 thru 1N5613		Transient Suppressors, See Table on Page 1-108											
1N5624	S			R*	200	0.95	3.0	0.3	125				
1N5625	S			R*	400	0.95	3.0	0.3	125				
1N5626	S			R*	600	0.95	3.0	0.3	125				
1N5627	S			R*	800	0.95	3.0	0.3	125				
1N5629,A thru 1N5665,A		Transient Suppressors, see Table on Page 1-108											
1N5679	S			R*	50	1.1	1.0	0.01	50				
1N5680	S			R*	100	1.1	1.0	0.01	50				
1N5711 thru 1N5713		Hot Carrier Diodes											



VARACTOR DIODES

INDEX AND SHORT-FORM SPECIFICATIONS

The following table provides a numerical index and short-form specifications for varactor diodes with EIA-registered type number introduced since the publication of the Motorola Semiconductor Data Book (4th Edition).

KEY

TYPE	REF.	CAPACITANCE					BV_R	Q @ f	P_D @ 25°C
		C_J C_T* pF	C Tol %	C (max) / C (min)	Voltage Range V_1 Volts	Voltage Range V_2 Volts	Volts	GHz	Watts
Numerical Listing of Registered Type Numbers									
	Reference device number indicates specific Data Sheet on which device is characterized								
		Nominal Capacitance usually C_J (junction capacitance) With *, specified value is C_T (total capacitance) $C_T = C_J + C_C$							
			Tolerance of capacitance listed in preceding column						
				Effective tuning Ratio (Capacitance at Voltage V_1 divided by capacitance at Voltage V_2)					
					Voltage range over which the tuning range is measured				
							Reverse Breakdown Voltage		
								Figure of Merit at this specified frequency	
									Power Dissipation at 25°C

TYPE	REF.	CAPACITANCE					BV_R	Q @ f		P_D @ 25°C
		C_J C_T*	C Tol	C (max) / C (min)	Voltage Range V_1	Voltage Range V_2				
		pF	%		Volts	Volts	Volts		GHz	Watts
1N950		35		2.51	4.0	130	130	7.0	0.05	
1N951		50		2.4	4.0	80	80	7.0	0.05	
1N952		70		2.43	4.0	60	60	7.0	0.05	
1N953		100		2.4	4.0	25	25	7.0	0.05	
1N954		35		2.51	4.0	25	25	7.0	0.05	
1N955		50		2.4	4.0	25	25	7.0	0.05	
1N956		70		2.43	4.0	25	25	7.0	0.05	
1N2627		2.75		1.75	0	5.0	5.0	10	1.0	
1N2628		2.5		1.5	0	5.0	5.0	14	1.0	
1N3182		33					20	65	0.05	0.163
1N3488		56					15	7.0	0.05	
1N3551		50	6.0	1.38	4.0	8.0	11	30	0.05	
1N3552		21.5	6.0				22	25	0.05	
1N3554		12					100			
1N3555		20					100	60	0.05	
1N3556		47					100	50	0.10	
1N3557		24					210	75	0.05	
1N3627		21.3		2.45	4.0	20	20	25	0.05	
1N3628		50		2.5	4.0	20	20	30	0.05	
1N3770		2.0					5.5			
1N3945		20		1.5	4.0	20	20	7.0	0.05	0.50
1N3946		71					9.0	7.0	0.05	0.50
1N3947		70					9.0	9.0	0.05	
1N4091		4.2		2.5			6.0			0.30
1N4387	1N4387	35					150	150	0.05	20
1N4388	1N4388	20					100	200	0.05	10
1N4598		22		4.04	4.0	90	90	50	0.05	0.25
1N4599		47		5.0	2.0	100	110	100	0.05	0.50
1N4609		22		2.64	4.0	35	35	60	0.05	0.25
1N4786		6.8	20	2.56	0	4.0	25	15	0.05	0.50
1N4786A		6.8	10	2.56	0	4.0	25	15	0.05	0.50
1N4786B		6.8	5.0	2.56	0	4.0	25	15	0.05	0.50
1N4786C		6.8	2.0	2.56	0	4.0	25	15	0.05	0.50
1N4786D		6.8	1.0	2.56	0	4.0	25	15	0.05	0.50
1N4787		8.2	20	2.56	0	4.0	25	15	0.05	0.50
1N4787A		8.2	10	2.56	0	4.0	25	15	0.05	0.50
1N4787B		8.2	5.0	2.56	0	4.0	25	15	0.05	0.50
1N4787C		8.2	2.0	2.56	0	4.0	25	15	0.05	0.50
1N4787D		8.2	1.0	2.56	0	4.0	25	15	0.05	0.50
1N4788		10	20	2.50	0	4.0	25	15	0.05	0.50
1N4788A		10	10	2.50	0	4.0	25	15	0.05	0.50
1N4788B		10	5.0	2.50	0	4.0	25	15	0.05	0.50
1N4788C		10	2.0	2.50	0	4.0	25	15	0.05	0.50
1N4788D		10	1.0	2.50	0	4.0	25	15	0.05	0.50
1N4789		12	20	2.49	0	4.0	25	15	0.05	0.50
1N4789A		12	10	2.49	0	4.0	25	15	0.05	0.50
1N4789B		12	5.0	2.49	0	4.0	25	15	0.05	0.50
1N4789C		12	2.0	2.49	0	4.0	25	15	0.05	0.50
1N4789D		12	1.0	2.49	0	4.0	25	15	0.05	0.50
1N4790		15	20	2.49	0	4.0	25	15	0.05	0.50
1N4790A		15	10	2.49	0	4.0	25	15	0.05	0.50
1N4790B		15	5.0	2.49	0	4.0	25	15	0.05	0.50
1N4790C		15	2.0	2.49	0	4.0	25	15	0.05	0.50
1N4790D		15	1.0	2.49	0	4.0	25	15	0.05	0.50
1N4791		18	20	2.48	0	4.0	20	15	0.05	0.50
1N4791A		18	10	2.48	0	4.0	20	15	0.05	0.50
1N4791B		18	5.0	2.48	0	4.0	20	15	0.05	0.50
1N4791C		18	2.0	2.48	0	4.0	20	15	0.05	0.50
1N4791D		18	1.0	2.48	0	4.0	20	15	0.05	0.50
1N4792		22	20	2.46	0	4.0	20	15	0.05	0.50
1N4792A		22	10	2.46	0	4.0	20	15	0.05	0.50
1N4792B		22	5.0	2.46	0	4.0	20	15	0.05	0.50
1N4792C		22	2.0	2.46	0	4.0	20	15	0.05	0.50
1N4792D		22	1.0	2.46	0	4.0	20	15	0.05	0.50
1N4793		27	20	2.46	0	4.0	20	15	0.05	0.50
1N4793A		27	10	2.46	0	4.0	20	15	0.05	0.50
1N4793B		27	5.0	2.46	0	4.0	20	15	0.05	0.50
1N4793C		27	2.0	2.46	0	4.0	20	15	0.05	0.50
1N4793D		27	1.0	2.46	0	4.0	20	15	0.05	0.50

1N4794–1N4807D

TYPE	REF.	CAPACITANCE					BV$_R$	Q @ f		P_D @ 25°C
		C_J C_T*	C Tol	C (max) / C (min)	Voltage Range V_1	Voltage Range V_2				
		pF	%		Volts	Volts	Volts		GHz	Watts
1N4794		33	20	2.46	0	4.0	20	15	0.05	0.50
1N4794A		33	10	2.46	0	4.0	20	15	0.05	0.50
1N4794B		33	5.0	2.46	0	4.0	20	15	0.05	0.50
1N4794C		33	2.0	2.46	0	4.0	20	15	0.05	0.50
1N4794D		33	1.0	2.46	0	4.0	20	15	0.05	0.50
1N4795		39	20	2.44	0	4.0	20	15	0.05	0.50
1N4795A		39	10	2.44	0	4.0	20	15	0.05	0.50
1N4795B		39	5.0	2.44	0	4.0	20	15	0.05	0.50
1N4795C		39	2.0	2.44	0	4.0	20	15	0.05	0.50
1N4795D		39	1.0	2.44	0	4.0	20	15	0.05	0.50
1N4796		47	20	2.43	0	4.0	20	15	0.05	0.50
1N4796A		47	10	2.43	0	4.0	20	15	0.05	0.50
1N4796B		47	5.0	2.43	0	4.0	20	15	0.05	0.50
1N4796C		47	2.0	2.43	0	4.0	20	15	0.05	0.50
1N4796D		47	1.0	2.43	0	4.0	20	15	0.05	0.50
1N4797		56	20	2.42	0	4.0	15	15	0.05	0.50
1N4797A		56	10	2.42	0	4.0	15	15	0.05	0.50
1N4797B		56	5.0	2.42	0	4.0	15	15	0.05	0.50
1N4797C		56	2.0	2.42	0	4.0	15	15	0.05	0.50
1N4797D		56	1.0	2.42	0	4.0	15	15	0.05	0.50
1N4798		68	20	2.40	0	4.0	15	15	0.05	0.50
1N4798A		68	10	2.40	0	4.0	15	15	0.05	0.50
1N4798B		68	5.0	2.40	0	4.0	15	15	0.05	0.50
1N4798C		68	2.0	2.40	0	4.0	15	15	0.05	0.50
1N4798D		68	1.0	2.40	0	4.0	15	15	0.05	0.50
1N4799		82	20	2.36	0	4.0	15	15	0.05	0.50
1N4799A		82	10	2.36	0	4.0	15	15	0.05	0.50
1N4799B		82	5.0	2.36	0	4.0	15	15	0.05	0.50
1N4799C		82	2.0	2.36	0	4.0	15	15	0.05	0.50
1N4799D		82	1.0	2.36	0	4.0	15	15	0.05	0.50
1N4800		100	20	2.33	0	4.0	15	15	0.05	0.50
1N4800A		100	10	2.33	0	4.0	15	15	0.05	0.50
1N4800B		100	5.0	2.33	0	4.0	15	15	0.05	0.50
1N4800C		100	2.0	2.33	0	4.0	15	15	0.05	0.50
1N4800D		100	1.0	2.33	0	4.0	15	15	0.05	0.50
1N4801		6.8	20	2.56	0	4.0	100	15	0.05	0.50
1N4801A		6.8	10	2.56	0	4.0	100	15	0.05	0.50
1N4801B		6.8	5.0	2.56	0	4.0	100	15	0.05	0.50
1N4801C		6.8	2.0	2.56	0	4.0	100	15	0.05	0.50
1N4801D		6.8	1.0	2.56	0	4.0	100	15	0.05	0.50
1N4802		8.2	20	2.58	0	4.0	100	15	0.05	0.50
1N4802A		8.2	10	2.58	0	4.0	100	15	0.05	0.50
1N4802B		8.2	5.0	2.58	0	4.0	100	15	0.05	0.50
1N4802C		8.2	2.0	2.58	0	4.0	100	15	0.05	0.50
1N4802D		8.2	1.0	2.58	0	4.0	100	15	0.05	0.50
1N4803		10	20	2.50	0	4.0	100	15	0.05	0.50
1N4803A		10	10	2.50	0	4.0	100	15	0.05	0.50
1N4803B		10	5.0	2.50	0	4.0	100	15	0.05	0.50
1N4803C		10	2.0	2.50	0	4.0	100	15	0.05	0.50
1N4803D		10	1.0	2.50	0	4.0	100	15	0.05	0.50
1N4804		12	20	2.49	0	4.0	100	15	0.05	0.50
1N4804A		12	10	2.49	0	4.0	100	15	0.05	0.50
1N4804B		12	5.0	2.49	0	4.0	100	15	0.05	0.50
1N4804C		12	2.0	2.49	0	4.0	100	15	0.05	0.50
1N4804D		12	1.0	2.49	0	4.0	100	15	0.05	0.50
1N4805		15	20	2.49	0	4.0	100	15	0.05	0.50
1N4805A		15	10	2.49	0	4.0	100	15	0.05	0.50
1N4805B		15	5.0	2.49	0	4.0	100	15	0.05	0.50
1N4805C		15	2.0	2.49	0	4.0	100	15	0.05	0.50
1N4805D		15	1.0	2.49	0	4.0	100	15	0.05	0.50
1N4806		18	20	2.48	0	4.0	90	15	0.05	
1N4806A		18	10	2.48	0	4.0	90	15	0.05	
1N4806B		18	5.0	2.48	0	4.0	90	15	0.05	
1N4806C		18	2.0	2.48	0	4.0	90	15	0.05	
1N4806D		18	1.0	2.48	0	4.0	90	15	0.05	
1N4807		22	20	2.46	0	4.0	90	15	0.05	0.50
1N4807A		22	10	2.46	0	4.0	90	15	0.05	0.50
1N4807B		22	5.0	2.46	0	4.0	90	15	0.05	0.50
1N4807C		22	2.0	2.46	0	4.0	90	15	0.05	0.50
1N4807D		22	1.0	2.46	0	4.0	90	15	0.05	0.50

TYPE	REF.	CAPACITANCE					BV_R	Q @ f		P_D @ 25°C
		C_J C_T*	C Tol	C (max) / C (min)	Voltage Range V_1	Voltage Range V_2				
		pF	%		Volts	Volts	Volts		GHz	Watts
1N4808		27	20	2.46	0	4.0	65	15	0.05	0.50
1N4808A		27	10	2.46	0	4.0	65	15	0.05	0.50
1N4808B		27	5.0	2.46	0	4.0	65	15	0.05	0.50
1N4808C		27	2.0	2.46	0	4.0	65	15	0.05	0.50
1N4808D		27	1.0	2.46	0	4.0	65	15	0.05	0.50
1N4809		33	20	2.46	0	4.0	60	15	0.05	0.50
1N4809A		33	10	2.46	0	4.0	60	15	0.05	0.50
1N4809B		33	5.0	2.46	0	4.0	60	15	0.05	0.50
1N4809C		33	2.0	2.46	0	4.0	60	15	0.05	0.50
1N4809D		33	1.0	2.46	0	4.0	60	15	0.05	0.50
1N4810		39	20	2.44	0	4.0	55	15	0.05	0.50
1N4810A		39	10	2.44	0	4.0	55	15	0.05	0.50
1N4810B		39	5.0	2.44	0	4.0	55	15	0.05	0.50
1N4810C		39	2.0	2.44	0	4.0	55	15	0.05	0.50
1N4810D		39	1.0	2.44	0	4.0	55	15	0.05	0.50
1N4811		47	20	2.43	0	4.0	50	15	0.05	0.50
1N4811A		47	10	2.43	0	4.0	50	15	0.05	0.50
1N4811B		47	5.0	2.43	0	4.0	50	15	0.05	0.50
1N4811C		47	2.0	2.43	0	4.0	50	15	0.05	0.50
1N4811D		47	1.0	2.43	0	4.0	50	15	0.05	0.50
1N4812		56	20	2.42	0	4.0	40	15	0.05	0.50
1N4812A		56	10	2.42	0	4.0	40	15	0.05	0.50
1N4812B		56	5.0	2.42	0	4.0	40	15	0.05	0.50
1N4812C		56	2.0	2.42	0	4.0	40	15	0.05	0.50
1N4812D		56	1.0	2.42	0	4.0	40	15	0.05	0.50
1N4813		68	20	2.40	0	4.0	30	15	0.05	0.50
1N4813A		68	10	2.40	0	4.0	30	15	0.05	0.50
1N4813B		68	5.0	2.40	0	4.0	30	15	0.05	0.50
1N4813C		68	2.0	2.40	0	4.0	30	15	0.05	0.50
1N4813D		68	1.0	2.40	0	4.0	30	15	0.05	0.50
1N4814		82	20	2.36	0	4.0	20	15	0.05	0.50
1N4814A		82	10	2.36	0	4.0	20	15	0.05	0.50
1N4814B		82	5.0	2.36	0	4.0	20	15	0.05	0.50
1N4814C		82	2.0	2.36	0	4.0	20	15	0.05	0.50
1N4814D		82	1.0	2.36	0	4.0	20	15	0.05	0.50
1N4815		100	20	2.33	0	4.0	20	15	0.05	0.50
1N4815A		100	10	2.33	0	4.0	20	15	0.05	0.50
1N4815B		100	5.0	2.33	0	4.0	20	15	0.05	0.50
1N4815C		100	2.0	2.33	0	4.0	20	15	0.05	0.50
1N4815D		100	1.0	2.33	0	4.0	20	15	0.05	0.50
1N4885		35		2.57	6.0	150	150			20
1N4886		35		2.57	6.0	120	120			20
1N4941		0.4		2.0	0	6.0	6.0	2000	10	0.1
1N5136		1.0*	20	2.2	4.0	60	60	350	0.05	0.4
1N5136A		1.0*	10	2.2	4.0	60	60	350	0.05	0.4
1N5137		2.2*	20	2.2	4.0	60	60	350	0.05	0.4
1N5137A		2.2*	10	2.2	4.0	60	60	350	0.05	0.4
1N5138		3.3*	20	2.4	4.0	60	60	350	0.05	0.4
1N5138A		3.3*	10	2.4	4.0	60	60	350	0.05	0.4
1N5139	1N5139	6.8*	10	2.9	4.0	60	60	350	0.05	0.4
1N5139A	1N5139	6.8*	5.0	2.9	4.0	60	60	350	0.05	0.4
1N5140	1N5139	10*	10	3.0	4.0	60	60	300	0.05	0.4
1N5140A	1N5139	10*	5.0	3.0	4.0	60	60	300	0.05	0.4
1N5141	1N5139	12*	10	3.0	4.0	60	60	300	0.05	0.4
1N5141A	1N5139	12*	5.0	3.0	4.0	60	60	300	0.05	0.4
1N5142	1N5139	15*	10	3.0	4.0	60	60	250	0.05	0.4
1N5142A	1N5139	15*	5.0	3.0	4.0	60	60	250	0.05	0.4
1N5143	1N5139	18*	10	3.0	4.0	60	60	250	0.05	0.4
1N5143A	1N5139	18*	5.0	3.0	4.0	60	60	250	0.05	0.4
1N5144	1N5139	22*	10	3.4	4.0	60	60	200	0.05	0.4
1N5144A	1N5139	22*	5.0	3.4	4.0	60	60	200	0.05	0.4
1N5145	1N5139	27*	10	3.4	4.0	60	60	200	0.05	0.4
1N5145A	1N5139	27*	5.0	3.4	4.0	60	60	200	0.05	0.4
1N5146	1N5139	33*	10	3.4	4.0	60	60	200	0.05	0.4
1N5146A	1N5139	33*	5.0	3.4	4.0	60	60	200	0.05	0.4
1N5147	1N5139	39*	10	3.4	4.0	60	60	200	0.05	0.4
1N5147A	1N5139	39*	5.0	3.4	4.0	60	60	200	0.05	0.4
1N5148	1N5139	47*	10	3.4	4.0	60	60	200	0.05	0.4
1N5148A	1N5139	47*	5.0	3.4	4.0	60	60	200	0.05	0.4
1N5149	1N5149	11.5*					80	800	0.05	10
1N5150	1N5149	11.5*					80	800	0.05	14
1N5150A	1N5150A	12	10				80	800	0.05	29.2
1N5151	1N5151	5.8*					75	1100	0.05	5.5
1N5152	1N5151	5.8*					75	1100	0.05	5.5
1N5152A	1N5150A	6.0	10				75	1100	0.05	11.7
1N5153	1N5151	5.8*					75	1100	0.05	5.5

1N5153A-1N5450D

TYPE	REF.	CAPACITANCE					BV_R	Q @ f		P_D @ 25°C
		C_J C_T*	C Tol	C (max) C (min)	Voltage Range V_1	Voltage Range V_2				
		pF	%		Volts	Volts	Volts		GHz	Watts
1N5153A	1N5150A	6.4	10				75	1100	0.05	11.7
1N5154	1N5154	2.1*					35	1700	0.05	3.5
1N5155	1N5154	2.1*					35	1700	0.05	3.5
1N5155A	1N5150A	1.9	10				35	1700	0.05	8.75
1N5156	1N5156	0.8	25				20	3600	0.05	3.25*
1N5157	1N5156	0.8	25				20	3600	0.05	3.25*
1N5421		210	20	4.1	4.0	100	210	200	0.025	0.25
1N5422		340	20	4.1	4.0	100	210	200	0.025	0.25
1N5423		680	20	4.1	4.0	100	210	150	0.025	0.25
1N5424		680	20	4.2	4.0	100	115	300	0.010	0.25
1N5425		1370	20	4.2	4.0	100	115	200	0.010	0.25
1N5439		3.3*	20	2.3	2.0	30	30	450	0.05	0.4
1N5439A		3.3*	10	2.3	2.0	30	30	450	0.05	0.4
1N5439B		3.3*	5.0	2.3	2.0	30	30	450	0.05	0.4
1N5439C		3.3*	2.0	2.3	2.0	30	30	450	0.05	0.4
1N5439D		3.3*	1.0	2.3	2.0	30	30	450	0.05	0.4
1N5440		4.7*	20	2.4	2.0	30	30	450	0.05	0.4
1N5440A		4.7*	10	2.4	2.0	30	30	450	0.05	0.4
1N5440B		4.7*	5.0	2.4	2.0	30	30	450	0.05	0.4
1N5440C		4.7*	2.0	2.4	2.0	30	30	450	0.05	0.4
1N5440D		4.7*	1.0	2.4	2.0	30	30	450	0.05	0.4
1N5441		6.8*	20	2.5	2.0	30	30	450	0.05	0.4
1N5441A	1N5441A	6.8*	10	2.5	2.0	30	30	450	0.05	0.4
1N5441B	1N5441A	6.8*	5.0	2.5	2.0	30	30	450	0.05	0.4
1N5441C	1N5441A	6.8*	2.0	2.5	2.0	30	30	450	0.05	0.4
1N5441D	1N5441A	6.8*	1.0	2.5	2.0	30	30	450	0.05	0.4
1N5442		8.2*	20	2.5	2.0	30	30	450	0.05	0.4
1N5442A	1N5441A	8.2*	10	2.5	2.0	30	30	450	0.05	0.4
1N5442B	1N5441A	8.2*	5.0	2.5	2.0	30	30	450	0.05	0.4
1N5442C	1N5441A	8.2*	2.0	2.5	2.0	30	30	450	0.05	0.4
1N5442D	1N5441A	8.2*	1.0	2.5	2.0	30	30	450	0.05	0.4
1N5443		10*	20	2.6	2.0	30	30	400	0.05	0.4
1N5443A	1N5441A	10*	10	2.6	2.0	30	30	400	0.05	0.4
1N5443B	1N5441A	10*	5.0	2.6	2.0	30	30	400	0.05	0.4
1N5443C	1N5441A	10*	2.0	2.6	2.0	30	30	400	0.05	0.4
1N5443D	1N5441A	10*	1.0	2.6	2.0	30	30	400	0.05	0.4
1N5444		12*	20	2.6	2.0	30	30	400	0.05	0.4
1N5444A	1N5441A	12*	10	2.6	2.0	30	30	400	0.05	0.4
1N5444B	1N5441A	12*	5.0	2.6	2.0	30	30	400	0.05	0.4
1N5444C	1N5441A	12*	2.0	2.6	2.0	30	30	400	0.05	0.4
1N5444D	1N5441A	12*	1.0	2.6	2.0	30	30	400	0.05	0.4
1N5445		15*	20	2.6	2.0	30	30	400	0.05	0.4
1N5445A	1N5441A	15*	10	2.6	2.0	30	30	400	0.05	0.4
1N5445B	1N5441A	15*	5.0	2.6	2.0	30	30	400	0.05	0.4
1N5445C	1N5441A	15*	2.0	2.6	2.0	30	30	400	0.05	0.4
1N5445D	1N5441A	15*	1.0	2.6	2.0	30	30	400	0.05	0.4
1N5446		18*	20	2.6	2.0	30	30	350	0.05	0.4
1N5446A	1N5441A	18*	10	2.6	2.0	30	30	350	0.05	0.4
1N5446B	1N5441A	18*	5.0	2.6	2.0	30	30	350	0.05	0.4
1N5446C	1N5441A	18*	2.0	2.6	2.0	30	30	350	0.05	0.4
1N5446D	1N5441A	18*	1.0	2.6	2.0	30	30	350	0.05	0.4
1N5447		20*	20	2.6	2.0	30	30	350	0.05	0.4
1N5447A	1N5441A	20*	10	2.6	2.0	30	30	350	0.05	0.4
1N5447B	1N5441A	20*	5.0	2.6	2.0	30	30	350	0.05	0.4
1N5447C	1N5441A	20*	2.0	2.6	2.0	30	30	350	0.05	0.4
1N5447D	1N5441A	20*	1.0	2.6	2.0	30	30	350	0.05	0.4
1N5448		22*	20	2.6	2.0	30	30	350	0.05	0.4
1N5448A	1N5441A	22*	10	2.6	2.0	30	30	350	0.05	0.4
1N5448B	1N5441A	22*	5.0	2.6	2.0	30	30	350	0.05	0.4
1N5448C	1N5441A	22*	2.0	2.6	2.0	30	30	350	0.05	0.4
1N5448D	1N5441A	22*	1.0	2.6	2.0	30	30	350	0.05	0.4
1N5449		27*	20	2.6	2.0	30	30	350	0.05	0.4
1N5449A	1N5441A	27*	10	2.6	2.0	30	30	350	0.05	0.4
1N5449B	1N5441A	27*	5.0	2.6	2.0	30	30	350	0.05	0.4
1N5449C	1N5441A	27*	2.0	2.6	2.0	30	30	350	0.05	0.4
1N5449D	1N5441A	27*	1.0	2.6	2.0	30	30	350	0.05	0.4
1N5450		33*	20	2.6	2.0	30	30	350	0.05	0.4
1N5450A	1N5441A	33*	10	2.6	2.0	30	30	350	0.05	0.4
1N5450B	1N5441A	33*	5.0	2.6	2.0	30	30	350	0.05	0.4
1N5450C	1N5441A	33*	2.0	2.6	2.0	30	30	350	0.05	0.4
1N5450D	1N5441A	33*	1.0	2.6	2.0	30	30	350	0.05	0.4

TYPE	REF.	CAPACITANCE					BV_R	Q @ f		P_D @ 25°C
		C_J C_T*	C Tol	C (max) / C (min)	Voltage Range V_1	Voltage Range V_2				
		pF	%		Volts	Volts	Volts		GHz	Watts
1N5451		39*	20	2.6	2.0	30	30	300	0.05	0.4
1N5451A	1N5441A	39*	10	2.6	2.0	30	30	300	0.05	0.4
1N5451B	1N5441A	39*	5.0	2.6	2.0	30	30	300	0.05	0.4
1N5451C	1N5441A	39*	2.0	2.6	2.0	30	30	300	0.05	0.4
1N5451D	1N5441A	39*	1.0	2.6	2.0	30	30	300	0.05	0.4
1N5452		47*	20	2.6	2.0	30	30	250	0.05	0.4
1N5452A	1N5441A	47*	10	2.6	2.0	30	30	250	0.05	0.4
1N5452B	1N5441A	47*	5.0	2.6	2.0	30	30	250	0.05	0.4
1N5452C	1N5441A	47*	2.0	2.6	2.0	30	30	250	0.05	0.4
1N5452D	1N5441A	47*	1.0	2.6	2.0	30	30	250	0.05	0.4
1N5453		56*	20	2.6	2.0	30	30	200	0.05	0.4
1N5453A	1N5441A	56*	10	2.6	2.0	30	30	200	0.05	0.4
1N5453B	1N5441A	56*	5.0	2.6	2.0	30	30	200	0.05	0.4
1N5453C	1N5441A	56*	2.0	2.6	2.0	30	30	200	0.05	0.4
1N5453D	1N5441A	56*	1.0	2.6	2.0	30	30	200	0.05	0.4
1N5454		68*	20	2.7	2.0	30	30	175	0.05	0.4
1N5454A	1N5441A	68*	10	2.7	2.0	30	30	175	0.05	0.4
1N5454B	1N5441A	68*	5.0	2.7	2.0	30	30	175	0.05	0.4
1N5454C	1N5441A	68*	2.0	2.7	2.0	30	30	175	0.05	0.4
1N5454D	1N5441A	68*	1.0	2.7	2.0	30	30	175	0.05	0.4
1N5455		82*	20	2.7	2.0	30	30	175	0.05	0.4
1N5455A	1N5441A	82*	10	2.7	2.0	30	30	175	0.05	0.4
1N5455B	1N5441A	82*	5.0	2.7	2.0	30	30	175	0.05	0.4
1N5455C	1N5441A	82*	2.0	2.7	2.0	30	30	175	0.05	0.4
1N5455D	1N5441A	82*	1.0	2.7	2.0	30	30	175	0.05	0.4
1N5456		100*	20	2.7	2.0	30	30	175	0.05	0.4
1N5456A	1N5441A	100*	10	2.7	2.0	30	30	175	0.05	0.4
1N5456B	1N5441A	100*	5.0	2.7	2.0	30	30	175	0.05	0.4
1N5456C	1N5441A	100*	2.0	2.7	2.0	30	30	175	0.05	0.4
1N5456D	1N5441A	100*	1.0	2.7	2.0	30	30	175	0.05	0.4
1N5457		120*	20	2.7	2.0	30	30	150	0.05	0.4
1N5457A		120*	10	2.7	2.0	30	30	150	0.05	0.4
1N5457B		120*	5.0	2.7	2.0	30	30	150	0.05	0.4
1N5457C		120*	2.0	2.7	2.0	30	30	150	0.05	0.4
1N5457D		120*	1.0	2.7	2.0	30	30	150	0.05	0.4
1N5458		3.9*	20	2.5	2.0	30	30	600	0.05	0.4
1N5458A		3.9*	10	2.5	2.0	30	30	600	0.05	0.4
1N5458B		3.9*	5.0	2.5	2.0	30	30	600	0.05	0.4
1N5458C		3.9*	2.0	2.5	2.0	30	30	600	0.05	0.4
1N5458D		3.9*	1.0	2.5	2.0	30	30	600	0.05	0.4
1N5459		4.7*	20	2.6	2.0	30	30	600	0.05	0.4
1N5459A		4.7*	10	2.6	2.0	30	30	600	0.05	0.4
1N5459B		4.7*	5.0	2.6	2.0	30	30	600	0.05	0.4
1N5459C		4.7*	2.0	2.6	2.0	30	30	600	0.05	0.4
1N5459D		4.7*	1.0	2.6	2.0	30	30	600	0.05	0.4
1N5460		5.6*	20	2.6	2.0	30	30	600	0.05	0.4
1N5460A		5.6*	10	2.6	2.0	30	30	600	0.05	0.4
1N5460B		5.6*	5.0	2.6	2.0	30	30	600	0.05	0.4
1N5460C		5.6*	2.0	2.6	2.0	30	30	600	0.05	0.4
1N5460D		5.6*	1.0	2.6	2.0	30	30	600	0.05	0.4
1N5461		6.8*	20	2.7	2.0	30	30	600	0.05	0.4
1N5461A	1N5461A	6.8*	10	2.7	2.0	30	30	600	0.05	0.4
1N5461B	1N5461A	6.8*	5.0	2.7	2.0	30	30	600	0.05	0.4
1N5461C	1N5461A	6.8*	2.0	2.7	2.0	30	30	600	0.05	0.4
1N5461D	1N5461A	6.8*	1.0	2.7	2.0	30	30	600	0.05	0.4
1N5462		8.2*	20	2.8	2.0	30	30	600	0.05	0.4
1N5462A	1N5461A	8.2*	10	2.8	2.0	30	30	600	0.05	0.4
1N5462B	1N5461A	8.2*	5.0	2.8	2.0	30	30	600	0.05	0.4
1N5462C	1N5461A	8.2*	2.0	2.8	2.0	30	30	600	0.05	0.4
1N5462D	1N5461A	8.2*	1.0	2.8	2.0	30	30	600	0.05	0.4
1N5463		10*	20	2.8	2.0	30	30	550	0.05	0.4
1N5463A	1N5461A	10*	10	2.8	2.0	30	30	550	0.05	0.4
1N5463B	1N5461A	10*	5.0	2.8	2.0	30	30	550	0.05	0.4
1N5463C	1N5461A	10*	2.0	2.8	2.0	30	30	550	0.05	0.4
1N5463D	1N5461A	10*	1.0	2.8	2.0	30	30	550	0.05	0.4
1N5464		12*	20	2.8	2.0	30	30	550	0.05	0.4
1N5464A	1N5461A	12*	10	2.8	2.0	30	30	550	0.05	0.4
1N5464B	1N5461A	12*	5.0	2.8	2.0	30	30	550	0.05	0.4
1N5464C	1N5461A	12*	2.0	2.8	2.0	30	30	550	0.05	0.4
1N5464D	1N5461A	12*	1.0	2.8	2.0	30	30	550	0.05	0.4

1N5465-1N5476D

TYPE	REF.	CAPACITANCE					BV_R	Q @ f		P_D @ 25°C
		C_J C_T*	C Tol	C (max) / C (min)	Voltage Range V_1	Voltage Range V_2				
		pF	%		Volts	Volts	Volts		GHz	Watts
1N5465		15*	20	2.8	2.0	30	30	550	0.05	0.4
1N5465A	1N5461A	15*	10	2.8	2.0	30	30	550	0.05	0.4
1N5465B	1N5461A	15*	5.0	2.8	2.0	30	30	550	0.05	0.4
1N5465C	1N5461A	15*	2.0	2.8	2.0	30	30	550	0.05	0.4
1N5465D	1N5461A	15*	1.0	2.8	2.0	30	30	550	0.05	0.4
1N5466		18*	20	2.9	2.0	30	30	500	0.05	0.4
1N5466A	1N5461A	18*	10	2.9	2.0	30	30	500	0.05	0.4
1N5466B	1N5461A	18*	5.0	2.9	2.0	30	30	500	0.05	0.4
1N5466C	1N5461A	18*	2.0	2.9	2.0	30	30	500	0.05	0.4
1N5466D	1N5461A	18*	1.0	2.9	2.0	30	30	500	0.05	0.4
1N5467		20*	20	2.9	2.0	30	30	500	0.05	0.4
1N5467A	1N5461A	20*	10	2.9	2.0	30	30	500	0.05	0.4
1N5467B	1N5461A	20*	5.0	2.9	2.0	30	30	500	0.05	0.4
1N5467C	1N5461A	20*	2.0	2.9	2.0	30	30	500	0.05	0.4
1N5467D	1N5461A	20*	1.0	2.9	2.0	30	30	500	0.05	0.4
1N5468		22*	20	2.9	2.0	30	30	500	0.05	0.4
1N5468A	1N5461A	22*	10	2.9	2.0	30	30	500	0.05	0.4
1N5468B	1N5461A	22*	5.0	2.9	2.0	30	30	500	0.05	0.4
1N5468C	1N5461A	22*	2.0	2.9	2.0	30	30	500	0.05	0.4
1N5468D	1N5461A	22*	1.0	2.9	2.0	30	30	500	0.05	0.4
1N5469		27*	20	2.9	2.0	30	30	500	0.05	0.4
1N5469A	1N5461A	27*	10	2.9	2.0	30	30	500	0.05	0.4
1N5469B	1N5461A	27*	5.0	2.9	2.0	30	30	500	0.05	0.4
1N5469C	1N5461A	27*	2.0	2.9	2.0	30	30	500	0.05	0.4
1N5469D	1N5461A	27*	1.0	2.9	2.0	30	30	500	0.05	0.4
1N5470		33*	20	2.9	2.0	30	30	500	0.05	0.4
1N5470A	1N5461A	33*	10	2.9	2.0	30	30	500	0.05	0.4
1N5470B	1N5461A	33*	5.0	2.9	2.0	30	30	500	0.05	0.4
1N5470C	1N5461A	33*	2.0	2.9	2.0	30	30	500	0.05	0.4
1N5470D	1N5461A	33*	1.0	2.9	2.0	30	30	500	0.05	0.4
1N5471		39*	20	2.9	2.0	30	30	450	0.05	0.4
1N5471A	1N5461A	39*	10	2.9	2.0	30	30	450	0.05	0.4
1N5471B	1N5461A	39*	5.0	2.9	2.0	30	30	450	0.05	0.4
1N5471C	1N5461A	39*	2.0	2.9	2.0	30	30	450	0.05	0.4
1N5471D	1N5461A	39*	1.0	2.9	2.0	30	30	450	0.05	0.4
1N5472		47*	20	2.9	2.0	30	30	400	0.05	0.4
1N5472A	1N5461A	47*	10	2.9	2.0	30	30	400	0.05	0.4
1N5472B	1N5461A	47*	5.0	2.9	2.0	30	30	400	0.05	0.4
1N5472C	1N5461A	47*	2.0	2.9	2.0	30	30	400	0.05	0.4
1N5472D	1N5461A	47*	1.0	2.9	2.0	30	30	400	0.05	0.4
1N5473		56*	20	2.9	2.0	30	30	300	0.05	0.4
1N5473A	1N5461A	56*	10	2.9	2.0	30	30	300	0.05	0.4
1N5473B	1N5461A	56*	5.0	2.9	2.0	30	30	300	0.05	0.4
1N5473C	1N5461A	56*	2.0	2.9	2.0	30	30	300	0.05	0.4
1N5473D	1N5461A	56*	1.0	2.9	2.0	30	30	300	0.05	0.4
1N5474		68*	20	2.9	2.0	30	30	250	0.05	0.4
1N5474A	1N5461A	68*	10	2.9	2.0	30	30	250	0.05	0.4
1N5474B	1N5461A	68*	5.0	2.9	2.0	30	30	250	0.05	0.4
1N5474C	1N5461A	68*	2.0	2.9	2.0	30	30	250	0.05	0.4
1N5474D	1N5461A	68*	1.0	2.9	2.0	30	30	250	0.05	0.4
1N5475		82*	20	2.9	2.0	30	30	225	0.05	0.4
1N5475A	1N5461A	82*	10	2.9	2.0	30	30	225	0.05	0.4
1N5475B	1N5461A	82*	5.0	2.9	2.0	30	30	225	0.05	0.4
1N5475C	1N5461A	82*	2.0	2.9	2.0	30	30	225	0.05	0.4
1N5475D	1N5461A	82*	1.0	2.9	2.0	30	30	225	0.05	0.4
1N5476		100*	20	2.9	2.0	30	30	200	0.05	0.4
1N5476A	1N5461A	100*	10	2.9	2.0	30	30	200	0.05	0.4
1N5476B	1N5461A	100*	5.0	2.9	2.0	30	30	200	0.05	0.4
1N5476C	1N5461A	100*	2.0	2.9	2.0	30	30	200	0.05	0.4
1N5476D	1N5461A	100*	1.0	2.9	2.0	30	30	200	0.05	0.4

TUNNEL DIODES

Index and Short-Form Specifications

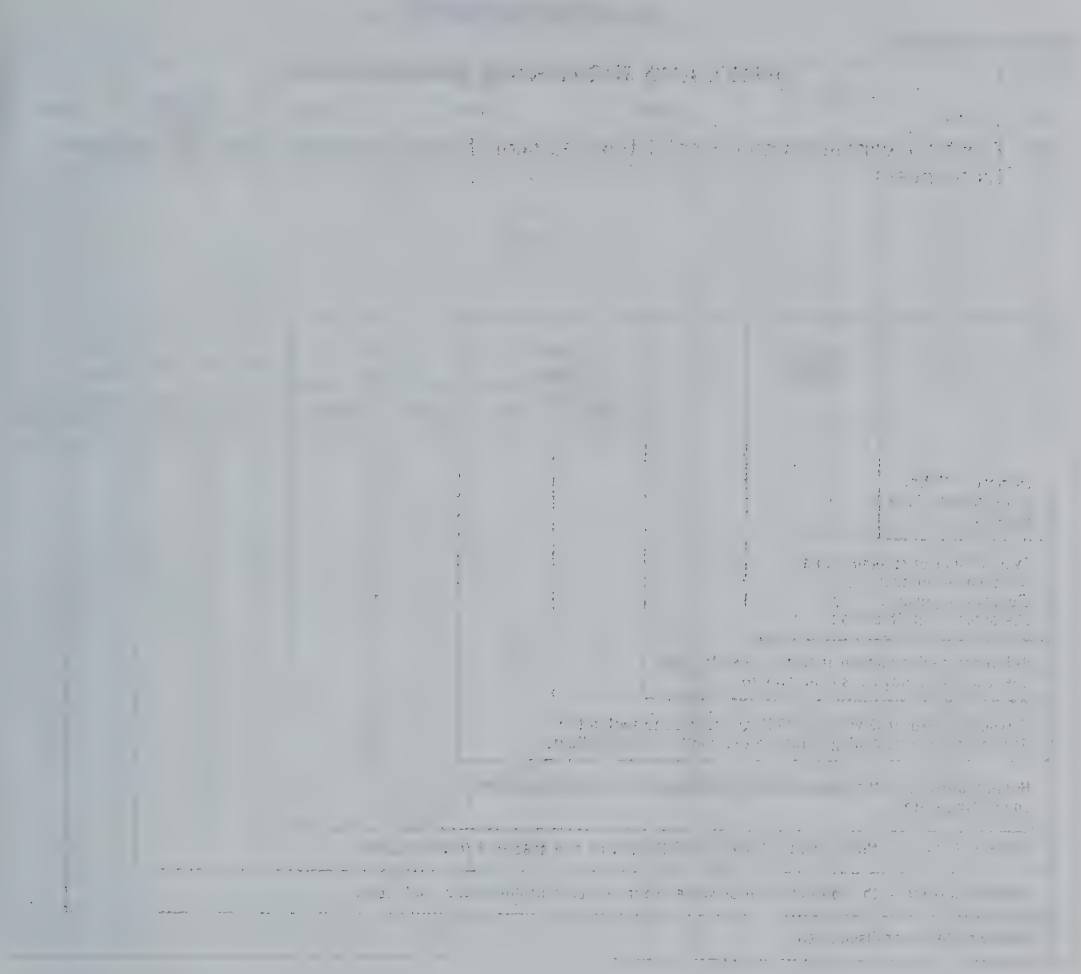
This table contains a numerical listing and short-form specifications for tunnel diodes with EIA-registered 1N numbers.

KEY

TYPE	MATERIAL	I_P (mA)	I_P/I_V	V_P (mV)	C C_J* (pF)	f (GHz)
Numerical Listing of Registered Type Numbers						Resistive Cutoff Frequency
S = Silicon G = Germanium GA = Gallium Arsenide					Total Capacitance *Junction Capacitance	
Peak Current				Forward Voltage measured at the Peak Point		
Ratio of Peak Current to Valley Current						

TYPE	MATERIAL	I_P (mA)	I_P/I_V	V_P (mV)	C C_J* (pF)	f (GHz)
1N2927	S	0.10	2.5	75	80	
1N2927A	S	0.10	3.2	70	80	
1N2928	S	0.47	2.5	80	100	
1N2928A	S	0.47	3.2	74	100	
1N2929	S	1.0	2.5	80	150	
1N2929A	S	1.0	3.2	75	150	
1N2930	S	4.7	2.5	85	250	
1N2930A	S	4.7	3.2	79	250	
1N2931	S	10	2.5	85	400	
1N2931A	S	10	3.2	80	400	
1N2932	S	22	2.5	90	1200	
1N2932A	S	22	3.2	82	1200	
1N2933	S	47	2.5	90	1800	
1N2933A	S	47	3.2	83	1800	
1N2934	S	100	2.5	90	2500	
1N2934A	S	100	3.2	85	2500	
1N2939	G	1.0	10	65	15	2.2
1N2939A	G	1.0	7.0	60	10	
1N2940	G	1.0	7.7	65	10	2.2
1N2940A	G	1.0	4.4	65	7.0	
1N2941	G	4.7	7.9	65	50	2.6
1N2941A	G	4.7	4.4	65	30	
1N2969	G	2.2	7.6	65	25	2.5
1N2969A	G	2.2	4.5	65	15	
1N3113	GA	1.0	10		10	
1N3114	GA	2.2	10		10	
1N3115	GA	2.2	10		10	
1N3116	GA	4.7	10		15	
1N3117	GA	4.7	9.0		15	
1N3118	GA	10	10	160	20*	
1N3119	GA	10			20	
1N3120	GA	22	10			
1N3128	G	5.0	8.0	65	15	
1N3129	G	20	8.0	90	20	
1N3130	G	50	8.0	120	25	
1N3138	GA	50	13	260	30	
1N3149	G	10	7.7	65	90	2.6
1N3149A	G	10	4.4	65	50	
1N3150	G	22	7.6	65	125	2.2
1N3217	G	0.47	4.7		8.0	
1N3218	G	1.0	5.0		10	
1N3218A	G	1.0	5.0		5.0	
1N3219	G	2.2	5.0		20	
1N3219A	G	2.2	5.0		10	
1N3220	G	4.7	4.7		30	
1N3221	G	10	5.0	65	100	2.6
1N3221A	G	10	6.0		35	
1N3222	G	22	5.1		150	
1N3560	G	1.0	5.0	55	20	1.3
1N3561	G	1.0	8.0	55	20	1.3
1N3562	G	5.0	6.0	55	85	1.3
1N3712	G	1.0	5.0	65	10	2.3
1N3713	G	1.0	7.0	65	5.0	3.2
1N3714	G	2.2	4.2	65	25*	2.2
1N3715	G	2.2	7.0	65	10	3.0
1N3716	G	4.7	4.0	65	50	1.8
1N3717	G	4.7	7.6	65	25	3.4
1N3718	G	10	4.1	65	90	1.6
1N3719	G	10	7.0	65	50	
1N3720	G	22	4.2	65	150	1.6

TYPE	MATERIAL	I_P (mA)	I_P/I_V	V_P (mV)	C C_J* (pF)	f (GHz)
1N3721	G	22	7.0	65	100	2.6
1N3847	G	5.0	6.0		25	
1N3848	G	10	6.0		25	
1N3849	G	20	6.0		30	
1N3850	G	50	6.0		40	
1N3851	G	100	6.0		40	
1N3852	G	5.0	8.0	70	15	
1N3853	G	10	8.0	75	15	
1N3854	G	20	8.0	85	20	
1N3855	G	50	8.0	105	25	
1N3856	G	100	8.0	115	25	
1N3857	G	5.0	8.0	70	8.0	
1N3858	G	10	8.0	75	8.0	
1N3859	G	20	8.0	85	10	
1N3860	G	50	8.0	105	12	
1N3948	S	4.7	3.5	80		
1N4393	S	0.10	2.5	75	80	
1N4393A	S	0.10	3.2	70	80	
1N4393B	S	0.10	3.5	65	80	
1N4394	S	0.22	2.5	80	90	
1N4394A	S	0.22	3.2	72	90	
1N4394B	S	0.22	3.6	67	90	
1N4395	S	0.47	2.5	80	100	
1N4395A	S	0.47	3.2	74	100	
1N4395B	S	0.47	3.5	69	100	
1N4396	S	1.0	2.5	80	150	
1N4396A	S	1.0	3.2	75	150	
1N4396B	S	1.0	3.5	70	150	
1N4397	S	2.2	2.5	80	200	
1N4397A	S	2.2	3.2	77	200	
1N4397B	S	2.2	3.5	73	200	
1N4398	S	4.7	2.5	85	250	
1N4398A	S	4.7	3.2	79	250	
1N4398B	S	4.7	3.5	74	250	
1N4399	S	10	2.5	85	400	
1N4399A	S	10	3.2	80	400	
1N4399B	S	10	3.5	75	400	



4-LAYER DIODES

INDEX AND SHORT-FORM SPECIFICATIONS

This table contains a numerical listing and short-form specifications with EIA-registered 1N numbers.

KEY

TYPE	REPLACE-MENT	REF.	$V_{(BR)F}$ (volts)		I_H (mA)		V_F @ I_F		I_F (mA)	P_D (mW)
			(min)	(max)	(min)	(max)	(volts)	(mA)	(max)	
Numerical listing of Registered Type Numbers										
	Type number of recommended replacement or nearest electrical equivalent fully characterized in this book									
		Reference device number indicates specific Data Sheet on which device is characterized								
			Forward Breakover (Switching) Voltage required to switch the device from the "blocking" state to the "on" state (in volts dc)							
					Holding Current — the value of current required to hold the diode in the conducting state					
							Forward Voltage — the forward voltage across the device at a specified forward current, I_F			
									Forward Current — the continuous or dc value of forward current during the "on" state	
										Steady state power dissipation

4-LAYER DIODES INDEX

TYPE	REPLACE-MENT	REF.	$V_{(BR)F}$ (volts)		I_H (mA)		V_F @ I_F		I_F (mA)	P_D
			(min)	(max)	(min)	(max)	(volts)	(mA)	(max)	(mW)
1N3299			36	44	1.0	15				150
1N3300			14.4	21.6	1.0	15	1.5	30	200	400
1N3300A			16.2	19.8	1.0	15	1.5	30	200	400
1N3301			17.6	26.4	1.0	15	1.5	30	200	400
1N3301A			19.8	24.2	1.0	15	1.5	30	200	400
1N3302			21.6	32.4	5.0	20	1.5	30	200	400
1N3302A			24.3	29.7	5.0	20	1.5	30	200	400
1N3303			26.4	39.6	5.0	20	1.5	30	200	400
1N3303A			29.7	36.3	5.0	20	1.5	30	200	400
1N3304			31.2	46.8	5.0	20	1.5	30	200	400
1N3304A			35.1	42.9	5.0	20	1.5	30	200	400
1N3489			16	24	1.0	6.0				150
1N3489A			16	24	1.0	6.0				150
1N3490			16	24	14	45				150
1N3771						4.0	1.2			
1N3772						50	1.2			
1N3831			16	24	0.5	15	1.2	15	150	150
1N3832			21	29	0.5	15	1.2	15	150	150
1N3833			26	34	0.5	15	1.2	15	150	150
1N3834			31	39	0.5	15	1.2	15	150	150
1N3835			36	44	0.5	15	1.2	15	150	150
1N3836			41	49	0.5	15	1.2	15	150	150
1N3837			46	54	0.5	15	1.2	15	150	150
1N3838			90	110	0.5	15	1.2	15	150	150
1N3839			16	24	14	50	1.2	50	150	150
1N3840			21	29	14	50	1.2	50	150	150
1N3841			26	34	14	50	1.2	50	150	150
1N3842			31	39	14	50	1.2	50	150	150
1N3843			36	44	14	50	1.2	50	150	150
1N3844			41	49	14	50	1.2	50	150	150
1N3845			46	54	14	50	1.2	50	150	150
1N3846			90	110	14	50	1.2	50	150	150
1N3935				30		30				
1N3936				20		8.0				
1N3937				100		3.5				
1N5158		M4L3052	8.0	10	1.0	20	1.5	150	150	150
1N5159		M4L3052	9.0	11	1.0	20	1.5	150	150	150
1N5160		M4L3052	10	12	1.0	20	1.5	150	150	150

TRANSIENT SUPPRESSOR DIODES

INDEX AND SHORT FORM SPECIFICATIONS

The following table provides a numerical index and short-form specifications for Voltage Transient Suppressor diodes with EIA-registered type numbers introduced since the publication of the Motorola Semiconductor Data Book (4th Edition).

KEY

TYPE	REPLACE-MENT	REFERENCE	$V_{(BR)R}$	I_R	V_{RM}	V_R	i_R	TC
Numerical Listing of Registered Type Numbers.								
	Type number of recommended replacement or of nearest electrical equivalent fully characterized in this book							
		Reference device number indicates specific Data Sheet on which device is characterized						
			Breakdown Voltage					
				Reverse Current				
					Reverse Voltage (working) @ $T_A = 25°C$			
						Peak Reverse Voltage during Reverse Surge		
							Maximum Surge Current	
								Temperature Coefficient of Breakdown Voltage

TYPE	MATERIAL	REPLACEMENT	REFERENCE	$V_{(BR)R}$ @ I_R Volts (min)	mAdc	V_{RM} Volts (wkg)	V_R Volts	I_R (surge) AMP (max)	TC %/°C (max)
1N5555	S	1N2991B	1N2970	33	0.005	21.5	30.5	-	0.093
1N5556	S	1N2995B	1N2970	43.7	0.005	28.5	40.3	-	0.094
1N5557	S	1N2997B	1N2970	54	0.005	34.5	49	-	0.096
1N5558	S	1N3015B	1N2970	191	0.005	124	175	-	0.100
1N5610	S	1N2991B	1N2970	33	1.0		30.5	32	+0.1
1N5611	S	1N2995B	1N2970	43.7	1.0		40.3	24	+0.1
1N5612	S	1N2997B	1N2970	54	1.0		49	19	+0.1
1N5613	S	1N3015B	1N2970	191	1.0		175	5.7	+0.1
1N5629	S	1N2970A	1N2970	6.12	10	5.5	10.8	139	0.057
1N5629A	S	1N2970B	1N2970	6.45	10	5.8	10.5	143	0.057
1N5630	S	1N2971A	1N2970	6.75	10	6.05	11.7	128	0.061
1N5630A	S	1N2971B	1N2970	7.13	10	6.40	11.3	132	0.061
1N5631	S	1N2972A	1N2970	7.38	10	6.63	12.5	120	0.065
1N5631A	S	1N2972B	1N2970	7.79	10	7.02	12.1	124	0.065
1N5632	S	1N2973A	1N2970	8.19	1.0	7.37	13.8	109	0.068
1N5632A	S	1N2973B	1N2970	8.65	1.0	7.78	13.4	112	0.068
1N5633	S	1N2974A	1N2970	9.0	1.0	8.10	15	100	0.073
1N5633A	S	1N2974B	1N2970	9.5	1.0	8.55	1.45	103	0.073
1N5634	S	1N2975A	1N2970	9.9	1.0	8.92	16.2	93	0.075
1N5634A	S	1N2975B	1N2970	10.5	1.0	9.40	15.6	96	0.075
1N5635	S	1N2976A	1N2970	10.8	1.0	9.72	17.3	87	0.078
1N5635A	S	1N2976B	1N2970	11.4	1.0	10	16.7	90	0.078
1N5636	S	1N2977A	1N2970	11.7	1.0	10.5	19	79	0.081
1N5636A	S	1N2977B	1N2970	12.4	1.0	11.1	18.2	82	0.081
1N5637	S	1N2979A	1N2970	13.5	1.0	12.1	22	68	0.084
1N5637A	S	1N2979B	1N2970	14.3	1.0	12.8	21.2	71	0.084
1N5638	S	1N2980A	1N2970	14.4	1.0	12.9	23.5	64	0.086
1N5638A	S	1N2980B	1N2970	15.2	1.0	13.6	22.5	67	0.086
1N5639	S	1N2982A	1N2970	16.2	1.0	14.5	26.5	56.5	0.088
1N5639A	S	1N2982B	1N2970	17.1	1.0	15.3	25.2	59.5	0.088
1N5640	S	1N2984A	1N2970	18	1.0	16.2	29.1	51.5	0.090
1N5640A	S	1N2984B	1N2970	19	1.0	17.1	27.7	54	0.090
1N5641	S	1N2985A	1N2970	19.8	1.0	17.8	31.9	47	0.092
1N5641A	S	1N2985B	1N2970	20.9	1.0	18.8	30.6	49	0.092
1N5642	S	1N2986A	1N2970	21.6	1.0	19.4	34.7	43	0.094
1N5642A	S	1N2986B	1N2970	22.8	1.0	20.5	33.2	45	0.094
1N5643	S	1N2988A	1N2970	24.3	1.0	21.8	39.1	38.5	0.096
1N5643A	S	1N2988B	1N2970	25.7	1.0	23.1	37.5	40	0.096
1N5644	S	1N2989A	1N2970	27	1.0	24.3	43.5	34.5	0.097
1N5644A	S	1N2989B	1N2970	28.5	1.0	25.6	41.4	36	0.097
1N5645	S	1N2990A	1N2970	29.7	1.0	26.8	47.7	31.5	0.098
1N5645A	S	1N2990B	1N2970	31.4	1.0	28.2	45.7	33	0.098
1N5646	S	1N2991A	1N2970	32.4	1.0	29.1	52	29	0.099
1N5646A	S	1N2991B	1N2970	34.2	1.0	30.8	49.9	30	0.099
1N5647	S	1N2992A	1N2970	35.1	1.0	31.6	56.4	26.5	0.100
1N5647A	S	1N2992B	1N2970	37.1	1.0	33.3	53.9	28	0.100
1N5648	S	1N2993A	1N2970	38.7	1.0	34.8	61.9	24	0.101
1N5648A	S	1N2993B	1N2970	40.9	1.0	36.8	59.3	25.3	0.101
1N5649	S	1N2995A	1N2970	42.3	1.0	38.1	67.8	22.2	0.101
1N5649A	S	1N2995B	1N2970	44.7	1.0	40.2	64.8	23.2	0.101
1N5650	S	1N2997A	1N2970	45.9	1.0	41.3	73.5	20.4	0.102
1N5650A	S	1N2997B	1N2970	48.5	1.0	43.6	70.1	21.4	0.102
1N5651	S	1N2999A	1N2970	50.4	1.0	45.4	80.5	18.6	0.103
1N5651A	S	1N2999B	1N2970	53.2	1.0	47.8	77	19.5	0.103
1N5652	S	1N3000A	1N2970	55.8	1.0	50.2	89	16.9	0.104
1N5652A	S	1N3000B	1N2970	58.9	1.0	53	85	17.7	0.104
1N5653	S	1N3001A	1N2970	61.2	1.0	55.1	98	15.3	0.104
1N5653A	S	1N3001B	1N2970	64.6	1.0	58.1	92	16.3	0.104
1N5654	S	1N3002A	1N2970	67.5	1.0	60.7	108	13.9	0.105
1N5654A	S	1N3002B	1N3970	71.3	1.0	64.1	103	14.6	0.105
1N5655	S	1N3003A	1N2970	73.8	1.0	66.4	118	12.7	0.105
1N5655A	S	1N3003B	1N2970	77.9	1.0	70.1	113	13.3	0.105
1N5656	S	1N3004A	1N2970	81.9	1.0	73.7	131	11.4	0.106
1N5656A	S	1N3004B	1N2970	86.5	1.0	77.8	125	12	0.106
1N5657	S	1N3005A	1N2970	90	1.0	81	144	10.4	0.106
1N5657A	S	1N3005B	1N2970	95	1.0	85.5	137	11	0.106
1N5658	S	1N3007A	1N2970	99	1.0	89.2	158	9.5	0.107
1N5658A	S	1N3007B	1N2970	105	1.0	94	152	9.9	0.107
1N5659	S	1N3008A	1N2970	108	1.0	97.2	173	8.7	0.107
1N5659A	S	1N3008B	1N2970	114	1.0	102	165	9.1	0.107
1N5660	S	1N3009A	1N2970	117	1.0	105	187	8.0	0.107
1N560A	S	1N3009B	1N2970	124	1.0	111	179	8.4	0.107
1N5661	S	1N3011A	1N2970	135	1.0	121	215	7.0	0.108
1N5661A	S	1N3011B	1N2970	143	1.0	128	207	7.2	0.108
1N5662	S	1N3012A	1N2970	144	1.0	130	230	6.5	0.108
1N5662A	S	1N3012B	1N2970	152	1.0	136	219	6.8	0.108
1N5663	S	1N3013A	1N2970	153	1.0	138	244	6.2	0.108
1N5663A	S	1N3013B	1N2970	162	1.0	145	234	6.4	0.108
1N5664	S	1N3014A	1N2970	162	1.0	146	258	5.8	0.108
1N5664A	S	1N3014B	1N2970	171	1.0	154	246	6.1	0.108
1N5665	S	1N3015A	1N2970	180	1.0	162	287	5.2	0.108
1N5665A	S	1N3015B	1N2970	190	1.0	171	274	5.5	0.108

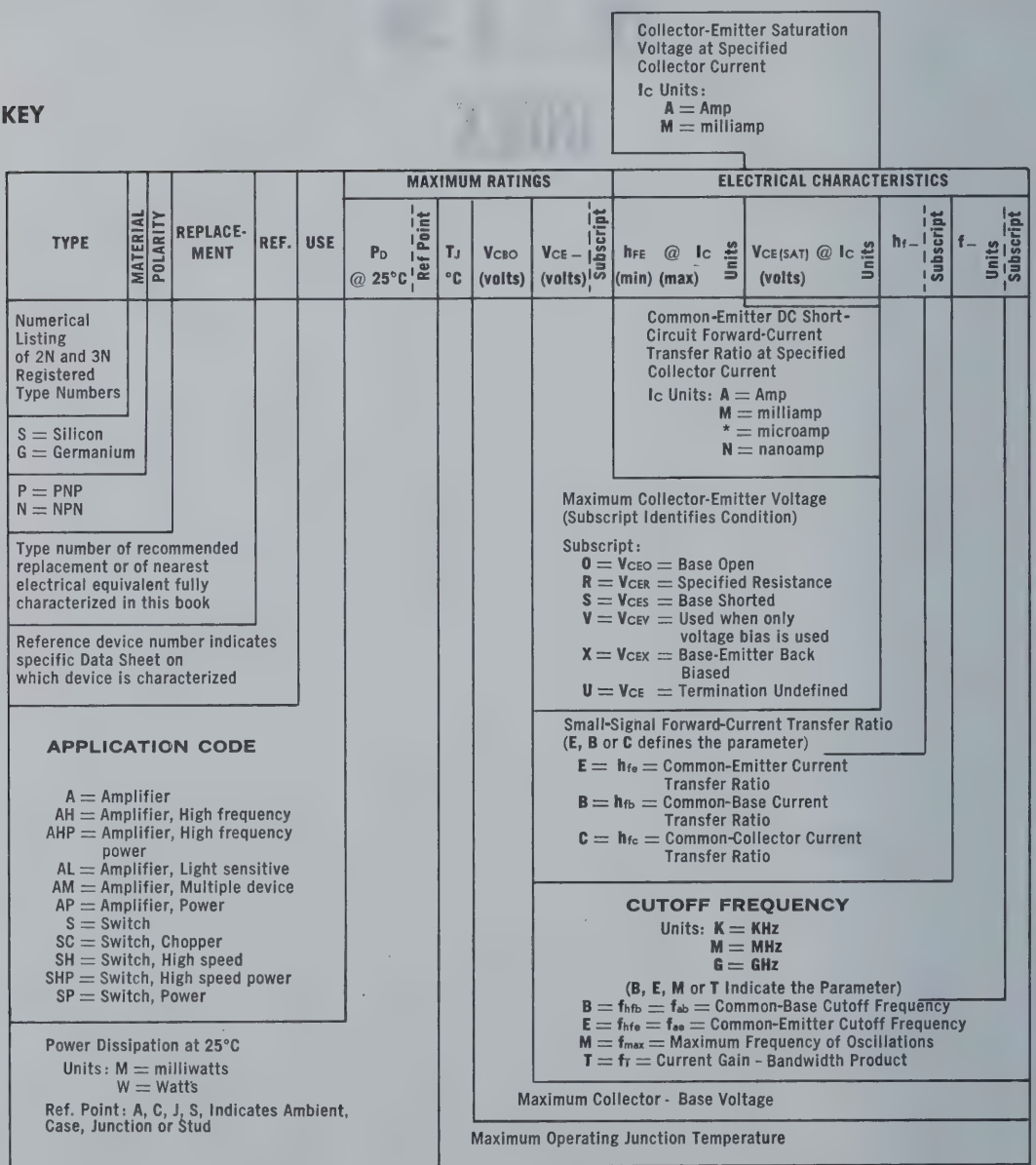
2N... & 3N

INDEX

NUMERICAL INDEX

Numerical Listing of EIA-Registered 2N and 3N Type Numbers and Short-Form specifications for devices introduced since the publication of the Motorola Semiconductor Data Book (4th Edition).

KEY



TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N21		P			S	0.12W	A	85	100											
2N22	G	P			S	145M	A	55	100	100	O						2.0	B		
2N23	G	P			S	105M	A	55	40	50	O						2.0	B		
2N24	G	P			A	145M	A	50	30	30	O						2.2	B		
2N25	G	P			AH	200M	A	60	50	50	O						2.5	B	3.0M	B
2N26	G	P			S	90M	A	55	30	40	O									
2N27		N			A	50M	A	85	35								0.95	B	1.0M	B
2N28		N			A	50M	A	85	30								0.94	B	0.5M	B
2N29		N			A	50M	A	85	35								0.96	B	1.0M	B
2N30	G	P			A	100M	A	40	35										3.0M	B
2N31	G	P			A	100M	A	40	35										3.0M	B
2N32	G	P			S	50M	A		40											
2N32A	G	P			S	50M	A		40											
2N33	G	P			AH	30M	A		8.5											
2N34	G	P	2N1191	2N1191	A	50M	A		25											
2N34A	G	P			A	50M	A		25											
2N35	G	P			A	50M	A		25											
2N35A	G	N																		
2N36	G	P	2N1191	2N1191	A	50M	A	50	20											
2N37	G	P	2N1191	2N1191	A	50M	A	20									30	E		
2N38	G	P	2N1191	2N1191	A	50M	A										15	E		
2N38A	G	P			A	50M	A	20	20											
2N41	G	P			A	50M	A		25											
2N43	G	P			A	240M	A	85	45	30	O	34		20M			30	E	500K	B
2N43A	G	P	2N525	2N524	A	240M	A	85	45	30	O	34	65	20M			30	E	500K	B
2N44	G	P	2N524	2N524	A	240M	A	85	45	30	O	18	43	20M					500K	B
2N45	G	P	2N524	2N524	A	240M	A	85	45	30	O	18		20M					500K	B
2N46	G	P			A	50M	A		25											
2N47	G	P	2N1191	2N1191	A	50M			35											
2N48	G	P			A	50M			35											
2N49	G	P	2N1191	2N1191	A	50M			35											
2N50	G				S	50M	A	50	15											
2N51	G				S	0.1W	A	50	50											
2N52	G				S	0.12W	A	50	50											
2N53	G				S	0.1W	A	50	50											
2N54	G	P	2N1191	2N1191	A	0.2W	A	60	45											
2N55	G	P	2N1191	2N1191	A	0.2W	A	60	45											
2N56	G	P	2N1191	2N1191	A	0.2W	A	60	45											
2N57	G	P			AP	20W	C		60											
2N59	G	P	2N1193	2N1191	A	180M	A	85	25	25	O									
2N59A	G	P			A	180M	A	85	40	40	O									
2N59B	G	P			A	180M	A	85	50	50	O									
2N59C	G	P			A	180M	A	85	60	60	O									
2N60	G	P	2N1193	2N1191	A	180M	A	85	25	25	O									
2N60A	G	P			A	180M	A	85	40	40	O									
2N60B	G	P			A	180M	A	85	50	50	O									
2N60C	G	P			A	180M	A	85	60	60	O									
2N61	G	P	2N1192	2N1191	A	180M	A	85	25	25	O									
2N61A	G	P			A	180M	A	85	40	40	O									
2N61B	G	P			A	180M	A	85	50	50	O									
2N61C	G	P			A	180M	A	85	60	60	O									
2N62	G	P	2N1191	2N1191	A	50M			35											
2N63	G	P	2N1191	2N1191	A	102M	A	85	44	44	S									
2N64	G	P	2N1191	2N1191	A	102M	A	85	30	30	S									
2N65	G	P	2N1193	2N1191	A		A	85	24	24	S									
2N66		P			AP	27.5W	C	80	60	40										
2N67		P			S	0.1W	A	85	50											
2N68	G	P			AP	2.0W	A	70	25											
2N71		P			AP	1.0W	A	60	75	50	U									
2N72	G	P			S	50M	A		40											
2N73		P			SC	0.2W	A			50	U									
2N74		P			S	0.2W	A			50	U									
2N75		P			S	0.2W	A			20	U									
2N76	G	P	2N319	2N319	A	5.0M	J	60	20										500K	B
2N77	G	P	2N1191	2N1191	A	35M	A		25											
2N78	G	N			AH	65M	A	85	15	15	O	45	135	1.0M			0.97	B	5.0M	B
2N78A	G	N			AH	65M	A	85	20	15	O	45	135	1.0M			0.97	B	5.0M	B
2N79	G	P	2N1191	2N1191	A	35M	A		35											
2N80	G	P			A	50M	A		25											
2N81	G	P	2N1191	2N1191	A	50M	A	100		20	O						20	E		
2N82	G	P	2N1191	2N1191	A	35M	A	71	20			20	60	1.0M						
2N94	G	N			AH	150M	A	85	20	20	R	20	80	1.0M			7.5		2.0M	B
2N94A	G	N			AH	150M	A	85	20	20	R	20	80	1.0M			5.0		5.0M	B
2N95		N			AP	2.5W	A	70	25											
2N96	G	P			A	50M	A		30										500K	B
2N97	G	N			A	50M	A	75	30								5.0	E	0.5M	B
2N97A	G	N			A	50M	A	85	40								5.0	E	0.5M	B
2N98	G	N			A	50M	A	75	40								19	E	0.8M	B
2N98A	G	N			A	50M	A	85	40								24	E	0.8M	B
2N99	G	N			A	50M	A	75	40								19	E	2.0M	B
2N100		N			A	25M	A	50	25								99	E	2.5M	B
2N101	G	P			AP	1.0W	A	70	25											
2N102	G	N			AF	1.0W	A	70	25											
2N103	G	N			A	50M	A	75	35								1.5	E		
2N104	G	P	2N650	2N650	A	150M	A	70	30											
2N105	G	P			A	35M	A	50	35											
2N106	G	P	2N1191	2N1191	A	102M	A	85	6.0											
2N107	G	P	2N464	2N464	A	50M	A	60	12	6.0	O						0.95	B		

2N108–1N184

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units	Subscript
2N108	G	P			A	50M	A													
2N109	G	P	2N1192	2N1191	A	165M	A	71	35	25	O	65	115	50M	0.15	50M	50	E		
2N110	G	P			S	0.2W	A	85	50						2.5	18M				
2N111	G	P			AH	150M	A	85	30	15	O	15		1.0M						
2N111A	G	P			AH	150M	A	85	30	15	O	15		1.0M						
2N112	G	P			AH	150M	A	85	30	15	O	15		1.0M						
2N112A	G	P			AH	150M	A	85	30	15	O	15		1.0M						
2N113	G	P			AH	96M	A	85	10											
2N114	G	P			AH	96M	A	85	10											
2N115	G	P			SP	50W	C	75	32	32	R		110	30M						
2N117	S	N			SH	150M	C	150	30								0.9	B	1.0M	B
2N118	S	N			SH	150M	C	150	30								0.95	B	2.0M	B
2N118A	S	N			SH	150M	C	150	45								0.974	B	2.0M	B
2N119	S	N			SH	150M	C	150	30								0.987	B		
2N120	S	N			AH	150M	C	175	45			76	333							
2N122	S	N			AP	8.75W	C	150	120			3.0		100M						
2N123	G	P			SH	50M	J	85	20	15	O						0.98	B	5.0M	B
2N124	G	N			S	50M	A	75	10			12	24	5.0M	0.3	5.0M			0.3M	B
2N125	G	N			S	50M	A	75	10			24	48	5.0M	0.3	5.0M			5.0M	B
2N126	G	N			S	50M	A	75	10			48	100	5.0M	0.3	5.0M			5.0M	B
2N127	G	N			S	50M	A	75	10			100	200	5.0M	0.3	5.0M			5.0M	B
2N128	G	P			AH	30M	A	85	10	4.5	U						19	E	45M	M
2N129	G	P			AH	30M	A	85	10	4.5	U						11.5	E	30M	M
2N130	G	P	2N1191	2N1191	A	85M	A	85	44											
2N130A	G	P	2N650	2N650	A	100M	A	85	45	40	O						14	E		
2N131	G	P	2N1192	2N1191	A	85M	A	85	30											
2N131A	G	P	2N651	2N650	A	100M	A	85	45	30	O						27	E		
2N132	G	P	2N1192	2N1191	A	85M	A	85	24											
2N132A	G	P	2N651	2N650	A	100M	A	85	35	20	O									
2N133	G	P	2N1192	2N1191	A	85M	A	85	30											
2N133A	G	P	2N651	2N650	A	100M	A	85	35	20	O									
2N135	G	P			AH	100M	A	85	20	12	R						20	E	4.5M	B
2N136	G	P			AH	100M	A	85	20	12	R						40	E	6.5M	B
2N137	G	P			AH	100M	A	85	10	6.0	R						60	E	10M	B
2N138	G	P			A	50M	A	50	24											
2N138A	G	P			A	150M	A	85	45	30	O	10		50M						
2N138B	G	P			A	100M	A	85	45											
2N139	G	P			A	80M	A	70	16											
2N140	G	P			A	80M	A	70	16											
2N141	G	P			AP	1.5W	A	25	60	30										
2N142	G	N			AP	1.5W	A	25	60	30										
2N143	G	P			AP	1.0W	A	25	60	30										
2N144	G	N			AP	1.0W	A	25	60	30										
2N145	G	N			AH	65M	A	75		20	U									
2N146	G	N			AH	65M	A	75		20	U									
2N147	G	N			AH	65M	A	75		20	U									
2N148	G	N			AH	65M	A	75		16	U									
2N148A	G	N			AH	65M	A	75		32	U									
2N149	G	N			AH	65M	A	75		16	U									
2N149A	G	N			AH	65M	A	75		32	U									
2N150	G	N			AH	65M	A	75		16	U									
2N150A	G	N			AH	65M	A	75		32	U									
2N155	G	P	2N176	2N176	AP	1.5W	A	85	30			24		0.5A	0.65	0.5A				
2N156	G	P	2N176	2N176	AP	1.5W	A	85	30			24		0.5A	0.6	1.0A			145K	B
2N157	G	P	2N1531	2N1529	AP	1.5W	A	85	60			20		0.5A					100K	B
2N157A	G	P	2N1532	2N1529	AP	1.5W	A	85	90			20		0.5A					100K	B
2N158	G	P	2N2139	2N2137	AP	1.5W	A	85	60			21		0.5A	0.75	1.0A			145K	B
2N158A	G	P	2N2141	2N2137	AP	1.5W	A	95	80	60	O	21		0.5A	0.75	1.0A			4.0K	E
2N160	S	N	2N2217		A	0.15W	A		40			9.0	19							
2N160A	S	N	2N2217		A	0.15W	A		40			9.0	19							
2N161	S	N	2N2217		A	0.15W	A		40			19	39							
2N161A	S	N	2N2217		A	0.15W	A		40			19	39							
2N162	S	N	2N2221	2N2218	A	0.15W	A		40			19	199							
2N162A	S	N	2N2221	2N2218	A	0.15W	A		40			19	199							
2N163	S	N	2N2221	2N2218	A	0.15W	A		40			39	199							
2N163A	S	N	2N2221	2N2218	A	0.15W	A		40			39	199							
2N166	G	N			AH	25M	A	50		6.0	O									
2N167	G	N			AH	75M	A	85	30	30	O						0.952	B	5.0M	B
2N167A	G	N			SH	75M	A	85	30	30	O	17	90	8.0M			0.952	B	5.0M	B
2N168	G	N			AH	55M	A	75	15	15	O						20	E		
2N168A	G	N			AH	65M	A	85	15	15	O						20	E		
2N169	G	N			AH	65M	A	85	15	15	O						30	E		
2N169A	G	N			A	65M	A	85	25	25	O						30	E		
2N170	G	N			AH	25M	A	50		6.0	O									
2N172	G	N			AH	65M	A	75		16	U									
2N173	G	P		2N277	AP	10W	C	95	60	50	S	35	70	5.0A	1.0	12A				
2N174	G	P		2N173	SP	100W	C	95	80	70	S	25	50	5.0A	0.9	12A				
2N174A	G	P			SP	100W	C	95	80	70	S	40	80	1.2A	0.7	12A			100K	B
2N175	G	P	2N1192	2N1191	AH	50M	A	71	10											
2N176	G	P		2N176	AH	90W	C	80	40	30	R	25		0.5A	0.4	3.0A			4.0K	E
2N178	G	P		2N178	A	40W	C	90	30	30	R	15	45	0.5A	0.6	3.0A			5.0K	E
2N179	G	P	2N176	2N176	A															
2N180	G	P	2N1192	2N1191	A	0.15W	A	75	30											
2N181	G	P	2N1192	2N1191	A	0.25W	A	75	30											
2N182	G	N			S	0.1W	A	75	25											
2N183	G	N			S	0.1W	A	75	25											
2N184	G	N			S	0.1W	A	75	25											

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N185	G	P	2N650	2N650	A	150M	A	50	20								35	E		
2N186	G	P	2N1191	2N1191	A	100M	A	85	25	25	R								800K	B
2N186A	G	P	2N1191	2N1191	A	200M	A	85	25	25	R								800K	B
2N187	G	P	2N1191	2N1191	A	100M	A	85	25	25	R								1.0M	B
2N187A	G	P	2N1191	2N1191	A	200M	A	85	25	25	R								1.0M	B
2N188	G	P	2N1191	2N1191	A	100M	A	85	25	25	R								1.2M	B
2N188A	G	P	2N1191	2N1191	A	200M	A	85	25	25	R								1.2M	B
2N189	G	P	2N1191	2N1191	A	75M	A	85	25	25	R								800K	B
2N190	G	P	2N1191	2N1191	A	75M	A	85	25	25	R								1.0M	B
2N191	G	P	2N1192	2N1191	A	75M	A	85	25	25	R								1.2M	B
2N192	G	P	2N1193	2N1191	A	75M	A	85	25	25	R								1.5M	B
2N193	G	N			AH	150M	A	85	18	18	R						4.0		2.0M	B
2N194	G	N			AH	50M	A	75	15	15	R						4.8		2.0M	B
2N194A	G	N			AH	50M	A	75	20	20	R						5.0		2.0M	B
2N206	G	P			A	75M	A		30											
2N207	G	P	2N1191	2N1191	A	50M	A	65	12	12	V						35	E		
2N207A	G	P	2N1193	2N1191	A	50M	A	65	12	12	V						35	E		
2N207B	G	P	2N1190	2N1189	A	50M	A	65	12	12	V						35	E		
2N211	G	N			AH	50M	A	75	10	10	R						3.8		2.0M	E
2N212	G	N			AH	150M	A	85	18	18		10		1.0M			10	E	4.0M	B
2N213	G	N			A	50M	A	75	40	25	R				0.6	100M	70	E		
2N213A	G	N			A	150M	A	85	40	25	R				1.0	100M	100	E	10K	E
2N214	G	N			A	125M	A	75	40			50	100	35M					600K	B
2N215	G	P	2N1189	2N1189	A	150M	A	70	30											
2N216	G	N			AH	50M	A	75	15								3.9	E	2.0M	B
2N217	G	P	2N1192	2N1191	A	150M	A	71	35	25	O	65	115	50M	0.15	50M				
2N218	G	P			A	80M	A	70	16											
2N219	G	P			A	80M	A	70	16											
2N220	G	P	2N1189	2N1189	A	50M	A	71	10											
2N223	G	P	2N1193	2N1191	A	100M	A	65		18	V						39	E		
2N224	G	P	2N1192	2N1191	A	250M	A	75	25			60	120	100M	0.25	100M				
2N225	G	P	2N1193	2N1191	A	250M	A	75	25			60	120	100M	0.25	100M				
2N226	G	P	2N1192	2N1191	A	250M	A	75	30			35	105	100M	0.25	100M				
2N227	G	P			A	250M	A	75	30			35	105	100M	0.25	100M				
2N228	G	P			A	50M	A	75	25			50	100	35M					600K	B
2N229	G	N			A	50M	A	75	10										550K	B
2N230	G	P			AP	15W	C	85	60	30	U	60	106	0.5A	0.8	2.0A			12K	E
2N231	G	P			AH	9.0M	A	55	4.5	4.5	V						19	E	30M	M
2N232	G	P			AH	9.0M	A	55	4.5	4.5	V						9.0	E	20M	M
2N233	G	N			AH	50M	A	75	10								3.0	E		
2N233A	G	N			AH	50M	A	75	10								3.5	E		
2N234	G	P	2N554	2N178	AP			90		25	R									
2N234A	G	P	2N555	2N178	AP	25W	C	90		25	R									
2N235	G	P	2N350A	2N350A	AP			90		40	U				0.8	1.0A				
2N235A	G	P	MP695A		AP	25W	C	90		40	U				0.8	1.0A				
2N235B	G	P	MP695B		AP	25W	C	85	50	35	R				0.8	1.0A			5.0K	E
2N236	G	P	2N350A	2N350A	AP			95		35	R				1.0	3.0A				
2N236A	G	P	2N351A	2N350A	AP	25W	C	95		35	R				1.0	3.0A				
2N236B	G	P	2N376A	2N350A	AP	25W		95	50	35	R				1.0	3.0A			5.0K	E
2N237	G	P			A	150M	A	55	45								0.98	B	500K	B
2N238	G	P	2N1192	2N1191	A	50M	A	60	20											
2N240	G	P			S	25M	A	85	6.0	6.0	S				0.1	8.0M	16	E	25M	T
2N241	G	P	2N321	2N319	A	100M	A	85	25	25	R								1.3M	B
2N241A	G	P	2N321	2N319	A	200M	A	85	25	25	R								1.3M	B
2N242	G	P		2N242	A	20W	C	85	45	45	R								5.0K	B
2N243	S	N			A	750M	C	150	60								0.9	B		
2N244	S	N			A	750M	C	150	60								0.961	B		
2N247	G	P			AH	80M	A		40											
2N248	G	P			A			75	25											
2N249	G	P			A	350M	A	60	25								30	E		
2N250	G	P	2N3611	2N3611	AP	12W	C	80	30			30		500M					8.0K	E
2N250A	G	P	2N3611	2N3611	AP	90W	C	100	40	35	V	25	100	3.0A	0.7	3.0A			200K	T
2N251	G	P	2N1530	2N1529	AP	12W	C	80	60			30		500M					8.0K	E
2N251A	G	P	2N3616	2N3615	AP	90W	C	100	60	55	V	25	100	3.0A	0.7	3.0A			200K	T
2N252	G	P			AH	30M	C	55		16	O									
2N253	G	N			AH	65M	C	75		12	O									
2N254	G	N			AH	65M	C	75		20	O									
2N255	G	P	MP708		AP	1.5W	A	85	15											
2N255A	G	P			AP	20W	C	85	15	15	R									
2N256	G	P	2N555	2N554	AP	1.5W	A	85	30											
2N256A	G	P			AP	20W	C	85	30	25	R									
2N257	G	P	MP707		AP	25W	C	85	40										7.0K	
2N258	S	P	2N2906	2N2906	A	250M	A	160	30	30	O						15	E		
2N259	S	P	2N2906	2N2906	A	250M	A	160	30	30	O						32	E		
2N260	S	P	2N2906	2N2906	A	0.2W	A	150	10											
2N260A	S	P	2N2906	2N2906	A	0.2W	A	150	30											
2N261	S	P	2N2906	2N2906	A	0.2W	A	150	75											
2N262	S	P	2N2906	2N2906	A	0.2W	A	150	10											
2N262A	S	P	2N2906	2N2906	A	0.2W	A	150	30											
2N263	S	N	2N2907	2N2907	A	150M	A	150	45	30	O	45	150	10M	1.5	10M	39	E	20M	B
2N264	S	N	2N2906	2N2906	A	125M	A	150	45	30	O	20	55	10M	1.5	10M	0.95	B	10M	B
2N265	G	P	2N1175	2N1413	A	75M	A	85		25	R								1.5M	B
2N266	G	P			A	75M	A	85		18	R								800K	B
2N267	G	P			AH	80M	A		40											
2N268	G	P	2N1530	2N1529	AP	25W	C	85	80										6.0K	
2N268A	G	P	MP759		SP	10W	C	90	80	60	V	20		2.0A	1.0	2.0A				
2N269	G	P			S	120M	A	85	25	24	O									
2N270	G	P	2N1193	2N1191	A	150M	A	50	25											

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N271	G	P			AH	150M	A	85	30	10	O									
2N271A	G	P			AH	150M	A	85	30	10	O									
2N272	G	P			A	150M	A	85	30	24	O						60	E		
2N273	G	P			A	150M	A	85	45	25	S	30		50M						
2N274	G	P			AH	120M	A	100	40	40	O	20	175	1.5M			20	E		
2N277	G	P		2N277	AP	70W	C	95	40	40	S	35	70	5.0A						
2N278	G	P		2N277	AP	70W	C	95	50	45	S	35	70	5.0A	1.0	12A				
2N279	G	P	2N650	2N650	A	125M	A	75		20							20	E		
2N280	G	P	2N650	2N650	A	125M	A	75		20							30	E		
2N281	G	P	2N651	2N650	A	167M	C	75	16	16	R	45	120						0.35M	B
2N282	G	P			A															
2N283	G	P	2N650	2N650	S	125M	A	75	20	20							30	E		
2N284	G	P			S	125M	A	75	32	32		15							0.35M	B
2N284A	G	P			S	125M	A	75	60	60		15							0.35M	B
2N285	G	P	2N285A		AP	25W	C	95		35	R				0.5	1.0A				
2N285A	G	P			AP	25W	C	95		35	R				0.5	1.0A				
2N290	G	P			AP	55W	C	95	70											
2N291	G	P	2N1191	2N1191	A	180M	A	50	25								30	E		
2N292	G	N			AH	65M	A	85	15	15	O	6.0	44							
2N293	G	N			AH	65M	A	85	15	15	O	6.0	55							
2N296	G	P	2N1531	2N1529	A	20W	C	85	60			19		1.0A	1.0	1.0A			4.0K	B
2N297	G	P	2N297A	2N297A	AP	35W	C	95	60	50	S	40	100	0.5A	1.0	2.0A			5.0K	E
2N297A	G	P		2N297A	AP	35W	C	95	60	50	S	40	100	0.5A	1.0	2.0A			5.0K	E
2N299	G	P			AH	20M	A	85	5.0	4.5	V								90M	M
2N300	G	P			AH	20M	A	85	5.0	4.5	V						11	E	85M	M
2N301	G	P			AP	11W	A	85	40											
2N301A	G	P			AP	11W	A	85	60											
2N302	G	P			AH	150M	A	85	30	10	O						45	E	7.0M	B
2N303	G	P			AH	150M	A	85	30	10	O						75	E	14M	B
2N306	G	N			A	50M	A	75	20	15	R				0.5	0.1A	25	E	0.6M	B
2N307	G	P		2N242	AP	25W	C	75	35	35	R	20		0.2A	1.0	0.2A			3.0K	E
2N307A	G	P		2N242	AP	25W	C	75	35	35	R	20		0.2A	0.8	1.0A			3.5K	E
2N308	G	P			AH	30M	A	55		20	O									
2N309	G	P			AH	30M	A	55		20	O									
2N310	G	P			AH	30M	A	55		30	O									
2N311	G	P			SP	75M	A	85	15	15	O	25	75	10M	0.075	10M				
2N312	G	N			SP	75M	A	85	15	15	O	25	75	10M	0.075	10M				
2N315	G	P			S	100M	A	85	20	15	O	15	30	100M	0.15	100M				
2N315A	G	P			S	150M	A	100	30	20	O	20	50	100M	0.15	100M				
2N315B	G	P			S	150M	A	100	30	20	O	20	50	100M	0.15	100M				
2N316	G	P			S	100M	A	85	20	10	O	20	50	200M	0.18	200M				
2N316A	G	P			S	150M	A	100	30	15	O	20	50	200M	0.18	200M				
2N317	G	P			S	100M	A	85	20	6.0	O	20	60	400M	0.2	400M				
2N317A	G	P			S	150M	A	100	25	10	O	20	60	400M	0.2	400M				
2N318	G	P			AL	50M	A		12											
2N319	G	P		2N319	A	225M	A	85		20	R									
2N320	G	P		2N319	A	225M	A	85		20	R									
2N321	G	P		2N319	A	225M	A	85		20	R									
2N322	G	P		2N322	A	140M	A	60	18	18	R	34	65	20M					1.0M	B
2N323	G	P		2N322	A	140M	A	60	18	18	R	53	125	20M					1.5M	B
2N324	G	P		2N322	A	140M	A	60	18	18	R	72	198	20M					2.0M	B
2N325	G	P	2N3611	2N3611	A	12W	C	85	35	35	S	30	60	500M	0.6	500M			150K	B
2N326	G	N			A	7.0W	C	85	35	35	S	30	60	500M	0.6	500M			150K	B
2N327	S	P	2N2906	2N2904	A	350M	A	160	50								9.0	E		
2N327A	S	P	2N2906	2N2904	AM	385M	A	160	50	40	O	9.0	22	3.0M	0.3	5.0M				
2N327B	S	P	2N2906	2N2904	AM	385M	A	200	50	40	O	9.0	22	3.0M	0.3	5.0M				
2N328	S	P		2N2904	A	350M	A	160	35								18	E		
2N328A	S	P		2N2904	AM	385M	A	160	50	35	O	18	44	3.0M	0.5	10M				
2N328B	S	P		2N2904	AM	385M	A	200	50	35	O	18	44	3.0M	0.5	10M				
2N329	S	P		2N2904	A	350M	A	160	30								36	E		
2N329A	S	P		2N2904	AM	385M	A	160	50	30	O	36	88	3.0M	0.6	15M				
2N329B	S	P		2N2904	AM	385M	A	200	50	30	O	36	88	3.0M	0.6	15M				
2N330	S	P		2N2904	A	350M	A	160	45								9.0	E		
2N330A	S	P	2N2906	2N2904	AM	385M	A	160	50	30	O									
2N331	G	P		2N331	A	200M	A	71	30											
2N332	S	N	2N2221	2N2218	AH	150M	A	175	45			9.0	20				0.9	B		
2N332A	S	N	2N2218	2N2218	A	500M	A	175	45	45	O				1.0	5.0M	0.9	B	2.5M	B
2N333	S	N	2N2221	2N2218	AH	150M	A	175	45			18	40				0.948	B		
2N333A	S	N	2N2218	2N2218	A	500M	A	175	45	45	O				1.0	5.0M	0.948	B	2.5M	B
2N334	S	N	2N2221	2N2218	AH	150M	A	175	45			18	86				0.948	B		
2N334A	S	N	2N2218	2N2218	A	500M	A	175	45	45	O				1.0	5.0M	0.948	B	8.0M	B
2N334B	S	N	2N2218	2N2218	A	500M	A	175	60	60	O	15	85	1.0M	1.0	5.0M	18	E	8.0M	B
2N335	S	N	2N2221	2N2218	AH	150M	A	175	45			36	86				0.973	B		
2N335A	S	N	2N2218	2N2218	A	500M	A	175	45	45	O				1.0	5.0M	0.973	B	2.5M	B
2N335B	S	N	2N2218	2N2218	A	500M	A	175	60	60	O	28	90	1.0M	1.0	5.0M	37	E	2.5M	B
2N336	S	N	2N2221	2N2218	AH	150M	A	175	45			76	333				0.987	B		
2N336A	S	N	2N2218	2N2218	A	500M	A	175	45	45	O				1.0	5.0M	0.987	B	2.5M	B
2N337	S	N	2N2221	2N2218	S	125M	C	150	45			20	55	10M					10M	B
2N337A	S	N	2N2218	2N2218	A	500M	A	175	45			20	55	10M			19	E	15M	B
2N338	S	N	2N2221	2N2218	S	125M	C	150	45			45	150	10M					20M	B
2N338A	S	N	2N2218	2N2218	A	500M	A	175	45			45	150	10M			39	E	25M	B
2N339	S	N			A	1.0W	C	150	55	55	O						0.9	B		
2N339A	S	N			AH	3.0W	A	200	60	60	O	20	80				25	E	10M	T
2N340	S	N			A	1.0W	C	150	85	85	O						0.9	B		
2N340A	S	N			AH	3.0W	A	200	85	85	O	20	80				25	E	10M	T
2N341	S	N			A	1.0W	C	150	125	85	O						0.9	B		
2N341A	S	N			AH	3.0W	A	200	125	125	O	20	80				25	E	10M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N342	S	N			A	1.0W	C	150	60	60	O						0.9	B		
2N342A	S	N			A	1.0W	C	150	85	85	O						0.9	B		
2N342B	S	N			A	750M	A	175	85	85	O						9.0	E		
2N343	S	N			A	1.0W	C	150	60	60	O						0.966	B		
2N343A	S	N			A	1.0W	C	150	60	60	O						0.966	B		
2N343B	S	N			A	750M	A	175	65	65	O						28	E		
2N344	G	P			AH	20M	A	55	5.0	5.0	V						11	E	30M	M
2N345	G	P			AH	20M	A	55	5.0	5.0	V						25	E	30M	M
2N346	G	P			AH	20M	A	55	5.0	5.0	V						10	E	60M	M
2N350	G	P			AP	10W	A	100	50	40	O	20	60	700M						
2N350A	G	P		2N350A	AP	90W	J	100	50	40	S	20	60	0.7A	1.75	3.0A			5.0K	E
2N351	G	P			AP	10W	A	100	50	40	O	25	90	700M						
2N351A	G	P		2N350A	AP	90W	J	100	50	40	S	25	90	0.7A	1.75	4.0A			5.0K	E
2N352	G	P	2N1536	2N1529	AP	25W	C	100		40	R	30	140	1.0A					10K	E
2N353	G	P	2N1536	2N1529	AP	30W	C	100		40	R	40	150	1.0A					7.0K	E
2N354	S	P	2N2906	2N2904	AH	150M	A	140	25	25	U						9.0	E	8.0M	M
2N355	S	P	2N2906	2N2904	S	150M	A	140	10	10	U				0.15	5.0M	9.0	E	8.0M	M
2N356	G	N			S	100M	A	85	20	18	O	20	50	100M	0.2	100M				
2N356A	G	N			S	150M	A	100	30	20	O	20	50	100M	0.2	100M				
2N357	G	N			S	100M	A	85	20	15	O	20	50	200M	0.2	200M				
2N357A	G	N			S	150M	A	100	30	20	O	25	75	200M	0.2	200M				
2N358	G	N			S	100M	A	85	20	12	O	20	50	300M	0.2	300M				
2N358A	G	N			S	150M	A	100	30	15	O	25	75	300M	0.2	300M				
2N359	G	P	2N652	2N650	A	170M	A	85	25	18	R	100	300	50M						
2N360	G	P	2N1192	2N1191	A	170M	A	85	32	30	R	50	150	50M						
2N361	G	P	2N1191	2N1191	A	170M	A	85	32	30	R	25	75	50M						
2N362	G	P	2N1192	2N1191	A	170M	A	85	25	18	O						50	E		
2N363	G	P	2N1192	2N1191	A	170M	A	85	32	28	O						25	E		
2N364	G	N			S	150M	A	100	30								9.0	E	1.0M	B
2N365	G	N			S	150M	A	100	30								19	E	1.0M	B
2N366	G	N			S	150M	A	100	30								49	E	1.0M	B
2N367	G	P	2N1191	2N1191	S	100M	A	75	30								9.0	E	300K	B
2N368	G	P	2N1191	2N1191	S	100M	A	75	30								19	E	400K	B
2N369	G	P	2N1191	2N1191	S	100M	A	75	30								49	E	500K	B
2N370	G	P	2N3324	2N3323	AH	80M	A	71	24											
2N371	G	P	2N3324	2N3323	AH	80M	A	71	24											
2N372	G	P	2N3324	2N3323	AH	80M	A	71	24											
2N373	G	P			AH	80M	A	71	25											
2N374	G	P	2N3325	2N3323	AH	80M	A	71	25											
2N375	G	P		2N350A	AP	58W	C	95	80	60	S	35	90	1.0A	1.0	2.0A			7.0K	E
2N376	G	P			AP	10W	A	100	50	40	O	35	120	700M						
2N376A	G	P		2N350A	AP	90W	J	100	50	40	S	35	120	0.7A	1.75	5.0A			5.0K	E
2N377	G	N			S	150M	A	100	25	20	V	20	60	30M	0.5	200M			5.0M	B
2N377A	G	N			S	150M	A	100	40	40	V	20	60	30M						
2N378	G	P		2N376A	SP	50W	C	100	20			40	80	2.0A	1.0	2.0A			5.0K	E
2N379	G	P		2N376A	SP	50W	C	100	40			20	70	2.0A	1.0	2.0A			5.0K	E
2N380	G	P		2N376A	SP	50W	C	100	30			30	70	2.0A	1.0	2.0A			5.0K	E
2N381	G	P		2N381	A	0.2W	A	100	50	25	R	35	65	20M			35	E		
2N382	G	P		2N381	A	0.2W	A	100	50	25	R	60	95	20M			70	E		
2N383	G	P		2N381	A	0.2W	A	100	50	25	R	75	120	20M			90	E		
2N384	G	P	2N3325	2N3323	AH	120M	A	100	40	40	O	20	175	1.5M						
2N385	G	N			S	150M	A	100	25	25	R	30	110	30M					4.0M	B
2N385A	G	N			S	150M	A	100	40	40	V	30	110	30M					4.0M	B
2N386	G	P	MP689		AP	500M	C	100	60	60	V	20		2.5A					7.0K	E
2N387	G	P	MP687		AP	500M	C	100	80	80	V	20		2.5A					6.0K	E
2N388	G	N			S	150M	A	100	25	20	R	60	180	30M					5.0M	B
2N388A	G	N			S	150M	A	100	40	40	V	60	200	0.30M					5.0M	B
2N389	S	N	2N3445	2N3445	AP	85W	C	200		60	R	12	60	1.0A						
2N389A	S	N			AP	85W	C	200		60	R	12	60	1.0A	0.75	1.0A			1.0M	T
2N392	G	P	2N1550	2N1539	AP	48W	C	95	60	40	R	60	150	3.0A	0.5	3.0A				
2N393	G	P	2N967	2N960	S	25M	A	100	6.0	6.0	S	20		50M	0.07	8.0M	40	E	25M	T
2N394	G	P			SH	150M	A	85	10	10	O	20	150	10M					4.0M	B
2N394A	G	P			SH	150M	A	85	10	30	O	30	120	10M					4.0M	B
2N395	G	P			SH	200M	A	100	30	15	R	20	150	10M	0.2	50M			3.0M	B
2N396	G	P			SH	200M	A	100	30	20	R	30	150	10M	0.2	50M			5.0M	B
2N396A	G	P			SH	200M	A	100	30	20	O	30	150	10M	0.2	50M			5.0M	B
2N397	G	P			SH	200M	A	100	30	15	R	40	150	10M	0.2	50M			10M	B
2N398	G	P		2N398	SP	50M	A	55	105	105	S	20		5.0M						
2N398A	G	P		2N398	A	150M	A	100	105	105	S	20		5.0M	0.35	5.0M	20	E		
2N398B	G	P	2N2043	2N2042	SP	250M	A	100	105	105	S	20		5.0M	0.25	5.0M	40	E	1.0M	B
2N399	G	P	2N351A	2N350A	AP	25W	C	90		35	R				1.0	1.2A				
2N400	G	P	2N350A	2N350A	AP	35W	C	95	25	20	O	40	300	0.5A	0.8	1.0A	25	E	3.0K	E
2N401	G	P	2N3611	2N3611	AP	25W	C	90		35	R				1.0	1.2A				
2N402	G	P	2N1191	2N1191	A	180M	A	85	25	20	O									
2N403	G	P	2N1191	2N1191	A	180M	A	85	25	20	O									
2N404	G	P			S	150M	A	85	25											
2N404A	G	P			S	150M	A	100	40	35	O	30		12M	0.15	12M			4.0M	B
2N405	G	P	2N322	2N322	A	150M	A	71	20											
2N406	G	P	2N322	2N322	A	150M	A	71	20											
2N407	G	P	2N324	2N322	A	150M	A	71	20											
2N408	G	P	2N324	2N322	A	150M	A	71	20											
2N409	G	P			AH	80M	A	71	13											
2N410	G	P			AH	80M	A	71	13											
2N411	G	P			AH	80M	A	71	13											
2N412	G	P			AH	80M	A	71	13											
2N413	G	P			AH	150M	A	85	30	18	O									
2N413A	G	P			AH	150M	A	85	30	15	O									
2N414	G	P			AH	150M	A	85	30	15	O									

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TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N414A	G	P			AH	150M	A	85	30	15	0									
2N414B	G	P			AH	0.2W	A	100	30	24	V									
2N414C	G	P			AH	0.2W	A	100	30	24	V									
2N415	G	P			AH	150M	A	85	30	10	0									
2N415A	G	P			AH	150M	A	85	30	10	0									
2N416	G	P			AH	150M	A	85	30	12	0									
2N417	G	P			AH	150M	A	85	30	10	0									
2N418	G	P	2N1537	2N1529	SP	25W	C	100	100	75	R	40		4.0A	2.0	4.0A				
2N419	G	P			AP	35W	C	95	25	20	0	50	350	0.5A	0.8	1.5A	25	E	3.0K	E
2N420	G	P	2N1535	2N1529	SP	25W	C	100	65	40	R	40		4.0A	2.0	4.0A				
2N420A	G	P	2N1537	2N1529	SP	25W	C	100	90	65	R	40		4.0A	2.0	4.0A				
2N422	G	P	2N651	2N650	A	150M	A	85	35	20	0									
2N422A	G	P			A	175M	A	100	35	20	0						30	E	1.5M	B
2N424	S	N	2N3446	2N3445	AP	85W	C	200		80	R	12	60	1.0A						
2N424A	S	N			AP	85W	C	200		80	R	12	60	1.0A	0.75	1.0A			1.0M	T
2N425	G	P			S	175M	A	85	30	20	0	20	40		0.32	100M			2.5M	B
2N426	G	P			S	175M	A	85	30	10	0	30	60		0.32	100M			3.0M	B
2N427	G	P			S	175M	A	85	30	15	0	40	80		0.32	150M			5.0M	B
2N428	G	P			S	175M	A	85	30	12	0	60			0.32	200M			10M	B
2N428A	G	P			S	0.15W	A	100	30	18	0	80			0.32	0.2A			10M	B
2N438	G	N			S	0.1W	A	85	30	25	0	20		50M					2.5M	B
2N438A	G	N			S	0.15W	A	85	30	25	0	20		50M					2.5M	B
2N439	G	N			S	0.1W	A	85	30	20	0	30		50M					5.0M	B
2N439A	G	N			S	0.15W	A	85	30	20	0	30		50M					5.0M	B
2N440	G	N			S	0.1W	A	85	30	15	0	40		50M					10M	B
2N440A	G	N			S	0.15W	A	85	30	15	0	40		50M		50M			10M	B
2N441	G	P		2N441	AP	50W	C	95	40	40	S	20	40	5.0A						
2N442	G	P		2N441	AP	50W	C	95	50	45	S	20	40	5.0A						
2N443	G	P		2N441	AP	50W	C	95	60	50	S	20	40	5.0A	1.0	12A				
2N444	G	N			A	100M	A	85	15	15	0								0.5M	B
2N444A	G	N			A	150M	A	100	40	25	0	20	40	20M			15	E	0.5M	B
2N445	G	N			A	100M	A	85	15	12	0								0.5M	B
2N445A	G	N			A	150M	A	100	30	18	0	40	160	20M			35	E	2.0M	B
2N446	G	N			S	100M	A	85	15	10	0								5.0M	B
2N446A	G	N			S	150M	A	100	30	15	0	60	250	20M			60	E	5.0M	B
2N447	G	N			S	100M	A	85	15	6.0	0								5.0M	B
2N447A	G	N			S	150M	A	100	30	12	0	80	300	20M			85	E	9.0M	B
2N447B	G	N			S	150M	A	100	25	12	0	80	300	20M			150	E	9.0M	B
2N448	G	N			AH	65M	A	85	15	15	0	8.0	51	1.0M						
2N449	G	N			AH	65M	A	85	15	15	0	34		1.0M						
2N450	G	P			SH	150M	A	85	20	12	0	30		10M	0.2	10M			5.0M	B
2N456	G	P	2N456A	2N456A	AP	50W	C	95	40	40	X				1.0	5.0A				
2N456A	G	P		2N456A	AP	150W	C		40	40	0	30	90	5.0A	0.5	5.0A			4.0K	E
2N456B	G	P	MP1971		AP	150W	C	100	40	30	0	30	90	5.0A	0.5	5.0A			200K	T
2N457	G	P	MP251		AP	50W		95	60	60	X				1.0	5.0A				
2N457A	G	P		2N456A	AP	150W	C		60	60	0	30	90	5.0A	0.5	5.0A			4.0K	E
2N457B	G	P	MP1972		AP	150W	C	100	60	40	0	30	90	5.0A	0.5	5.0A			200K	T
2N458	G	P			AP	50W		95	80	80	X				1.0	5.0A				
2N458A	G	P		2N456A	AP	150W	C		80	80	0	30	90	5.0A	0.5	5.0A			4.0K	E
2N458B	G	P	MP1973		AP	150W	C	100	80	45	0	30	90	5.0A	0.5	5.0A			200K	T
2N459	G	P		2N376A	SP	50W	C	100	60			20	70	2.0A	1.0	2.0A			5.0K	E
2N459A	G	P		2N376A	SP	106W	C	110	105	60	0	40	70	2.0A	0.3	2.0A			5.0K	E
2N460	G	P		2N460	A	0.2W	A	100	45			16	32							
2N461	G	P		2N460	A	0.2W	A	100	45			32	100							
2N462	G	P			S	150M	A	75	40			20		200M					500K	B
2N463	G	P	2N1551	2N1539	AP	37.5W	C	100	60	60		20	60	2.0A					4.0K	E
2N464	G	P		2N464	A	150M	A	85	45	40	0									
2N465	G	P		2N464	A	150M	A	85	45	30	0									
2N466	G	P		2N464	A	150M	A	85	35	20	0									
2N467	G	P		2N464	A	150M	A	85	35	15	0									
2N469	G	P			AL	50M	A	75	6.0			10		1.0M						
2N469A	G	P			AL	50M	A	85	20	15	R						30	E		
2N470	S	N	2N2221	2N2218	AH	0.2W	A	200	15	15	0				1.5	5.0M	10	E	8.0M	T
2N471	S	N	2N2221	2N2218	A	0.2W	A	200	30	30	0				1.5	5.0M	10	E	8.0M	T
2N471A	S	N	2N2221	2N2218	A	0.2W	A	200	30	30	0				1.0	5.0M	10	E	8.0M	T
2N472	S	N	2N2221	2N2218	AH	0.2W	A	200	45	45	0				1.5	5.0M	10	E	8.0M	T
2N472A	S	N	2N2221	2N2218	A	0.2W	A	200	45	45	0				1.0	5.0M	10	E	8.0M	T
2N473	S	N	2N2221	2N2218	A	0.2W	A	200	15	15	0				1.5	5.0M	20	E	8.0M	T
2N474	S	N	2N2221	2N2218	A	0.2W	A	200	30	30	0				1.5	5.0M	20	E	8.0M	T
2N474A	S	N	2N2221	2N2218	A	0.2W	A	200	30	30	0	10			1.0	5.0M	20	E	8.0M	T
2N475	S	N	2N2221	2N2218	A	0.2W	A	200	45	45	0				1.5	5.0M	20	E	8.0M	T
2N475A	S	N	2N2221	2N2218	A	0.2W	A	200	45	45	0	10			1.0	5.0M	20	E	8.0M	T
2N476	S	N	2N2221	2N2218	A	0.2W	A	200	15	15	0				1.5	5.0M	30	E	12M	T
2N477	S	N	2N2221	2N2218	A	0.2W	A	200	30	30	0				1.5	5.0M	30	E	12M	T
2N478	S	N	2N2221	2N2218	AH	0.2W	A	200	15	15	0				1.5	5.0M	40	E	20M	T
2N479	S	N	2N2221	2N2218	AH	0.2W	A	200	30	30	0				1.5	5.0M	40	E	20M	T
2N479A	S	N	2N2221	2N2218	A	0.2W	A	200	30	30	0	10			1.0	5.0M	40	E	20M	T
2N480	S	N	2N2221	2N2218	AH	0.2W	A	200	45	45	0				1.5	5.0M	40	E	20M	T
2N480A	S	N	2N2221	2N2218	A	0.2W	A	200	45	45	0	10			1.0	5.0M	40	E	20M	T
2N481	G	P			AH	150M	A	85	12	12	0									
2N482	G	P			AH	150M	A	85	12	12	0									
2N483	G	P			AH	150M	A	85	12	12	0									
2N484	G	P			AH	150M	A	85	12	12	0									
2N485	G	P			AH	150M	A	85	12	12	0									
2N486	G	P			AH	150M	A	85	12	12	0									
2N487	G	P			A	100M	A	85	18	18	R	20		1.0M			10	E	10M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N489 thru 2N494	Unijunction Transistors, see Table on Page 184																		
2N495	S	P			AH	150M	A	140	25	25	U						15	E	8.0M	M
2N496	S	P			S	150M	A	140	10	10	U	15		15M	0.15	5.0M	9.0	E	7.2M	T
2N497	S	N	2N4238	2N4237	A	4.0W	C	200	60	60	0	12	36	200M						
2N497A	S	N			A	5.0W	C	200	60	60	0	12	36	200M						
2N498	S	N	2N4239	2N4237	A	4.0W	C	200	100	100	0	12	36	200M						
2N498A	S	N			A	5.0W	C	200	100	100	0	12	36	200M						
2N499	G	P		2N499	AH	30M	A	85	30	18	0								120M	T
2N499A	G	P		2N499	AH	60M	A	100	30	18	0						20	E	120M	T
2N500	G	P	2N3323	2N3323	AH	50M	A	85	20	15										
2N501	G	P			SH	60M	A	100	15	12	S	20		10M	0.2	10M			90M	T
2N501A	G	P			SH	60M	A	100	15	12	S	30		10M	0.2	10M			90M	T
2N502	G	P		2N499	AH	60M	A	85	20	20	S						9.0	E	220M	T
2N502A	G	P		2N499	AH	75M	A	100	30	30	S						15	E	220M	T
2N502B	G	P		2N499	AH	75M	A	100	30	30	S						20	E		
2N503	G	P	2N3284	2N3283	AH	25M	A	85	20	20	S						9.0	E	168M	T
2N504	G	P	2N3323	2N3323	AH	30M	A	85	35	25	S	20	200	10M			16	E	50M	M
2N506	G	P			A	50M	A	85	40			25	50	50M	0.6	50M			600K	B
2N507	G	N			A	50M	A	85	40			25	50	50M	0.6	50M			600K	B
2N508	G	P		2N322	A	200M	A	100	18	18	R	99	198	20M					2.5M	B
2N508A	G	P		2N508A	A	0.2W	A	100	30	30	S	100	200	20M			75	E	2.5M	B
2N509	G	P			AH	225M	A	100	30								0.96	B	400M	T
2N511	G	P	2N1554	2N1539	AP	150W	C		40			20	60	10A	0.5	10A			260K	T
2N511A	G	P	2N1555	2N1539	AP	150W	C		60			20	60	10A	0.5	10A			260K	T
2N511B	G	P	2N1556	2N1539	SP	150W	C		80			20	60	10A	0.5	10A			260K	T
2N512	G	P	2N1558	2N1539	AP	150W	C		40			20	60	15A	0.75	15A			260K	T
2N512A	G	P	2N1559	2N1539	AP	150W	C		60			20	60	15A	0.75	15A			260K	T
2N512B	G	P	2N1560	2N1539	SP	150W	C		80			20	60	15A	0.5	10A			260K	T
2N513	G	P	2N1163	2N1162	AP	150W	C		40			20	60	20A	1.25	20A			300K	T
2N513A	G	P	2N1165	2N1162	AP	150W	C		60			20	60	20A	1.25	20A			260K	T
2N513B	G	P	2N1167	2N1162	SP	150W	C		80			20	60	20A	0.5	10A			260K	T
2N514	G	P	2N1163	2N1162	SP	80W	C	95	40	40	X				1.25	25A				
2N514A	G	P	2N1165	2N1162	SP	80W	C	95	60	60	X				1.25	25A				
2N514B	G	P	2N1167	2N1162	SP	80W	C	95	80	80	X				1.25	25A				
2N515	G	N			AH	50M	A	75	20	18	R						4.0	E	2.0M	B
2N516	G	N			AH	50M	A	75	20	18	R						4.0	E	2.0M	B
2N517	G	N			AH	50M	A	75	20	18	R						4.0	E	2.0M	B
2N518	G	P			S	0.15W	A	85	45	12	0	60		10M	0.15	10M			10M	B
2N519	G	P			S	100M	A	85	15	15	0						15	E	0.5M	B
2N519A	G	P			S	150M	A	100	25	18	0	20	50	20M			15	E	0.5M	B
2N520	G	P			S	100M	A	85	15	12	0						20	E	3.0M	B
2N520A	G	P			S	150M	A	100	25	15	0	40	170	20M			40	E	2.0M	B
2N521	G	P			S	100M	A	85	15	10	0						35	E	8.0M	B
2N521A	G	P			S	150M	A	100	25	12	0	60	250	20M			70	E	8.0M	B
2N522	G	P			S	100M	A	85	15	8.0	0						60	E	15M	B
2N522A	G	P			S	150M	A	100	25	10	0	80	320	20M			100	E	15M	B
2N523	G	P			S	100M	A	85	15	6.0	0						80	E	21M	B
2N523A	G	P			S	150M	A	100	20	6.0	0	100	400	20M			125	E	21M	B
2N524	G	P		2N524	A	225M	A	100	45	30	R	25	42	20M	0.13	20M	16	E	800K	B
2N524A	G	P			A	225M	A	100	45	30	R	25	42	20M	0.13	20M	18	E	0.8M	B
2N525	G	P		2N524	A	225M	A	100	45	30	R	34	65	20M	0.13	20M	30	E	1.0M	B
2N525A	G	P			A	225M	A	100	45	30	R	34	65	20M	0.13	20M	30	E	1.0M	B
2N526	G	P		2N524	A	225M	A	100	45	30	R	53	90	20M	0.13	20M	44	E	1.3M	B
2N526A	G	P			A	225M	A	100	45	30	R	53	90	20M	0.13	20M	44	E	1.3M	B
2N527	G	P		2N524	A	225M	A	100	45	30	R	72	121	20M	0.13	20M	60	E	1.5M	B
2N527A	G	P			A	225M	A	100	45	30	R	72	121	20M	0.13	20M	60	E	1.5M	B
2N528	G	P				2.5W	C	100	40	40		20		0.5A						
2N529	G					100M	A	85	15	15	0									
2N530	G					100M	A	85	15	15	0									
2N531	G					100M	A	85	15	15	0									
2N532	G					100M	A	85	15	15	0									
2N533	G					100M	A	85	15	15	0									
2N534	G	P	2N1189	2N1189	A	25M	A	65	50	50	U						35	E		
2N535	G	P	2N1192	2N1191	A	50M	A	85	20	20	U						35	E		
2N535A	G	P	2N1192	2N1191	A	50M	A	85	20	20	U						35	E		
2N535B	G	P			A	50M	A	85	20	20	U						35	E		
2N536	G	P	2N1193	2N1191	S	50M	A	85	20	20	U	100		30M	0.13	10M			1.0M	B
2N537	G	P			AH			100	30						4.0	70M	0.9	B		
2N538	G	P	2N2140	2N2137	SP	34W	J	95	80	60		20	50	2.0A	0.6	2.0A				
2N538A	G	P	2N2140	2N2137	SP	34W	J	95	80	60		20	50	2.0A	0.6	2.0A				
2N539	G	P	2N2145	2N2137	SP	34W	J	95	80	55		30	75	2.0A	0.6	2.0A				
2N539A	G	P	2N2145	2N2137	SP	11W	J	95	80	55		30	75	2.0A	0.6	2.0A				
2N540	G	P	2N1551	2N1539	SP	34W	J	95	80	55		45	113	2.0A	0.6	2.0A				
2N540A	G	P	2N1551	2N1539	SP	34W	J	95	80	55		45	113	2.0A	0.6	2.0A				
2N541	S	N	2N2221	2N2218	AH	0.2W	A	200	15	15	U				1.5	5.0M	80	E	10M	T
2N541A	S	N	2N2221	2N2218	A	0.2W	A	200	15	15	0	20			1.0	5.0M	80	E	8.0M	T
2N542	S	N	2N2221	2N2218	AH	0.2W	A	200	30	30	U				1.5	5.0M	80	E	10M	T
2N542A	S	N	2N2221	2N2218	A	0.2W	A	200	30	30	0	20			1.0	5.0M	80	E	10M	T
2N543	S	N	2N2221	2N2218	AH	0.2W	A	200	50	50	U				1.5	5.0M	80	E	10M	T
2N543A	S	N	2N2221	2N2218	A	0.2W	A	200	45	45	0	20			1.0	5.0M	80	E	10M	T
2N544	G	P			AH	80M	A	71	34											
2N545	S	N			AH	5W	C	200	60	60	0	15	80	0.5A	5.0	0.5A				
2N546	S	N			AH	5W	C	200	30	30	0	15	80	0.5A	3.0	0.5A				
2N547	S	N	2N3766	2N3766	AH	5W	C	200	60	60	0	20	80	0.5A	5.0	0.5A			4.0M	T
2N548	S	N	2N4898	2N4898	AH	5W	C	200	30	30	0	20	80	0.5A	3.0	0.5A			4.0M	T
2N549	S	N			AH	5W	C	200	60	60	0	20	80	0.2A	4.0	0.2A			4.0M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N550	S	N			AH	5W	C	200	30	30	0	20	80	0.2A	4.0	0.2A			4.0M	T
2N551	S	N			AH	5W	C	200	60	60	0	20	80	50M	2.0	50M			3.0M	T
2N552	S	N			AH	5W	C	200	30	30	0	20	80	50M	2.0	50M			3.0M	T
2N553	G	P			SP	35W	C	95	80			40	80	500M	0.9	3.0A				
2N554	G	P		2N178	AP	40W	J	90											5.0K	B
2N555	G	P		2N178	AP	10W	J	90	40											
2N556	G	N			S	100M	A	85	25	20	X	35	70	1.0M	0.5	200M				
2N557	G	N			S	100M	A	85	20	20	X	20		1.0M	0.5	200M				
2N558	G	N			S	100M	A	75	15	15	X	60		1.0M	0.75	200M				
2N559	G	P		2N554	S	0.15W	A	100	15	15					0.3	10M				
2N560	S	N			S	500M	A	150		60	S	20		100M	0.5	10M				
2N561	G	P	MP447		A	50W	A	100	80	50	0	20	50	4.0A						
2N563	G	P	2N650	2N650	S	150M	A	85	30	25	0	10	30							
2N564	G	P	2N650	2N650	S	120M	A	85	30	25	0	10	30							
2N565	G	P	2N651	2N650	S	150M	A	85	30	25	0	30	50							
2N566	G	P	2N651	2N650	S	120M	A	85	30	25	0	30	50							
2N567	G	P	2N651	2N650	S	150M	A	85	30	25	0	50	70							
2N568	G	P	2N651	2N650	S	120M	A	85	30	25	0	50	70							
2N569	G	P	2N1193	2N1191	S	150M	A	85	30	20	0	70	100							
2N570	G	P	2N1192	2N1191	S	120M	A	85	30	20	0	70	100							
2N571	G	P	2N1193	2N1191	S	150M	A	85	30	10	0	100								
2N572	G	P	2N1193	2N1191	S	120M	A	85	30	10	0	100								
2N573	G	P			A	0.2W	A	100	40	25	0	30	300	50M						
2N574	G	P	2N1550	2N1539	SP	180W	J	100	60	55	0	9.0	22	10A	0.2	10A				
2N574A	G	P	2N1551	2N1539	SP	180W	J	100	80	60	0	9.0	22	10A	0.2	10A				
2N575	G	P	2N1554	2N1539	SP	180W	J	100	60	50	0	19	42	10A	0.5	25A				
2N575A	G	P	2N1555	2N1539	SP	180W	J	100	80	55	0	19	42	10A	0.5	25A				
2N576	G	N			S	200M	A	100	20	20	R	20	60	400M	0.4	400M			2.0M	B
2N576A	G	N			S	200M	A	100	40	20	R	20	60	400M	0.4	400M			5.0M	B
2N577	G	P			AL	25M	A	55	25											
2N578	G	P			S	120M	A	71	20			10		400M	0.3	400M			3.0M	B
2N579	G	P			S	120M	A	71	20			20		400M	0.3	400M			5.0M	B
2N580	G	P			S	120M	A	71	20			30		400M	0.3	400M			10M	B
2N581	G	P			S	80M	A	71	18			20		20M		20M			4.0M	B
2N582	G	P			S	120M	A	71	25			40		20M	0.3	100M			14M	B
2N583	G	P			S	80M	A	71	18			20		20M		20M			4.0M	B
2N584	G	P			S	120M	A	71	25			40		20M	0.3	100M			14M	B
2N585	G	P			S	120M	A	71	25			20		20M	0.2	20M			3.0M	B
2N586	G	P	2N1191	2N1191	S	250M	A	85	45			35		250M	0.5	250M				
2N587	G	N			S	150M	A	100	40	20	R	20		200M	0.5	200M				
2N588	G	P	2N3324	2N3323	AH	30M	A	85	15	15	S								200M	M
2N588A	G	P			AH	60M	A	85	15	15	S	30		10M	0.2	10M			200M	M
2N589	G	P	2N1532	2N1529	AP	90W	C	100	100	75	S	20	40	3.0A	1.5	3.0A			5.0K	E
2N591	G	P	2N1192	2N1191	A	50M	A	71	32	32	0									
2N592	G	P			S	125M	A	85	20	20	0	20								
2N593	G	P			S	125M	A	85	40	30	0	30								
2N594	G	N			S	100M	A	85	20	20	0	20							1.5M	E
2N595	G	N			S	100M	A	85	15	15	0	35							3.0M	E
2N596	G	N			S	100M	A	85	10	10	0	50							5.0M	E
2N597	G	P	2N3427	2N3427	S	250M	A	100	45	40	S	40		100M	0.2	10M			3.0M	B
2N598	G	P	2N3427	2N3427	S	250M	A	100	35	35	S	70	225	100M	0.2	10M			5.6M	T
2N599	G	P	2N3428	2N3427	S	250M	A	100	30	20	S	100		100M	0.2	10M			10M	T
2N600	G	P	2N3427	2N3427	SP	750M	C	100	35	35	S	70	225	100M	0.2	10M			5.6M	T
2N601	G	P	2N3428	2N3427	SP	750M	C	100	30	20	S	100		100M	0.2	10M			10M	T
2N602	G	P			SH	120M	A	85	20	20	0	20	80		0.25	10M			10M	T
2N603	G	P			SH	120M	A	85	30	20	0	30	100		0.25	15M			30M	T
2N604	G	P			SH	120M	A	85	30	20	0	40	140		0.25	20M			50M	T
2N605	G	P			AH	0.12W	A	85	15	15	0									
2N606	G	P			AH	0.12W	A	85	15	15	0									
2N607	G	P			AH	0.12W	A	85	15	15	0									
2N608	G	P			AH	0.12W	A	85	15	15	0									
2N609	G	P	2N1193	2N1191	A	180M	A	85	25	15	0									
2N610	G	P	2N1193	2N1191	A	180M	A	85	25	15	0									
2N611	G	P	2N1192	2N1191	A	180M	A	85	25	15	0									
2N612	G	P	2N1191	2N1191	A	180M	A	85	25	15	0									
2N613	G	P	2N1191	2N1191	A	180M	A	85	25	15	0									
2N614	G	P			AH	180M	A	85	20	15	0									
2N615	G	P			AH	180M	A	85	20	15	0									
2N616	G	P			AH	180M	A	85	15	12	0									
2N617	G	P			AH	180M	A	85	15	12	0									
2N618	G	P		2N350A	AP	90W	C	95	80	60	S	60	140	1.0A	0.8	2.0A			5.0K	E
2N619	S	N			A	175M	A	160	50	40	0	9.0	22	5.0M	0.5	8.0M			200K	B
2N620	S	N	2N2222A	2N2218	A	175M	A	160	50	35	0	18	44	5.0M	0.4	8.0M			250K	B
2N621	S	N	2N2222A	2N2218	A	175M	A	160	50	30	0	36	88	5.0M	0.3	8.0M			300K	B
2N622	S	N	2N2222A	2N2218	AM	385M	A	160	50	30	0								300K	B
2N624	G	P			AH	100M	A	100	30	20	S						20	E	20M	E
2N625	G	N			S	1500M	C	100	40	30	S	20		500M	1.0	500M				
2N626	G	P																		
2N627	G	P			AP	90W	C	100	40	30	S	10	30	10A	1.0	10A			5.0K	E
2N628	G	P			AP	90W	C	100	60	45	S	10	30	10A	1.0	10A			5.0K	E
2N629	G	P			AP	90W	C	100	80	60	S	10	30	10A	1.0	10A			5.0K	E
2N630	G	P			AP	90W	C	100	100	75	S	10	30	10A	1.0	10A			5.0K	E
2N631	G	P	2N1194	2N1191	A	167M	A	85	25	20	R									
2N632	G	P	2N1193	2N1191	A	167M	A	85	36	20	R									
2N633	G	P	2N1192	2N1191	A	167M	A	85	35	30	R									
2N634	G	N			SH	150M	A	85	20	20	0	15		200M					5.0M	B
2N634A	G	N			S	2.5M	J	85	25	20	R	40	120	10M	0.2	10M			5.0M	B
2N635	G	N			SH	150M	A	85	20	20	0	25		200M					10M	B

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N635A	G	N			S	2.5M	J	85	25	20	R	80	240	10M	0.2	10M			10M	B
2N636	G	N			SH	150M	A	85	20	20	O	35		200M					15M	B
2N636A	G	N			S	2.5M	J	85	25	15	R	100	300	10M	0.15	10M			15M	B
2N637	G	P	MP277		SP	60W	C	100		35	R	30	60	3.0A	1.5	3.0A				
2N637A	G	P	MP278		SP	60W	C	100		65	R	30	60	3.0A	1.5	3.0A				
2N637B	G	P	MP279		SP	60W	C	100		75	R	30	60	3.0A	1.5	3.0A				
2N638	G	P	MP1338		SP	60W	C	100		35	R	20	40	3.0A	2.0	3.0A				
2N638A	G	P	MP1338A		SP	60W	C	100		65	R	20	40	3.0A	2.0	3.0A				
2N638B	G	P	MP1338B		SP	60W	C	100		75	R	20	40	3.0A	2.0	3.0A				
2N639	G	P	MP259		SP	37W	C	100		35	R	15		3.0A	2.5	3.0A				
2N639A	G	P	MP260		SP	37W	C	100		65	R	15		3.0A	2.5	3.0A				
2N639B	G	P	MP261		SP	37W	C	100		75	R	15		3.0A	2.5	3.0A				
2N640	G	P			A	80M	A	71	34											
2N641	G	P			A	80M	A	71	34											
2N642	G	P			A	80M	A	71	34											
2N643	G	P	2N2955	2N2955	S	120M	A	71	30			20		10M					20M	T
2N644	G	P	2N2955	2N2955	S	120M	A	71	30			20		10M					20M	T
2N645	G	P	2N2955	2B2955	S	120M	A	71	30			20		10M					20M	T
2N646	G	N			A	100M	A	85	25	25	O	50	150	30M						
2N647	G	N			A	100M	A	71	25	25	O									
2N649	G	N			A	100M	A	71	20	18	O									
2N650	G	P		2N650	A	0.2W	A	100	45	30	R	30		10M	0.25	50M	30	E	0.75M	E
2N650A	G	P		2N650	A	0.2W	A	100	45	30	R	33		10M	0.25	50M	30	E	0.75M	B
2N651	G	P		2N650	A	0.2W	A	100	45	30	R	45		10M	0.25	50M	50	E	1.0M	E
2N651A	G	P		2N650	A	0.2W	A	100	45	30	R	45		10M	0.25	50M	50	E	1.0M	B
2N652	G	P		2N650	A	0.2W	A	100	45	30	R	80		10M	0.25	50M	100	E		
2N652A	G	P		2N650	A	0.2W	A	100	45	30	R	80		10M	0.25	50M	100	E		
2N653	G	P		2N653	A	0.2W	A	100	30	25	R	20		10M			30	E		
2N654	G	P		2N653	A	0.2W	A	100	30	25	R	40		10M			50	E		
2N655	G	P		2N653	A	0.2W	A	100	30	25	R	70		10M			100	E		
2N656	S	N	2N4238	2N4237	A	4.0W	C	200	60	60	O	30	90	200M						
2N656A	S	N			A	5.0W	C	200	60	60	O	30	90	200M						
2N657	S	N	2N4239	2N4237	A	4.0W	C	200	100	100	O	30	90	200M						
2N657A	S	N			A	5.0W	C	200	100	100	O	30	90	200M						
2N658	G	P			S	167M	A	85	25	16	O	25	80		3.45	150M			2.5M	B
2N659	G	P			S	167M	A	85	25	14	O	40	110		3.5	250M			5.0M	B
2N660	G	P			S	167M	A	85	25	11	O	60	150		3.5	400M			10M	B
2N661	G	P			S	167M	A	85	25	9.0	O	80			3.5	550M			15M	B
2N662	G	P			S	167M	A	85	25	11	O	30			3.4	180M			4.0M	B
2N663	G	P	MP967		SP	35W	C	100	50	25	O	25	75	500M	1.0	3.0A			15K	E
2N665	G	P		2N665	SP	35W	C	95	80	40	O	40	80	500M	0.9	3.0A			20K	E
2N669	G	P		2N176	AP	62.5W	C	100	40	30	S		250	0.5A					3.0K	E
2N670	G	P	2N3428	2N3427	A	300M	A	85	40	40	V	40	250	1.0A	0.35	1.0A			500K	B
2N671	G	P	2N3428	2N3427	A	800M	C	85	40	40	V	40	250	1.0A	0.35	1.0A			500K	B
2N672	G	P	2N3428	2N3427	A	300M	A	85	25	25	S				0.2	400M				
2N673	G	P	2N3428	2N3427	A	800M	C	85	25	25	S				0.2	400M				
2N674	G	P	2N3428	2N3427	A	300M	A	85	75	75	V	40	250	1.0A	0.35	1.0A			400K	B
2N675	G	P	2N3428	2N3427	A	800M	C	85	75	75	V	40	250	1.0A	0.35	1.0A			400K	B
2N677	G	P	MP439		AP	90W	C	100	50	30	S	20	60	10A	1.0	10A				
2N677A	G	P	MP439A		AP	90W	C	100	60	40	S	20	60	10A	1.0	10A				
2N677B	G	P	MP439B		AP	90W	C	100	90	70	S	20	60	10A	1.0	10A				
2N677C	G	P	MP439C		AP	90W	C	100	100	80	S	20	60	10A	1.0	10A				
2N678	G	P	MP327		AP	90W	C	100	50	20	O	50	100	10A	1.0	10A				
2N678A	G	P	MP328		AP	90W	C	100	60	30	O	50	100	10A	1.0	10A				
2N678B	G	P	MP329		AP	90W	C	100	90	60	O	50	100	10A	1.0	10A				
2N678C	G	P	MP330		AP	90W	C	100	100	70	O	50	100	10A	1.0	10A				
2N679	G	N			S	150M	A	85	25	20	X	20		30M	0.3	100M			2.0M	B
2N680	G	P	2N1191	2N1191	A	150M	A	75	20	20	S	18	165	50M	0.75	50M	15	E		
2N681 thru 2N692	Thyristors, see Table on Page 2-66																			
2N694	G	P			AH	0.1W	A	100	30	15	O	10		2.0M			0.9	B	340M	T
2N695	G	P			SH	75M	A	100	15	15	S	25		10M	1.0	50M				
2N696	S	N		2N696	S	600M	A	175	60	40	R	20	60	150M	1.5	150M			40M	T
2N696A	S	N	2N2218	2N2218	S	800M	A	300	60	35	O	20	60	150M	1.5	150M	15	E	40M	T
2N697	S	N		2N696	S	600M	A	175	60	40	R	40	120	150M	1.5	150M			40M	T
2N697A	S	N	2N2218	2N2218	S	800M	A	300	60	35	O	40	120	150M	1.5	150M	25	E	50M	T
2N698	S	N	2N3498	2N3498	S	800M	A	200	120	80	R	20	60	150M	1.2	50M	15	E	40M	T
2N699	S	N		2N699	S	600M	A	175	120	80	R	40	120	150M	5.0	150M	35	E	50M	T
2N699A	S	N			S	800M	A	300	120	80	R	40	120	150M	5.0	150M	35	E	50M	T
2N699B	S	N	2N3498	2N3498	S	870M	A	200	120	100	R	40	120	150M	1.2	50M	35	E	60M	T
2N700	G	P		2N700	AH	75M	A	100	25	20	S	1.5		2.0M			4.0	E	270M	T
2N700A	G	P		2N700	AH	75M	A	100	25	25	O	1.5		6.0M			4.0	E	360M	T
2N702	S	N		2N702	SH	300M	A	175	25	25	O	20	60	10M	0.5	10M			70M	T
2N703	S	N		2N702	SH	300M	A	175	25	25	O	40	100	10M	0.5	10M			70M	T
2N705	G	P		2N705	SH	300M	C	100	15	15	S	25		10M	0.3	10M				
2N705A	G	P			SH	150M	A	100	15	15	S	25		10M	0.3	10M				
2N706	S	N		2N706	SH	300M	A	175	25	20	R	20		10M	0.6	10M			200M	T
2N706A	S	N		2N706	SH	300M	A	175	25	20	R	20	60	10M	0.6	10M			200M	T
2N706B	S	N		2N706	SH	300M	A	175	25	15	O	20	60	10M	0.4	10M			200M	T
2N706C	S	N	2N835	2N834	SH	360M	A	200	40	20	R	20	60	10M	0.4	10M			200M	T
2N707	S	N		2N707	AHP	300M	A	175	56	28	R	9.0		10M	0.6	10M				
2N707A	S	N		2N707	AH	500M	A	175	70	40	O	9.0	50	10M	0.6	10M			70M	T
2N708	S	N		2N708	SH	360M	A	200	40	20	R	30	120	10M	0.4	10M			300M	T
2N708A	S	N	2N834	2N834	SH	360M	A	200	50	30	R	40	120	10M	0.15	10M			300M	T
2N709	S	N	MM709	MM709	SH	300M	A	200	15	6.0	O	20	120	10M	0.3	3.0M			600M	T
2N709A	S	N			SH	300M	A	200	15	6.0	O	30	90	10M	0.3	3.0M			800M	T
2N710	G	P			SH	300M	C	100	15	15	S	25		10*	0.5	10M				

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N710A	G	P			SH	150M	A	100	15	15	S	25		10M	0.5	10M				
2N711	G	P		2N711	SH	150M	A	100	12	12	S	20	250	10M	0.5	10M			150M	T
2N711A	G	P		2N711	SH	150M	A	100	15	7.0	O	25	150	10M	0.55	50M			150M	T
2N711B	G	P		2N711	SH	150M	A	100	18	7.0	O	30	150	10M	0.25	10M			150M	T
2N715	S	N	2N2221	2N2218	AH	500M	A	175	50	35	O	10	50	15M	1.2	15M			70M	E
2N716	S	N	2N2221	2N2218	AH	500M	A	175	70	40	O	10	50	15M	1.2	15M			70M	E
2N717	S	N	2N2221	2B2218	AH	400M	A	175	60	40	R	20	60	150M	1.5	150M			40M	T
2N718	S	N		2N718	AH	400M	A	175	60	40	R	40	120	150M	1.5	150M			50M	T
2N718A	S	N		2N718A	AH	500M	A	200	75	50	R	40	120	150M	1.5	150M	30	E	60M	T
2N719	S	N	2N3498	2N3498	AH	400M	A	175	120	80	R	20	60	150M	5.0	150M	15	E	40M	T
2N719A	S	N	2N3498	2N3498	AH	500M	A	200	120	80	R	20	60	150M	1.2	50M	15	E	40M	T
2N720	S	N	2N3498	2N3498	AH	400M	A	175	120	80	R	40	120	150M	5.0	150M	35	E	50M	T
2N720A	S	N	2N3498	2N3498	S	500M	A	200	120	100	R	40	120	150M	5.0	150M	30	E	50M	T
2N721	S	P		2N721	AH	400M	A	200	50	50	R	20	45	150M	1.5	150M	15	E	50M	T
2N721A	S	P	2N2905	2N2904	AH	500M	A	200	50	50	R	20	45	150M	0.5	150M	15	E	50M	T
2N722	S	P		2N722	AH	400M	A	175	50	50	R	30	90	150M	1.5	150M	25	E	60M	T
2N722A	S	P	2N2837	2N2800	AH	500M	A	200	50	50	R	30	90	150M	0.5	150M	25	E	60M	T
2N725	G	P			SH	150M	A	100	15	12	S	20		10M						
2N726	S	P		2N726	A	300M	A	175	25	20	O	15	45	10M	0.6	10M	15	E	140M	T
2N727	S	P		2N726	A	300M	A	175	25	20	O	30	120	10M	0.6	10M	30	E	140M	T
2N728	S	N	2N2539	2N2537	SH	4.0M	A	175	15	15	O	20	200	10M	0.7	10M			100M	T
2N729	S	N	2N2539	2N2537	SH	4.0M	A	175	30	30	O	20	200	10M	0.7	10M			100M	T
2N730	S	N	2N2218	2N2218	A	500M	A	175	60	40	R	20	60	150M	1.5	150M			40M	T
2N731	S	N		2N731	A	500M	A	175	60	40	R	40	120	150M	1.5	150M			25M	T
2N734	S	N	2N2221	2N2218	A	500M	A	175	80	60	O	15	50	5.0M	1.0	10M	20	E		
2N734A	S	N	2N2218A	2N2218	A	0.5W	A	200	80	60	O	15	50	5.0M	0.5	10M	20	E	30M	T
2N735	S	N	2N2221	2N2218	A	500M	A	175	80	60	O	30	100	5.0M	1.0	10M	40	E		
2N735A	S	N	2N2218A	2N2218	A	0.5W	A	200	80	60	O	30	100	5.0M	0.5	10M	40	E	60M	T
2N736	S	N	2N2222	2N2218	A	500M	A	175	80	60	O	60	200	5.0M	1.0	10M	80	E		
2N736A	S	N	2N2222	2N2218	A	500M	A	175	80	60	O	60	200	5.0M	0.6	10M	80	E	100M	T
2N736B	S	N	2N2896	2N2895	A	0.5W	A	200	80	60	O	60	200	5.0M	0.5	10M	80	E	100M	T
2N738	S	N	2N2896	2N2895	A	500M	A	175	125	80	O	15	50	5.0M	1.0	10M	20	E		
2N738A	S	N	2N2896	2N2895	A	0.5W	A	200	125	80	O	15	50	5.0M	0.5	10M	20	E	30M	T
2N739	S	N		2N735	A	500M	A	175	125	80	O	30	100	5.0M	1.0	10M	40	E		
2N739A	S	N	2N2896	2N2895	A	0.5W	A	200	125	80	O	30	100	5.0M	0.5	10M	40	E	60M	T
2N740	S	N		2N735	A	0.5W	A	200	125	80	O	60	200	5.0M			80	E		
2N740A	S	N	2N2896	2N2895	A	0.5W	A	200	125	80	O	60	200	5.0M	0.5	10M	80	E	100M	T
2N741	G	P		2N741	AH	150M	A	100	15	15	S	10		5.0M			20	E		
2N741A	G	P		2N741	AH	150M	A	100	20	20	S	10		5.0M			20	E	300M	T
2N742	S	N	2N2218	2N2218	S	0.5W	A	200	60	60	O	25		10M	0.5	10M				
2N742A	S	N	2N2218	2N2218	S	0.5W	A	200	60	60	O	25		10M	0.5	10M				
2N743	S	N		2N743	SH	300M	A	200	20	12	O	20	60	10M	0.35	10M			200M	T
2N743A	S	N	2N2369	2N2369	SH	0.36W	A	200	40	15	O	20	60	10M					500M	T
2N744	S	N		2N744	SH	300M	A	175	20	12	O	40	120	10M	0.35	10M			300M	T
2N744A	S	N	2N2369	2N2369	SH	0.36W	A	200	40	15	O	40	120	10M					500M	T
2N745	S	N	2N2221	2N2218	A	0.15W	A	175	45	30	O	20	55	10M			19	E	10M	B
2N746	S	N	2N2221	2N2218	A	0.15W	A	175	45	30	O	45	150	10M			39	E	10M	B
2N747	S	N	2N2221	2N2218	S	200M	A	175	25	25	O	30	90	10M	0.6	5.0M				
2N748	S	N	2N2221	2N2218	S	200M	A	175	30	30	O	20	40	10M	0.5	5.0M				
2N749	S	N	2N2221	2N2218	AH	200M	A	175	45	25	O	15	55	10M			30	E	50M	B
2N751	S	N	2N2221	2N2218	AH	200M	A	175	20	20	O	30	150	10M			10	E	20M	B
2N752	S	N	2N2221	2N2218	AH	0.5W	A	200	85	45	O				1.2	15M	40	E	200M	T
2N753	S	N		2N706	SH	300M	A	175		20	R	40	120	10M	0.6	10M			200M	T
2N754	S	N	2N2218	2N2218	AH	0.3W	A	175	60	60	R	20	80	5.0M	0.8	10M			30M	T
2N755	S	N	2N2218	2N2218	AH	0.3W	A	175	100	80	R	20	80	5.0M	0.8	10M			30M	T
2N756	S	N	2N2218	2N2218	A	0.5W	A	200	45	45	O				1.0	10M	12	E	50M	B
2N756A	S	N	2N2218	2N2218	A	0.5W	A	200	60	60	O				1.0	10M	12	E	50M	B
2N757	S	N	2N2218	2N2218	A	0.5W	A	200	45	45	O				1.0	10M	18	E	50M	B
2N757A	S	N	2N2218	2N2218	A	0.5W	A	200	60	60	O				1.0	10M	18	E	50M	B
2N758	S	N	2N2218	2N2218	A	0.5W	A	200	45	45	O				1.0	10M	18	E	50M	B
2N758A	S	N	2N2218	2N2218	A	0.5W	A	200	60	60	O				1.0	10M	18	E	50M	B
2N758B	S	N	2N2218	2N2218	A	0.5W	A	200	60	60	O	12		1.0M	0.5	10M	18	E	50M	B
2N759	S	N	2N2218	2N2218	A	0.5W	A	200	45	45	O				1.0	10M	36	E	50M	B
2N759A	S	N	2N3019	2N3019	A	0.5W	A	200	60	60	O				1.0	10M	36	E	50M	B
2N759B	S	N	2N3019	2N3019	A	0.5W	A	200	60	60	O	25		1.0M	0.5	10M	36	E	50M	B
2N760	S	N	2N2218	2N2218	A	0.5W	A	200	45	45	O				1.0	10M	76	E	50M	B
2N760A	S	N	2N3019	2N3019	A	0.5W	A	200	60	60	O				1.0	10M	76	E	50M	B
2N760B	S	N	2N3019	2N3019	A	0.5W	A	200	60	60	O	50		1.0M	0.5	10M	76	E	50M	B
2N761	S	N			A	0.5W	A	200	50	30	O	20	55	10M	1.0	10M	19	E	50M	B
2N762	S	N	2N2218A	2N2218	A	0.5W	A	200	50	30	O	45	150	10M	1.0	10M	39	E	50M	B
2N764 thru 2N767			Thyristors, see Table on Page 2-66																	
2N768	G	P	2N961	2N956	SH	35M	A	100	12	10	S	25		2.0M	0.13	2.0M			125M	T
2N769	G	P	2N961	2N956	SH	35M	A	100	12	7.0	O	25		20M	0.25	10M			100M	T
2N770	S	N	2N3014	2N3013	SH	150M	A	150	20	15	O	12	60	20M	0.25	10M			75M	T
2N771	S	N	2N3014	2N3013	SH	150M	A	150	20	15	O	30	150	20M	0.25	10M			100M	T
2N772	S	N	2N3014	2N3013	SH	150M	A	150	25	25	O	20		10M	0.25	10M			75M	T
2N773	S	N	2N3014	2N3013	AH	150M	A	150	20	15	O	4.0	16	1.5M			6.0	E		
2N774	S	N	2N3014	2N3013	AH	150M	A	150	20	15	O	7.0	30	1.5M			11	E		
2N775	S	N	2N3014	2N3013	AH	150M	A	150	20	15	O	20	80	1.5M			28	E		
2N776	S	N	2N3014	2N3013	AH	150M	A	150	20	15	O	4.0	16	1.5M			6.0	E		
2N777	S	N	2N3014	2N3013	AH	150M	A	150	20	15	O	7.0	30	1.5M			11	E		
2N778	S	N	2N3014	2N3013	AH	150M	A	150	20	15	O	20	80	1.5M			28	E		
2N779	G	P	2N964	2N956	SH	60M	A	100	15	15	S	50	200	10M	0.16	10M			320M	T
2N779A	G	P	2N964	2N956	SH	60M	A	100	15	15	S	50	200	10M	0.125	10M			320M	T
2N779B	G	P	2N964	2N956	SH	150M	A	100	15	15	S	50	200	10M	0.125	10M			320M	T
2N780	S	N	2N2220		A	1.0W	C	175	45	45		35	140	500*	1.0	10M			60M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N781	G	P			SH	150M	A	100	15	15	S	25		10M	0.16	10M				
2N782	G	P			SH	150M	A	100	12	12	S	20		10M	0.20	10M				
2N783	S	N	2N834	2N834	SH	300M		175	40	20	R	20	60	10M	0.25	10M			200M	T
2N784	S	N	2N834	2N834	SH	300M	A	175	30	15	R	25		10M	0.19	10M			200M	T
2N784A	S	N	2N834	2N834	SH	350M	A	200	40	20	R	25	150	10M	0.65	100M			300M	T
2N785	G	P			A	50M	A	85	12	12	S						40	E		
2N789	S	N	2N3946	2N3946	A	150M	A	175	45	30	O				1.0	5.0M	9.0	E	1.0M	B
2N790	S	N	2N3946	2N3946	A	150M	A	175	45	30	O				1.0	5.0M	18	E	2.0M	B
2N791	S	N	2N3946	2N3946	A	150M	A	175	45	30	O				1.0	5.0M	18	E	8.0M	B
2N792	S	N	2N3946	2N3946	A	150M	A	175	45	30	O				1.0	5.0M	36	E	2.0M	B
2N793	S	N	2N3946	2N3946	A	150M	A	175	45	30	O				1.0	5.0M	76	E	2.0M	B
2N794	G	P			SH	120M	A	85	13			30		10M	0.3	10M			25M	T
2N795	G	P			SH	120M	A	85	13			30		10M	0.5	40M			35M	T
2N796	G	P			SH	120M	A	85	13			50		10M	0.5	40M			50M	T
2N797	G	N			SH	150M	A	100	20	7.0	O	40		10M	0.14	10M			600M	T
2N799	G	P			S	75M	A	85	25	12	O	30		12M	0.15	12M			4.0M	B
2N800	G	P			S	75M	A	85	25	12	O	30			0.15	12M			4.0M	B
2N801	G	P			S	75M	A	85	30	18	O	30	60							
2N802	G	P			S	75M	A	85	30	18	O	30	60							
2N803	G	P			S	75M	A	85	30	15	O	40	80							
2N804	G	P			S	75M	A	85	30	15	O	40	80							
2N805	G	P			S	75M	A	85	30	12	O	60								
2N806	G	P			S	75M	A	85	30	12	O	60								
2N807	G	P			S	70M	A	85	25	14	V	40		20M	0.2	20M			14M	B
2N808	G	P			S	70M	A	85	25	14	V	40		20M	0.2	20M			14M	B
2N809	G	P			AH	75M	A	85	30	15	O	25	110	25M			30	E	3.0M	B
2N810	G	P			AH	75M	A	85	30	15	O	25	110	25M			30	E	3.0M	B
2N811	G	P			AH	75M	A	85	30	12	O	45	180	45M			50	E	5.0M	B
2N812	G	P			AH	75M	A	85	30	12	O	45	180	45M			50	E	5.0M	B
2N813	G	P			AH	75M	A	85	30	10	O	55	220	55M			70	E	15M	B
2N814	G	P			AH	75M	A	85	30	10	O	55	220	55M			70	E	15M	B
2N815	G	N			S	75M	A	85	25	15	O	60	180	30M	0.75	200M				
2N816	G	N			S	75M	A	85	25	15	O	60	180	30M	0.75	200M				
2N817	G	N			S	75M	A	85	30	15	O	20		50M	0.25	50M				
2N818	G	N			S	75M	A	85	30	15	O	20		50M	0.25	50M				
2N819	G	N			S	75M	A	85	30	20	O	30		50M	0.25	50M				
2N820	G	N			S	75M	A	85	30	20	O	30		50M	0.25	50M				
2N821	G	N			S	75M	A	85	30	25	O	40		50M	0.25	50M				
2N822	G	N			S	75M	A	85	30	25	O	40		50M	0.25	50M				
2N823	G	N			S	75M	A	85	25	12	O	40		20M	0.15	12M			4.0M	B
2N824	G	P			AH	70M	A	85	30	18	O								2.0M	B
2N825	G	P			S	70M	A	85	30	20	O	40	40						2.5M	B
2N826	G	P			S	70M	A	85	30	20	O	20	40						2.5M	B
2N827	G	P		2N827	SH	150M	A	100	20	20	S	100		10M	0.25	10M			250M	T
2N828	G	P		2N828	SH	150M	A	100	15	15	S	25		10M	0.2	10M			300M	T
2N828A	G	P		2N828	SH	150M	A	100	15	15	S	25		10M	0.2	10M			300M	T
2N829	G	P		2N828	SH	150M	A	100	15	15	S	50		10M	0.2	10M			300M	T
2N834	S	N		2N834	SH	300M	A	175	40	30	S	25		10M	0.25	10M			350M	T
2N834A	S	N			SH	360M	A	200	40	30	S	25		10M	0.25	10M			500M	T
2N835	S	N		2N834	SH	0.3W	A	175	25	20	O	20		10M	0.3	10M			300M	T
2N837	G	P			SH	150M	A	100	12	12	S	30		10M	0.25	10M				
2N838	G	P		2N838	SH	150M	A	100	30	30	S	30		10M	0.18	10M			300M	T
2N839	S	N	2N2222	2N2218	AH	0.3W	A	175	45	45	O	15	50	10M	2.0	10M	20	E	30M	T
2N840	S	N	2N2221	2N2218	AH	0.3W	A	175	45	45	O	30	100	10M	2.0	10M	40	E	30M	T
2N841	S	N	2N2222	2N2218	AH	0.3W	A	175	45	45	O	60	400	10M	2.0	10M	80	E	40M	T
2N842	S	N	2N2221	2N2218	AH	0.3W	A	175	45	45	O	20	55	10M	1.2	10M	20	E	30M	T
2N843	S	N	2N2222	2N2218	AH	0.3W	A	175	45	45	O	45	150	10M	1.2	10M	40	E	40M	T
2N844	S	N	2N2896	2N2895	AH	0.3W	A	175	60	60	R	40	120	5.0M	0.8	10M			50M	T
2N845	S	N	2N2896	2N2895	AH	0.3W	A	175	100	80	R	40	120	5.0M	0.8	10M			50M	T
2N846	G	P	2N960	2N956	SH	60M	A	100	15	15	S	25	125	10M	0.18	10M			320M	T
2N846A	G	P	2N960	2N956	SH	60M	A	100	15	15	S	25	125	10M	0.14	10M			320M	T
2N846B	G	P	2N960	2N956	SH	150M	A	100	15	15	S	25	125	10M	0.14	10M			320M	T
2N847	S	N	2N835	2N834	S	0.2W	A	175	20	15	O				1.5	10M				
2N848	S	N	2N834	2N834	S	0.2W	A	175	40	25	O				1.5	10M				
2N849	S	N	2N835	2N834	SH	300M	A	175	25	15	O	20	60	10M	0.6	10M			600M	T
2N850	S	N	2N834	2N834	SH	300M	A	175	25	15	O	40	120	10M	0.6	10M			600M	T
2N851	S	N	2N835	2N834	SH	300M	A	175	20	12	O	20	60	10M					300M	T
2N852	S	N	2N834	2N834	SH	300M	A	175	20	12	O	40	120	10M					300M	T
2N858	S	P	2N2906	2N2904	S	150M	A	140	40	40	O	10	60	5.0M	0.15	5.0M	15	E	5.0M	T
2N859	S	P			S	150M	A	140	40	40	O	25	100	5.0M	0.15	5.0M	30	E	6.0M	T
2N860	S	P			S	150M	A	140	25	25	O	10	40	5.0M	0.15	5.0M	15	E	6.5M	T
2N861	S	P			S	150M	A	140	25	25	O	25	75	5.0M	0.15	5.0M	30	E	7.5M	T
2N862	S	P	2N2906	2N2904	S	150M	A	140	15	15	O	12	48	5.0M	0.15	5.0M	20	E	8.0M	T
2N863	S	P	2N2906	2N2904	S	150M	A	140	15	15	O	25	100	5.0M	0.15	5.0M	40	E	10M	T
2N864	S	P	2N2906	2N2904	S	150M	A	140	6.0	6.0	O	20	100	5.0M	0.1	5.0M	25	E	16M	T
2N864A	S	P	2N2906	2N2904	S	300M	A		6.0	6.0	O	20	250	5.0M	0.1	5.0M	25	E	16M	T
2N865	S	P	2N2906	2N2904	S	150M	A	140	10	6.0	O	45	125	5.0M	0.1	5.0M	100	E	24M	T
2N865A	S	P	2N2906	2N2904	S	300M	A		10	10	O	45	400	5.0M	0.1	5.0M	100	E	24M	T
2N866	S	N	2N2906	2N2904	S	500M	A	175	30	20	R	15	45	150M	1.5	150M			40M	T
2N867	S	N	2N2906	2N2904	S	500M	A	175	30	20	R	30	90	150M	1.5	150M			50M	T
2N869	S	P		2N869	AH	360M	A	200	25	18	O	20	120	10M	1.0	10M			100M	T
2N869A	S	P		2N869A	S	360M	A	200	25	18	O	40	120	30M	0.15	10M			400M	T
2N870	S	N			AH	500M	A	200	100	80	R	40	120	150M	1.2	50M	30	E	50M	T
2N871	S	N	2N2895	2N2895	AH	500M	A	200	100	80	R	100	300	150M	1.2	50M	50	E	60M	T
2N876 thru 2N901	Thyristors, see Table on Page 2-66																			
2N902	S	N	2N2221	2N2218	A	150M	A	175	45	30	O				1.0	5.0M	9.0	E	1.0M	

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N903	S	N	2N2221	2N2218	A	150M	A	175	45	30	O				1.0	5.0M	18	E	2.0M	
2N904	S	N	2N2221	2N2218	A	150M	A	175	45	30	O				1.0	5.0M	18	E	8.0M	
2N905	S	N	2N2221	2N2218	A	150M	A	175	45	30	O				1.0	5.0M	36	E	2.0M	
2N906	S	N	2N2221	2N2218	A	150M	A	175	45	30	O				1.0	5.0M	76	E	2.0M	
2N907	S	N	2N2221	2N2218	A	0.15W	A	175	45	30	O	20	55	10M			19	E	12M	T
2N908	S	N	2N2221	2N2218	A	0.15W	A	175	45	30	O	45	150	10M			39	E	25M	T
2N909	S	N	2N2222	2N2218	A	400M	A	175	60	30	R	110	350	50M	0.5	10M	40	E	50M	T
2N910	S	N		2N910	A	500M	A	200	100	80	R	75		10M	0.4	10M	76	E	60M	T
2N911	S	N		2N910	A	500M	A	200	100	80	R	35		10M	0.4	10M	36	E	50M	T
2N912	S	N	2N2895	2N2895	A	500M	A	200	100	80	R	15		10M	0.4	10M	18	E	40M	T
2N914	S	N		2N914	SH	360M	A	200	40	20	R	30	120	10M	0.7	200M			300M	T
2N914A	S	N	2N2369	2N2369	SH	360M	A	200	40	20	R	30	120	10M	0.4	200M			300M	T
2N915	S	N		2N915	AH	360M	A	200	70	50	O	50	200	10M	1.0	10M	50	E	250M	T
2N915A	S	N			AHP	1.2W	C	200	70	50	O	50	250	5.0M	0.2	10M	50	E	600M	T
2N916	S	N		2N916	AH	360M	A	200	45	25	O	50	200	10M	0.5	10M	50	E	300M	T
2N916A	S	N	2N918	2N918	AH	360M	A	200	45	25	O	50	200	10M	0.5	10M	50	E	300M	T
2N916B	S	N	2N918	2N918	AHP	1.2W	C	200	60	30	O	50	200	10M	0.2	10M	50	E	500M	T
2N917	S	N	2N918	2N918	AH	200M	A	200	30	15	G	20	200	3.0M	0.5	3.0M			500M	T
2N917A	S	N	2N918	2N918	AH	200M	A	200	30	15	O	20	200	3.0M	0.4	10M			600M	T
2N918	S	N		2N918	AH	200M	A	200	30	15	O	20		3.0M	0.4	10M			600M	T
2N919	S	N	2N834	2N834	SH	0.36W	A	200	25	15	O	20	60	10M	0.2	10M			200M	T
2N920	S	N	2N834	2N834	SH	0.36W	A	200	25	15	O	40	120	10M	0.2	10M			200M	T
2N921	S	N	2N834	2N834	SH	0.36W	A	200	50	20	O	20	60	10M	0.3	10M			200M	T
2N922	S	N	2N834	2N834	SH	0.36W	A	200	50	20	O	40	120	10M	0.3	10M			200M	T
2N923	S	P	2N2906	2N2904	A	0.25W	A	200	40	25	O				0.5	5.0M	12	E	0.8M	B
2N924	S	P	2N2906	2N2904	A	0.25W	A	200	40	25	O				0.5	5.0M	24	E	0.8M	B
2N925	S	P	2N2906	2N2904	A	0.25W	A	200	50	40	O				0.5	5.0M	10	E	0.8M	B
2N926	S	P	2N2906	2N2904	A	0.25W	A	200	50	40	O				0.5	5.0M	20	E	0.8M	B
2N927	S	P	2N2906	2N2904	A	0.25W	A	200	70	60	O				0.5	5.0M	8.0	E	0.8M	B
2N928	S	P	2N2906	2N2904	A	0.25W	A	200	70	60	O				0.5	5.0M	18	E	0.8M	B
2N929	S	N		2N929	A	600M	C	175	45	45	O	40	120	10*	1.0	10M	150	E	1.0M	E
2N929A	S	N		2N929	A	0.5W	A	200	60	45	O	40	120	10*	0.5	10M	60	E	45M	T
2N930	S	N		2N929	A	600M	C	175	45	45	O	100	300	10*	1.0	10M	150	E	1.0M	E
2N930A	S	N		2N929	A	0.5W	A	200	60	45	O	100	300	10*	0.5	10M	150	E	45M	T
2N930B	S	N			A	500M	A		60	45	O	100	300	10*	0.5	10M	150	E	45M	T
2N934	G	P	2N965	2N960	SH	150M	A	85	13	12		40		40M	0.3	40M			35M	T
2N935	S	P	2N2907A	2N2904	A	0.25W	A	160	50	40	O	9.0	22		0.3	5.0M				
2N936	S	P	2N2907A	2N2904	A	0.25W	A	160	50	35	O	18	44		0.5	5.0M				
2N937	S	P	2N2907A	2N2904	A	0.25W	A	160	50	30	O	36	88		0.6	5.0M				
2N938	S	P	2N2907A	2N2904	A	0.25W	A	175	40	35	O				0.3	5.0M	9.0	E	1.0M	B
2N939	S	P	2N2907A	2N2904	A	0.25W	A	175	40	35	O				0.3	5.0M	18	E	2.0M	B
2N940	S	P	2N2907A	2N2904	A	0.25W	A	175	40	35	O				0.3	5.0M	36	E	2.0M	B
2N941	S	P	2N2907A	2N2904	SC	0.25W	A	175	25	8	U	10		1.0M			25	E	16M	T
2N942	S	P	2N2907A	2N2904	SC	0.25W	A	175	25	8	U	10		1.0M			25	E	10M	T
2N943	S	P	2N2907A	2N2904	SC	0.25W	A	175	40	18	O	10			0.003		25	E	1.0M	B
2N944	S	P	2N2907A	2N2904	SC	0.25W	A	175	40	18	O	10			0.004		25	E	1.0M	B
2N945	S	P	2N2907A	2N2904	SC	0.25W	A	175	50	50	O	10			0.005		25	E	1.0M	B
2N946	S	P	2N2907A	2N2904	SC	0.25W	A	175	80	80	O	10			0.005		25	E	1.0M	B
2N947	S	N	2N834	2N834	S	360M	A	150	20	15	R	20		10M	0.4	5.0M			200M	T
2N948 thru 2N951	Thyristors, see Table on Page 2-66																			
2N955	G	N			SH	150M	A	100	12	8.0	O	30		30M	0.5	30M				
2N955A	G	N			SH	150M	A	100	12	8.0	O	30		30M	0.3	30M				
2N956	S	N	2N2222	2N2218	AH	500M	A	200	75	50	R	100	300	150M	1.5	150M	50	E	70M	T
2N957	S	N	2N2501	2N2501	AH	250M	A	150	40	20	O	45		10M	1.5	10M			200M	T
2N958	S	N	2N835	2N834	SH	0.25W	C	150	25	15	O	20		10M	0.2	10M			200M	T
2N959	S	N	2N835	2N834	SH	0.25W	C	150	25	15	O	40		10M	0.2	10M			200M	T
2N960	G	P		2N956	SH	150M	A	100	15	15	S	20		10M	0.2	10M			300M	T
2N961	G	P		2N956	SH	150M	A	100	12	12	S	20		10M	0.2	10M			300M	T
2N962	G	P		2N956	SH	150M	A	100	12	12	S	20		10M	0.2	10M			300M	T
2N963	G	P		2N960	SH	150M	A	100	12	12	S	20		10M	0.2	10M			250M	T
2N964	G	P		2N960	SH	150M	A	100	15	15	S	40		10M	0.18	10M			300M	T
2N964A	G	P		2N964	SH	150M	A	100	15	15	S	40		10M	0.18	10M			300M	T
2N965	G	P		2N960	SH	150M	A	100	12	12	S	40		10M	0.18	10M			300M	T
2N966	G	P		2N960	SH	150M	A	100	12	12	S	40		10M	0.18	10M			300M	T
2N967	G	P		2N960	SH	150M	A	100	12	12	S	40		10M	0.2	10M			250M	T
2N968	G	P		2N965	SH	150M	A	100	15	15	S	17		10M	0.25	10M			300M	T
2N969	G	P		2N965	SH	150M	A	100	12	12	S	17		10M	0.25	10M			300M	T
2N970	G	P		2N965	SH	150M	A	100	12	12	S	17		10M	0.25	10M			300M	T
2N971	G	P		2N965	SH	150M	A	100	7.0	7.0	S	17		10M	0.25	10M			300M	T
2N972	G	P		2N965	SH	150M	A	100	15	15	S	40		10M	0.25	10M			300M	T
2N973	G	P		2N965	SH	150M	A	100	12	12	S	40		10M	0.25	10M			300M	T
2N974	G	P		2N965	SH	150M	A	100	12	12	S	40		10M	0.25	10M			300M	T
2N975	G	P		2N965	SH	150M	A	100	7.0	7.0	S	40		10M	0.25	10M			300M	T
2N976	G	P	2N964	2N960	SH	100M	A	100	15	10	O	30		20M	0.17	20M			249M	T
2N977	G	P	2N964	2N960	SH	150M	A	100	15	10	O	50		40M	0.2	40M			400M	T
2N978	S	P		2N978	AH	330M	A	150	30	20	O	15	60	150M	1.5	150M			40M	T
2N979	G	P			SH	60M	A	100	20	15	O	30		10M	0.25	10M			100M	T
2N980	G	P			SH	60M	A	100	20	12	O	30		10M	0.25	10M			100M	T
2N981	S	N			A	0.5W	A	200	80	80	O				3.0	10M	36	E	50M	B
2N982	G	P			SH	60M	A	100	20	15	O	50		10M	0.125	10M				
2N983	G	P			SH	60M	A	100	15	15	O	40		10M	0.15	10M				
2N984	G	P			SH	60M	A	100	15	10	O	50		10M	0.18	10M				
2N985	G	P		2N985	SH	150M	A	100	15	7.0	O	40		10M	0.15	10M			300M	T
2N986	S	N	2N2895	2N2895	AL	500M	A	200	100	80	R									
2N987	G	P			AH	0.1W	A	100	40	40	O	40	250	1.0M			40	E		
2N988	S	N	2N2221	2N2218	AH	0.3W	A	175	20	10	O	20	120	10M	0.5	10M			300M	T
2N989	S	N	2N2221	2N2218	AH	0.3W	A	175	20	10	O	20	120	10M	0.5	10M			300M	T
2N990	G	P			AH	67M	A	75	20	20	R	40		1.0M			40	E	44M	T
2N991	G	P			AH	67M	A	75	20	20	R	40		1.0M			40	E	44M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N992	G	P			AH	67M	A	75	20	20	R	40		1.0M			40	E		
2N993	G	P			AH	67M	A	75	20	20	R	40		1.0M			40	E	44M	T
2N994	G	P			SH	200M	A	150	15	6.0	O	45	140	10M	0.18	10M				
2N995	S	P	2N3250	2N3250	AH	360M	A	200	20	15	O	35	140	20M	0.2	20M			100M	T
2N995A	S	P	2N3250	2N3250	AH	360M	A	200	20	15	O	35	140	20M	0.2	20M			100M	T
2N996	S	P		2N996	AH	360M	A	200	15	12	O	35		20M	0.3	60M			100M	T
2N997	S	N			A	500M	A	175	75	40	O	35		100*	1.6	100M				
2N998	S	N		2N998	AL	500M	A	200	100	60	O				1.2	50M	1000	E		
2N999	S	N		2N998	AL	500M	A	200	60	60	O				1.6	100M				
2N1000	G	N			S	150M	A	100	40	25	O	40		10M	0.25	100M			7.0M	E
2N1003	G	P			AH	120M	A	100	35	20	U						10	E		
2N1004	G	P			AH	120M	A	100	35	20	U						10	E		
2N1005	S	N	2N2242	2N2242	A	150M	A	175	15	15	O	10	25	10M	0.6	10M				
2N1006	S	N	2N2242	2N2242	A	150M	A	175	15	15	O	25	150	10M	0.6	10M				
2N1007	G	P			AP	35W	C	95	25	20	O	50	250	1.0A	1.0	2.0A	25	E	60K	T
2N1008	G	P		2N1008	A	0.3W	C	85	20	15	R				0.25	0.1A	40	E		
2N1008A	G	P		2N1008	A	0.3W	C	85	40	35	R				0.25	0.1A	40	E		
2N1008B	G	P		2N1008	A	0.3W	C	85	60	55	R				0.25	0.1A	40	E		
2N1009	G	P			A	0.4W	C	85	35	35	R				0.25	0.1A	40	E	7.5K	E
2N1010	G	N			A	20M	A	55	10	10	O									
2N1011	G	P		2N1011	AP	35W	C	95	80	80	S	30	75	3.0A	1.5	3.0A	20	E	5.0K	E
2N1012	G	N			S	150M	A	100	40	22	O	40		100M	0.2	100M			3.0M	E
2N1014	G	P	MP448		AP	50W	C	100	100	65	O	20	50	4.0A	0.8	4.0A			0.5M	B
2N1015	S	N	2N3713	2N3713	SP	150W	C	150	30	30	V	10		2.0A	1.5	2.0A				
2N1015A	S	N			SP	150W	C	150	60	60	V	10		2.0A	1.5	2.0A				
2N1015B	S	N			SP	150W	C	150	100	100	V	10		2.0A	1.5	2.0A				
2N1015C	S	N			SP	150W	C	150	150	150	V	10		2.0A	1.5	2.0A				
2N1015D	S	N			SP	150W	C	150	200	200	V	10		2.0A	1.5	2.0A				
2N1015E	S	N			SP	150W	C	150	250	250	V	10		2.0A	1.5	2.0A				
2N1015F	S	N			SP	150W	C	150	300	300	V	10		2.0A	1.5	2.0A				
2N1016	S	N	2N3713	2N3713	SP	150W	C	150	30	30	V	10		5.0A	2.5	5.0A				
2N1016A	S	N			SP	150W	C	150	60	60	V	10		5.0A	2.5	5.0A				
2N1016B	S	N			SP	150W	C	150	100	100	V	10		5.0A	2.5	5.0A				
2N1016C	S	N			SP	150W	C	150	150	150	V	10		5.0A	2.5	5.0A				
2N1016D	S	N			SP	150W	C	150	200	200	V	10		5.0A	2.5	5.0A				
2N1016E	S	N			SP	150W	C	150	250	250	V	10		5.0A	2.5	5.0A				
2N1016F	S	N			SP	150W	C	150	300	300	V	10		5.0A	2.5	5.0A				
2N1017	G	P			S	150M	A	85	30	10	O	70		20M	2.6	200M			15M	B
2N1018	G	P			S	200M	A	100	30	6.0	O	70		70M	2.6	200M			20M	B
2N1021	G	P		2N1021	AP	50W	C	95	100	100	X	23	70	1.0A	1.0	5.0A				
2N1021A	G	P	MP1974		AP	150W	C	100	100	50	O	30	90	5.0A	0.5	5.0A			200K	T
2N1022	G	P		2N1021	AP	50W	C	95	120	120	X	23	70	5.0A	1.0	5.0A				
2N1022A	G	P	MP1975		AP	150W	C	100	120	55	O	30	90	5.0A	0.5	5.0A			200K	T
2N1023	G	P	2N3323	2N3323	A	120M	A	100	40	40	O	20	175	1.5M						
2N1024	S	P	2N3250	2N3250	A	0.25W	A	175	18	15	U						9.0	E	1.0M	B
2N1025	S	P	2N3250	2N3250	A	0.25W	A	175	40	35	U						9.0	E	1.0M	B
2N1026	S	P	2N3250	2N3250	A	0.25W	A	175	40	35	U						18	E	2.0M	B
2N1027	S	P	2N3250	2N3250	A	0.25W	A	175	18	15	U						18	E	4.0M	B
2N1028	S	P			A	0.25W	A	175	12	10	U						9.0	E	7.2M	T
2N1029	G	P	2N1553	2N1539	AP	90W	C	100	50	20	O	20	60	10A	1.0	10A				
2N1029A	G	P	2N1554	2N1539	AP	90W	C	100	60	30	O	20	60	10A	1.0	10A				
2N1029B	G	P	2N1555	2N1539	AP	90W	C	100	90	60	O	20	60	10A	1.0	10A				
2N1029C	G	P	2N1556	2N1539	AP	90W	C	100	100	70	O	20	60	10A	1.0	10A				
2N1030	G	P	2N1557	2N1539	AP	90W	C	100	50	20	O	50	100	10A	1.0	10A				
2N1030A	G	P	2N1558	2N1539	AP	90W	C	100	60	30	O	50	100	10A	1.0	10A				
2N1030B	G	P	2N1559	2N1539	AP			100	90	60	O	50	100	10A	1.0	10A				
2N1030C	G	P	2N1560	2N1539	AP			100	100	70	O	50	100	10A	1.0	10A				
2N1031	G	P	2N1553	2N1539	AP	90W	C	100	50	30	S	20	60	10A	1.0	10A	10	E	2.0K	E
2N1031A	G	P	2N1554	2N1539	AP	90W	C	100	60	40	S	20	60	10A	1.0	10A	10	E	2.0K	E
2N1031B	G	P	2N1555	2N1539	AP	90W	C	100	90	70	S	20	60	10A	1.0	10A	10	E	2.0K	E
2N1031C	G	P	2N1556	2N1539	AP	90W	C	100	100	80	S	20	60	10A	1.0	10A	10	E	2.0K	E
2N1032	G	P	MP327		AP	90W	C	100	50	30	S	50	100	10A	1.0	10A	25	E	2.0K	E
2N1032A	G	P	MP328		AP	90W	C	100	60	40	S	50	100	10A	1.0	10A	25	E	2.0K	E
2N1032B	G	P	MP329		AP	90W	C	100	90	70	S	50	100	10A	1.0	10A	25	E	2.0K	E
2N1032C	G	P	MP330		AP	90W	C	100	100	80	S	50	100	10A	1.0	10A	25	E	2.0K	E
2N1034	S	P			A	250M	A	160	50	40	O				0.5	8.0M	9.0	E	150K	B
2N1035	S	P			A	250M	A	160	50	35	O				0.4	8.0M	18	E	200K	B
2N1036	S	P			A	250M	A	160	50	30	O				0.3	8.0M	34	E	300K	B
2N1037	S	P			A	250M	A	160	50	35	O				0.5	8.0M	9.0	E	150K	B
2N1038	G	P		2N1038	AP	20W	C	95	40	40	V	20	60	1.0A	0.25	1.0A	18	E	8.0K	E
2N1039	G	P		2N1038	AP	20W	C	95	60	60	V	20	60	1.0A	0.25	1.0A	18	E	8.0K	E
2N1040	G	P		2N1038	AP	20W	C	95	80	80	V	20	60	1.0A	0.25	1.0A	18	E	8.0K	E
2N1041	G	P		2N1038	AP	20W	C	95	100	100	V	20	60	1.0A	0.25	1.0A	18	E	8.0K	E
2N1042	G	P	2N2143	2N2137	AP	20W	C	100	40	40	V	20	60	3.0A	0.75	3.0A	2.0	E	250K	T
2N1043	G	P	2N2144	2N2137	AP	20W	C	100	60	60	V	20	60	3.0A	0.25	1.0A			250K	T
2N1044	G	P	2N2145	2N2137	AP	20W	C	100	80	80	V	20	60	3.0A	0.25	1.0A			250K	T
2N1045	G	P	2N2146	2N2137	AP	20W	C	100	100	100	V	20	60	3.0A	0.25	1.0A			250K	T
2N1046	G	P	MP1046		AHP	50W	C	100	100	50	O	40		5.0A	0.2	500M			15M	T
2N1046A	G	P	MP1046		AHP	50W	C	100	130	50	O	40		5.0A	0.4	5.0A			15M	T
2N1046B	G	P	MP1046		AHP	50W	C	100	130	50	O	20		10A	0.4	5.0A			15M	T
2N1047	S	N			AP	40W	C	200	80			12	36	500M	7.5	500M				
2N1047A	S	N			AP	40W	C	200	80	80	O	12	36	500M	7.5	500M			75K	E
2N1047B	S	N			AP	40W	C	200	80	80	O	12	36	500M	2.0	500M			125K	E
2N1047C	S	N			AP	40W	C	200	80	80	O	12	36	500M	1.0	500M			125K	E
2N1048	S	N			AP	40W	C	200	120			12	36	500M	7.5	500M				
2N1048A	S	N			AP	40W	C	200	120	120	O	12	36	500M	7.5	500M			75K	E
2N1048B	S	N			AP	40W	C	200	120	120	O	12	36	500M	2.0	500M			125K	E
2N1048C	S	N			AP	40W	C	200	120	120	O	12	36	500M	1.0	500M			125K	E

2N1049–2N1136A

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N1049	S	N			AP	40W	C	200	80			30	90	500M	7.5	500M				
2N1049A	S	N			AP	40W	C	200	80	80	O	30	90	500M	7.5	500M			75K	E
2N1049B	S	N			AP	40W	C	200	80	80	O	30	90	500M	2.0	500M			125K	E
2N1049C	S	N			AP	40W	C	200	80	80	O	30	90	500M	1.0	500M			125K	E
2N1050	S	N			AP	40W	C	200	120			30	90	500M	7.5	500M				
2N1050A	S	N			AP	40W	C	200	120	120	O	30	90	500M	7.5	500M			75K	E
2N1050B	S	N			AP	40W	C	200	120	120	O	30	90	500M	2.0	500M			125K	E
2N1050C	S	N			AP	40W	C	200	120	80	O	30	90	500M	1.0	500M			125K	E
2N1051	S	N	2N2218	2N2218	AH	0.5W	A	150	40	40	O	25		50M	3.0	50M	30	E	80M	T
2N1052	S	N	2N2218	2N2218	AH	6.0M	A	200	200	200	V	20	80	0.2A	5.0	0.2A				
2N1054	S	N	2N2218	2N2218	AH	0.8W	A	200	125	115	O	20		0.2A			15	E	8.0M	T
2N1055	S	N	2N2218	2N2218	AH	5.5M	A	200	100	100	O	20	80	50M	2.0	50M			3.0M	T
2N1056	G	P	2N2043	2N2042	A	240M	A	100	70	50	R	18	43	20M	0.13	20M			500K	B
2N1057	G	P	2N1924	2N1924	A	240M	A	100	45	45	V	34	90	20M	0.13	20M			500K	B
2N1058	G	N				50M		75	20	20	R						10	B	4.0M	B
2N1059	G	N			A	180M		75	40	15	R			10M					10K	E
2N1060	S	N	2N2501	2N2501	SH	0.25W	A	150	40	40	O	17		5.0M	0.3	5.0M				
2N1065	G	P			A	0.12W	A	85	40	20	O	20	80		0.25	10M			10M	T
2N1066	G	P	2N3323	2N3323	AH	120M	A	100	40	40	O	20	175	1.5M						
2N1067	S	N	2N3766	2N3766	SP	5.0W	C	175	60	30	O	15	75	200M	2.0	200M			0.75M	B
2N1068	S	N	2N3766	2N3766	SP	10W	C	175	60	30	O	15	75	750M	2.0	200M			0.75M	B
2N1069	S	N	2N4913	2N4913	SP	50W	C	175	60	45	O	20	50	1.5A	1.33	0.5A			0.5M	B
2N1070	S	N	2N4913	2N4913	SP	50W	C	175	60	45	O	20	50	1.5A	0.5	1.5A			0.5M	B
2N1072	S	N	2N3766	2N3766	SP	2.0W	A	150	75	30	O	20		0.75A	2.0	0.75A				
2N1073	G	P		2N1073	AP			110	40	40	R	20	60	5.0A	1.0	5.0A				
2N1073A	G	P		2N1073	AP			110	80	80	R	20	60	5.0A	1.0	5.0A				
2N1073B	G	P		2N1073	AP			110	120	120	R	20	60	5.0A	1.0	5.0A				
2N1074	S	N	2N2218	2N2218	A	250M	A	160	50	40	O						9.0	E	200K	B
2N1075	S	N	2N2218	2N2218	A	250M	A	160	50	35	O						18	E	250K	B
2N1076	S	N	2N2218	2N2218	A	250M	A	160	50	30	O						36	E	300K	B
2N1077	S	N	2N2218	2N2218	A	250M	A	160	50	35	O				1.0	8.0M	9.0	E	200K	B
2N1078	G	P			AP	20W	C	85	60	60	S	40		0.5A	1.0	1.0A				
2N1079	S	N			AHP	60W	C	200	60	60	S	20	80	1.0A	3.0	1.0A	20	E	10M	T
2N1080	S	N			AHP	60W	C	200	60	60	S	20	80	2.0A	5.0	2.0A	20	E	10M	T
2N1081	S	N	2N2221	2N2218	S	6.0M	A	200	40	40	O	20	100	0.5A	4.0	0.5A				
2N1082	S	N	2N2221	2N2218	AH	0.2W	A	200	25	25	S	10	50	10M			10	E	17M	T
2N1086	G	N			AH	65M	A	85	9.0	9.0	O	17	195	1.0M						
2N1086A	G	N			AH	65M	A	85	9.0	9.0	O	17	195	1.0M						
2N1087	G	N			AH	65M	A	85	9.0	9.0	O	17	195	1.0M						
2N1090	G	N			S	120M	A	85	25			30		20M	0.2	20M			5.0M	B
2N1091	G	N			S	120M	A	85	25			40		20M	0.3	200M			10M	B
2N1092	S	N			SP	2.0W	A	175	60	30	O	15	75	200M	2.0	200M			0.75M	B
2N1093	G	P			A	150M	A	95	30	15	O	50	150	20M	0.2	20M	40	E	5.0M	B
2N1094	G	P			AH	0.15W	A	100	30	15	O	15		4.0M			0.96	B	560M	T
2N1097	G	P	2N1414	2N1413	A	200M	A	100	18	18	R	34	90	20M					1.0M	B
2N1098	G	P	2N1414	2N1413	A	200M	A	100	18	18	R	25	90	20M					1.0M	B
2N1099	G	P		2N277	AP	50W	C	95	80	70	S	35	70	5.0A	0.7	12A				
2N1100	G	P		2N173	AP	50W	C	95	100	65	O	25	50	5.0A	0.7	12A				
2N1101	G	N			A	180M		75	20	15	R	25	50	35M	0.5	100M			10K	E
2N1102	G	N			A	180M		75	40	25	R	25	50	35M	0.5	100M			10K	E
2N1103	S	N	2N2221	2N2218	A	125M	A	150	45	35	O	30	65	10M	1.5	10M	20	E	10M	B
2N1104	S	N	2N2221	2N2218	A	125M	A	150	45	35	O	45	150	10M	1.5	10M	40	E	20M	B
2N1105	S	N	MM3005	MM3005	A	800M	A	200	60	60	O	12	36	200M	5.0	200M				
2N1106	S	N	MM3007	MM3005	A	800M	A	200	100	100	O	12	36	200M	5.0	200M				
2N1107	G	P			AH	30M	C		16										40M	B
2N1108	G	P			AH	30M	C		16										35M	B
2N1109	G	P			AH	30M	C		16										35M	B
2N1110	G	P			AH	30M	C		16										35M	B
2N1111	G	P			AH	30M	C		16										35M	B
2N1114	G	N			S	150M		100	25	15	R	40	180	20M					7.0M	B
2N1115	G	P			S	150M	A	85	20	15	O				0.35	60M			5.0M	B
2N1115A	G	P			S	150M	A	85	20	15	O				0.35	60M			5.0M	B
2N1116	S	N	MM3005	MM3005	AH	600M	C	200	60	60	O	40	150	0.5A	5.0	0.5A			6.0M	T
2N1117	S	N	MM3005	MM3005	AH	600M	C	200	60	60	O	40	150	0.2A	4.0	0.2A			4.0M	T
2N1118	S	P	2N3250	2N3250	AH	150M	A	140	25	25	U						15	E	8.0M	M
2N1118A	S	P	2N3250	2N3250	AH	150M	A	140	25	25	U		25	15M			15	E	8.0M	M
2N1119	S	P	2N3546	2N3546	S	150M	A	140	10	10	U	15		15M	0.15	5.0M			7.2M	T
2N1120	G	P		2N1120	AP	45W	C	95	80	70	S	20	50	10A	1.0	10A	30	E	3.0K	E
2N1121	G	N			AH	65M	C	85	15	15	O	34		1.0M						
2N1122	G	P	2N961	2N956	SH	25M	A	100	12	11	S	25		10M	0.1	8.0M	35	E	40M	
2N1122A	G	P	2N960	2N956	SH	25M	A	100	15	14	S	25		10M	0.1	8.0M	35	E	40M	
2N1123	G	P	2N3427	2N3427	SH	10M	C	100	45	40	S	40		100M	0.2	10M			3.0M	B
2N1124	G	P	2N651	2N650	A	300M	A	85	40	35	V				0.2	100M	40	E	400K	B
2N1125	G	P	2N651	2N650	SH	300M	A	85	40	40	V	50	150	500M	0.3	500M			1.0M	B
2N1126	G	P	2N651	2N650	S	1.0W	C	85	40	35	V				0.2	100M	40	E	400K	B
2N1127	G	P	2N3428	2N3427	S	1.0W	C	85	40	40	V	50	150	500M	0.3	500M			1.0M	B
2N1128	G	P	2N1192	2N1191	A	150M	A	85	25	18	S						70	E		
2N1129	G	P	2N3427	2N3427	A	150M	A	85	25	25	V	100	200	100M	0.25	100M				
2N1130	G	P	2N1193	2N1191	A	150M	A	85	30			50	165	100M	0.25	100M				
2N1131	S	P		2N1131	S	600M	A	175	50	35	O	20	45	150M	1.5	150M	15	E	50M	T
2N1131A	S	P		2N1131	S	0.6W	A	175	60	40	O	20	45	0.15A	1.5	0.15A	15	E	50M	T
2N1132	S	P		2N722	S	600M	A	175	50	35	O	30	90	150M	1.5	150M	25	E	60M	T
2N1132A	S	P		2N722	S	0.6W	A	175	60	40	O	30	90	0.15A	1.5	0.15A	25	E	60M	T
2N1132B	S	P	2N2369	2N2369	S	0.6W	A	175	70	45	O	30	90	0.15A	1.5	0.15A	25	E	60M	T
2N1135	S	P	2N2369	2N2369	S	100M	A	140	12	12	O								5.6M	T
2N1135A	S	P	2N2369	2N2369	S	100M	A	140	12	12	O								5.6M	T
2N1136	G	P	MP249		AP			100	60	35	R	50	100	3.0A	1.0	3.0A			4.0K	E
2N1136A	G	P	MP249A		AP			100	90	35	R	50	100	3.0A	1.0	3.0A			4.0K	E

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N1136B	G	P	MP249B		AP			100	100	75	R	50	100	3.0A	1.0	3.0A			4.0K	E
2N1137	G	P	MP438		AP			100	60	25	O	75	150	3.0A	1.0	3.0A				
2N1137A	G	P	MP438A		AP			100	90	55	O	75	150	3.0A	1.0	3.0A				
2N1137B	G	P	MP438B		AP			100	100	65	O	75	150	3.0A	1.0	3.0A				
2N1138	G	P	MP280		AP			100	60	25	O	100	200	3.0A	1.0	3.0A				
2N1138A	G	P	MP281		AP			100	90	55	O	100	200	3.0A	1.0	3.0A				
2N1138B	G	P	MP282		AP			100	100	65	O	100	200	3.0A	1.0	3.0A				
2N1139	S	N	2N742	2N742	SH	6.6M	A	175	15	15	O	20	200	10M	0.7	10M			100M	T
2N1141	G	P		2N1141	AH	750M	C	100	35			10		10M	2.0	50M	12	E		
2N1141A	G	P			AH	750M	C	100	35	25	S	15		10M	2.0	50M	0.94	B	500M	T
2N1142	G	P		2N1141	AH	750M	C	100	30			10		10M	2.0	50M	0.98	B	600M	B
2N1142A	G	P			AH	750M	C	100	30	25	S	15		10*	2.0	50M	0.94	B	400M	T
2N1143	G	P		2N1141	AH	750M	C	100	25			10		10M	2.0	50M	0.98	B	480M	B
2N1143A	G	P			AH	750M	C	100	30	25	S	15		10M	2.0	50M	0.94	B	400M	T
2N1144	G	P	2N321	2N319	A	175M	A	85	16	16	R	34	90	20M					1.0M	B
2N1145	G	P	2N1414	2N1413	A	175M	A	85	16	16	R	25	90	20M					1.0M	B
2N1146	G	P			SP	87W	C	95	40	20	O	60	150	5.0A	1.0	15A			0.15M	E
2N1146A	G	P			SP	87W	C	95	60	30	O	60	150	5.0A	1.0	15A			0.15M	E
2N1146B	G	P			SP	87W	C	95	80	40	O	60	150	5.0A	1.0	15A			0.15M	E
2N1146C	G	P			SP	87W	C	95	100	50	O	60	150	5.0A	1.0	15A			0.15M	E
2N1147	G	P			SP	87W	C	95	40	20	O	60	150	5.0A	1.0	15A			0.15M	E
2N1147A	G	P			SP	87W	C	95	60	30	O	60	150	5.0A	1.0	15A			0.15M	E
2N1147B	G	P			SP	87W	C	95	80	40	O	60	150	5.0A	1.0	15A			0.15M	E
2N1147C	G	P			SP	87W	C	95	100	50	O	60	150	5.0A	1.0	15A			0.15M	E
2N1149	S	N	2N2221	2N2218	A	150M	A	175	45			9.0	20	25M			0.9	B	4.0M	B
2N1150	S	N	2N2221	2N2218	A	150M	A	175	45			18	40	25M			0.948	B	5.0M	B
2N1151	S	N	2N2221	2N2218	A	150M	A	175	45			18	90	25M			0.948	B	8.0M	B
2N1152	S	N	2N2221	2N2218	A	150M	A	175	45			36	90	25M			0.973	B	6.0M	B
2N1153	S	N	2N2221	2N2218	A	150M	A	175	45			76	333	25M			0.987	B	7.0M	B
2N1154	S	N	2N2221	2N2218	A	750M	C	150	50			9.0		60M			0.9	B		
2N1155	S	N	2N2221	2N2218	A	750M	C	150	80			9.0		50M			0.9	B		
2N1156	S	N	2N2221	2N2218	A	750M	C	150	120			9.0		40M			0.9	B		
2N1157	G	P	MP501	MP500	SP	187W	J	100	60	45	O	38	84	10A	0.8	40A			75K	T
2N1157A	G	P	MP502	MP500	SP	187W	J	100	80	50	O	38	84	10A	0.8	40A			75K	T
2N1158	G	P	2N1143	2N1141	AH	60M	A	100	20	20	S						5.7	E		
2N1158A	G	P	2N1142	2N1141	AH	75M	A	100	20	20	S						9.0	E		
2N1159	G	P	2N3616	2N3615	SP	35W	C	95	80	60	O	30	75	3.0A	1.0	3.0A				
2N1160	G	P	2N3616	2N3615	SP	35W	C	95	80	60	O	20	50	5.0A	1.0	5.0A				
2N1162	G	P		2N1162	SP	90W	C	100	50	35	S	15	65	25A	0.8	25A			1.0K	E
2N1162A	G	P		2N1162	SP	90W	C	100	50	35	S	15	65	25A	0.8	25A			3.0K	E
2N1163	G	P		2N1162	SP	90W	C	100	50	35	S	15	65	25A	0.8	25A			1.0K	E
2N1163A	G	P		2N1162	SP	90W	C	100	50	35	S	15	65	25A	0.8	25A			3.0K	E
2N1164	G	P		2N1162	SP	90W	C	100	80	60	S	15	65	25A	0.8	25A			1.0K	E
2N1164A	G	P		2N1162	SP	90W	C	100	80	60	S	15	65	25A	0.8	25A			3.0K	E
2N1165	G	P		2N1162	SP	90W	C	100	80	60	S	15	65	25A	0.8	25A			1.0K	E
2N1165A	G	P		2N1162	SP	90W	C	100	80	60	S	15	65	25A	0.8	25A			3.0K	E
2N1166	G	P		2N1162	SP	90W	C	100	100	75	S	15	65	25A	0.8	25A			1.0K	E
2N1166A	G	P		2N1162	SP	90W	C	100	100	75	S	15	65	25A	0.8	25A			3.0K	E
2N1167	G	P		2N1162	SP	90W	C	100	100	75	S	15	65	25A	0.8	25A			1.0K	E
2N1167A	G	P		2N1162	SP	90W	C	100	100	75	S	15	65	25A	0.8	25A			3.0K	E
2N1168	G	P	2N3614	2N3611	AP	45W	C	95	50	30	R									
2N1169	G	N			S	120M	A	71	40	20	O	20		200M	0.3	200M			4.5M	B
2N1170	G	N			S	120M	A	71	40	20	O	20		200M	0.3	200M			4.5M	B
2N1171	G	P			S	170M	A	85	30	12	O	30		30M					10M	B
2N1172	G	P	2N2137	2N2137	SP			95	40	30	O	30	90	100M						
2N1173	G	N			S	0.25W	A	100	35	20	O	50	200	10M	0.075	10M	50	E		
2N1174	G	P			S	0.25W	A	100	35	20	O	50	200	10M	0.075	10M	50	E		
2N1175	G	P		2N1413	A	200M	A	85	35	25	R	70	140	20M					1.5M	B
2N1176	G	P	2N1189	2N1189	A	0.3W	C	85	10	10	R				0.3	0.1A	20	E		
2N1177	G	P	2N2957	2N2955	AH	80M	A	71	30											
2N1178	G	P	2N2955	2N2955	AH	80M	A	71	30											
2N1179	G	P	2N2956	2N2955	AH	80M	A	71	30											
2N1180	G	P	2N2956	2N2955	AH	80M	A	71	30											
2N1182	G	P	2N2140	2N2137	SP	106W	C	100	50	60	O	30	85	0.5A	0.9	2.0A			5.0K	E
2N1183	G	P	2N2140	2N2137	SP	7.5W	C	100	45	20	O	20	60	400M	0.5	400M			500K	B
2N1183A	G	P	2N2140	2N2137	SP	7.5W	C	100	60	30	O	20	60	400M	0.5	400M			500K	B
2N1183B	G	P	2N2141	2N2137	SP	7.5W	C	100	80	40	O	20	60	400M	0.5	400M			500K	B
2N1184	G	P	2N2144	2N2137	SP	7.5W	C	100	45	20	O	40	120	400M	0.5	400M			500K	B
2N1184A	G	P	2N2145	2N2137	SP	7.5W	C	100	60	30	O	40	120	400M	0.5	400M			500K	B
2N1184B	G	P	2N2146	2N2137	SP	7.5W	C	100	80	40	O	40	120	400M	0.5	400M			500K	B
2N1185	G	P		2N1175	A	200M	A	100	45	30	R	130		10M			190	E	1.7M	B
2N1186	G	P		2N1175	A	200M	A	100	60	45	R	33		10M			30	E	0.75M	B
2N1187	G	P		2N1175	A	200M	A	100	60	45	R	45		10M			50	E	1.0M	B
2N1188	G	P		2N1175	A	200M	A	100	60	45	R	80		10M			100	E	1.2M	B
2N1189	G	P		2N1189	A	200M	A	100	45	30	R	60		10M	0.22	50M	75	E	1.7M	B
2N1190	G	P		2N1189	A	200M	A	100	45	30	R	100		10M	0.22	50M	125	E	2.2M	B
2N1191	G	P		2N1191	A	200M	A	100	40	25	R	20	80	10M			30	E		
2N1192	G	P		2N1191	A	200M	A	100	40	25	R	40	135	10M			50	E		
2N1193	G	P		2N1191	A	200M	A	100	40	25	R	70	300	10M			100	E		
2N1194	G	P		2N1191	A	200M	A	100	40	25	R	125	600	10M			190	E		
2N1195	G	P		2N1141	AH	225M	A	100	30								0.96	B	400M	T
2N1196	S	P			AH	0.35W	A	200	70	70	O	5.0	30	2.0M			0.85	B		
2N1197	S	P			AH	0.35W	A	200	70	70	O	5.0	30	2.0M			0.85	B		
2N1198	G	N			SH	65M	A	85	25	25	O	17	90	8.0M			0.952	B	5.0M	B
2N1199	S	N	2N835	2N834	SH	150M	A	150	20	15	O	12	60	20M	0.25	10M			75M	T
2N1199A	S	N	2N835	2N834	SH	150M	A	150	20	15	O	12	60	20M	0.25	10M			75M	T
2N1200	S	N			AH	100M	A	150	20	15	O	7.0	200	1.5M			9.0	E		
2N1201	S	N			AH	100M	A	150	20	15	O	7.0	200	1.5M			9.0	E		

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N1202	G	P	2N2145	2N2137	SP	34W	J	95	80	60	O	40	120	500M	0.3	500M			200K	T
2N1203	G	P	2N2146	2N2137	SP	34W	J	95	120	70	O	25	75	2.0A	0.6	2.0A			200K	T
2N1204	G	P		2N1204	SH	200M	A	100	20	15	O	15		400M	0.5	200M			220M	T
2N1204A	G	P		2N1204	SH	200M	A	100	20	15	O	25		200M	0.4	200M			220M	T
2N1206	S	N			AH	3.0M	A	200	60	60	O	20	80				25	E	10M	T
2N1207	S	N			AH	3.0M	A	200	125	125	O	20	80				25	E	10M	T
2N1208	S	N	2N3487	2N3485	AP	45W	C	200	60	60	O	15		2.0A	5.0	2.0A				
2N1209	S	N	2N3487	2N3485	AHP	45W	C	200	45	45	O	20	80	2.0A	5.0	2.0A			3.0M	T
2N1210	S	N	2N3713	2N3713	AHP	30W	C	175	60	60	O	15	75	2.0A	2.0	2.0A			3.0M	T
2N1211	S	N	2N3445	2N3445	AHP	30W	C	175	80	80	V	15	75	2.0A	2.0	2.0A			3.0M	T
2N1212	S	N	2N3487	2N3485	AHP	45W	C	200	60	60	O	12	36	1.0A	5.0	1.0A			3.0M	T
2N1213	G	P			SH	75M	A	71	25											
2N1214	G	P			SH	75M	A	71	25											
2N1215	G	P			SH	75M	A	71	25											
2N1216	G	P			SH	75M	A	71	25											
2N1217	G	N			SH	75M	A	85	20	20	O	40	100	500*					6.0M	B
2N1218	G	N			AP	20W	C	90	45	45	R	30	120	1.0A	1.0	1.0A			7.0K	E
2N1219	S	P			A	0.25W	A	175	30	25	O	18		5.0M					5.0M	B
2N1220	S	P			A	0.25W	A	175	30	25	O	9.0		5.0M					2.0M	B
2N1221	S	P			A	0.25W	A	175	30	25	O						18	E	5.0M	B
2N1222	S	P			A	0.25W	A	175	30	25	O						9.0	E	2.0M	B
2N1223	S	P			A	0.25W	A	175	40	40	O						6.0	E		
2N1224	G	P			SH	120M	A	85	40											
2N1225	G	P			AH	120M	A	85	40											
2N1226	G	P			AH	120M	A	85	60											
2N1227	G	P	2N3611	2N3611	AP	50W	C	95	35	20	O	50	350	0.5A	0.8	1.5A	25	E	3.0K	E
2N1228	S	P			S	0.4W	A	160	15	15	O				0.2	10M	14	E		
2N1229	S	P			S	0.4W	A	160	15	15	O				0.2	10M	28	E		
2N1230	S	P			S	0.4W	A	160	35	35	O				0.2	10M	14	E		
2N1231	S	P			S	0.4W	A	160	35	35	O				0.2	10M	28	E		
2N1232	S	P			S	0.4W	A	160	60	60	O				0.2	10M	14	E		
2N1233	S	P			S	0.4W	A	160	60	60	O				0.2	10M	28	E		
2N1234	S	P			S	0.4W	A	160	110	110	O				0.2	10M	14	E		
2N1235	S	N			AP	85W	C	200	120	120	R	12	60	1.0A	5.0	1.0A			50K	E
2N1238	S	P			S	1.0W	A	160	15	15	O				0.2	10M	14	E		
2N1239	S	P			S	1.0W	A	160	15	15	O				0.2	10M	28	E		
2N1240	S	P			S	1.0W	A	160	35	35	O				0.2	10M	14	E		
2N1241	S	P			S	1.0W	A	160	35	35	O				0.2	10M	28	E		
2N1242	S	P			S	1.0W	A	160	60	60	O				0.2	10M	14	E		
2N1243	S	P			S	1.0W	A	160	60	60	O				0.2	10M	28	E		
2N1244	S	P			S	1.0W	A	160	110	110	O				0.2	10M	14	E		
2N1245	G	P			AP	20W	C	85	30	25	R	50		0.5A						
2N1246	G	P			AP	20W	C	85	30	25	R	50		0.5A						
2N1247	S	N			A	30M	A	150	6.0	6.0	O	15		5.0*						
2N1248	S	N			A	30M	A	150	6.0	6.0	O	15		20*						
2N1249	S	N			A	30M	A	150	6.0	6.0	O	20		30*						
2N1250	S	N	2N3713	2N3713	AP	85W	C	200	60	60	O	15		2.0A	5.0	2.0A				
2N1251	G	N			A	150M		85	20	15	R				0.5	100M	70	E	7.5K	E
2N1252	S	N	2N2537	2N2537	S	600M	A	175	30	20	R	15	45	150M	1.5	150M			40M	T
2N1252A	S	N	2N2537	2N2537	S	800M	A	300	60	30	O	15	45	150M	1.5	150M			40M	T
2N1253	S	N	2N2537	2N2537	S	600M	A	175	30	20	R	30	90	150M	1.5	150M			50M	T
2N1253A	S	N	2N2537	2N2537	S	800M	A	300	60	30	O	30	90	150M	1.5	150M			50M	T
2N1254	S	P			SH	275M	A	200	30	30	O	25	50	10M	0.3	10M			30M	T
2N1255	S	P			SH	275M	A	200	30	30	O	40	80	10M	0.3	10M			50M	T
2N1256	S	P			SH	275M	A	200	40	40	O	25	50	10M	0.3	10M			30M	T
2N1257	S	P			SH	275M	A	200	40	40	O	40	80	10M	0.3	10M			50M	T
2N1258	S	P			SH	275M	A	200	30	30	O	75	150	10M	0.6	10M			50M	T
2N1259	S	P			SH	275M	A	200	50	50	O	25	100	10M	0.3	10M			40M	T
2N1260	S	N			AP	85W	C	200	120	120	R	12	60	1.0A	10	1.0A			50K	E
2N1261	G	P	2N1531	2N1529	SP	34W	J	95	80	45		20	50	2.0A	0.6	2.0A			200K	T
2N1262	G	P	2N1531	2N1529	SP	34W	J	95	80	45	O	30	75	2.0A	0.6	2.0A			200K	T
2N1263	G	P	2N3617	2N3615	SP	34W	J	95	80	45	O	45	113	2.0A	0.6	2.0A			200K	T
2N1264	G	P	2N1191	2N1191	AH	50M	A	75	20								15	E		
2N1265	G	P	2N1192	2N1191	AH	50M	A	85	12	10	R				0.5	100M	25	E	600K	B
2N1266	G	P	2N1191	2N1191	AH	80M	A	85	10								10	E		
2N1267	S	N	2N2481	2N2481	AH	150M	A	150	20	15	O	4.0	16	1.5M			6.0	E		
2N1268	S	N	2N2481	2N2481	AH	150M	A	150	20	15	O	7.0	30	1.5M			11	E		
2N1269	S	N	2N2481	2N2481	AH	150M	A	150	20	15	O	20	80	1.5M			28	E		
2N1270	S	N	2N2481	2N2481	AH	150M	A	150	20	15	O	4.0	16	1.5M			6.0	E		
2N1271	S	N	2N2481	2N2481	AH	150M	A	150	20	15	O	7.0	30	1.5M			11	E		
2N1272	S	N	2N2481	2N2481	AH	150M	A	150	20	15	O	20	80	1.5M			28	E		
2N1273	G	P			A	250M	A	100	15	15	R	27	165	50M	1.0	100M	20	E		
2N1274	G	P			A	250M	A	100	25	25	R	27	165	50M	1.0	100M	20	E		
2N1275	S	P			AM	250M	A	160	100	80	O	9.0	25	1.0M	0.3	5.0M			100K	B
2N1276	S	N	2N2501	2N2501	A	150M	A	150	40	30	O				1.0	5.0M	9.0	E	15M	B
2N1277	S	N			A	150M	A	150	40	30	O				1.0	5.0M	18	E	15M	B
2N1278	S	N	2N2501	2N2501	A	150M	A	150	40	30	O				1.0	5.0M	37	E	15M	B
2N1279	S	N	2N2501	2N2501	A	150M	A	150	40	30	O				1.0	5.0M	76	E	15M	B
2N1280	G	P			S	0.2W	A	85	16	16	O	40		20M					5.0M	B
2N1281	G	P			S	0.2W	A	85	16	12	O	60		20M					7.0M	B
2N1282	G	P			S	0.2W	A	85	16	6.0	O	70		20M					10M	B
2N1284	G	P			S	0.15W	A	85	20	15	O	30	150	10M	0.2	10M			5.0M	B
2N1285	G	P			AH	240M	A	71	40	40	V	30	100	1.5M						
2N1287	G	P	2N651	2N650	A	0.3W	C	85	25	25	R				0.5	20M	40	E		
2N1287A	G	P	2N652	2N650	A	0.3W	C	85	25	25	R				0.5	20M	60	E		
2N1288	G	N			SH	75M	A	100	15	10	R	50	300	10M	0.3	10M				
2N1289	G	N			SH	75M	A	85	20	15	O	50	300	10M	0.3	10M			40M	B
2N1291	G	P	2N1529	2N1529	AP	20W	C	85	35	30	S	40		0.5A	1.0	1.0A				

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units	Subscript
2N1292	G	N			AP	25W	C	100	35	30	S	30		0.5A	1.0	1.0A				
2N1293	G	P	2N1531	2N1529	AP	20W	C	85	60	60	S	40		0.5A	1.0	1.0A				
2N1294	G	N			AP	25W	C	100	60	45	S	30		0.5A	1.0	1.0A				
2N1295	G	P	2N1532	2N1529	AP	20W	C	85	80	80	S	40		0.5A	1.0	1.0A				
2N1296	G	N			AP	25W	C	100	80	60	S	30		0.5A	1.0	1.0A				
2N1297	G	P	2N1533	2N1529	AP	20W	C	85	100	100	S	40		0.5A	1.0	1.0A				
2N1298	G	N			AP	25W	C	100	100	80	S	30		0.5A	1.0	1.0A				
2N1299	G	N			S	150M		100	40	20	R	35	110	50M	0.17	15M			4.0M	B
2N1300	G	P			SH	150M	A	85	13	12	O	30		10M					25M	T
2N1301	G	P			SH	150M	A	85	13	12	O	30		10M					35M	T
2N1302	G	N			S	150M	A	85	25			20		10M	0.2	10M			3.0M	B
2N1303	G	P	2N1192	2N1191	S	150M	A	85	30			20		10M	0.2	10M			3.0M	B
2N1304	G	N			S	150M	A	85	25			40	200	10M	0.2	10M			5.0M	B
2N1305	G	P			S	150M	A	85	30			40	200	10M	0.2	10M			5.0M	B
2N1306	G	N			S	150M	A	85	25			60	300	10M	0.2	10M			10M	B
2N1307	G	P			S	150M	A	85	30			60	300	10M	0.2	10M			10M	B
2N1308	G	N			S	150M	A	85	25			80		10M	0.2	10M			15M	B
2N1309	G	P			S	150M	A	85	30			80		10M	0.2	10M			15M	B
2N1309A	G	P			S	0.15W	A	85	35	15	O	80		10M	0.2	10M			15M	B
2N1310	G	N	MP2373-1		AL	120M	A	85	90			20		5.0M						
2N1311	S	N	MP2373-3		AL	120M	A	85	75	75		15		5.0M						
2N1312	G	N			S	120M	A	85	50	50		20		20M		20M				
2N1313	G	P	MP2373-4		S	0.18W	A	100	30	15	O	40	125		0.28	0.3A			6.0M	B
2N1314	G	P	2N3611	2N3611	AP	125W	C	90	40	40	R	20	55	1.0A						
2N1315	G	P	2N3611	2N3611	AP	125W	C	90	32	16		45	135	1.0A						
2N1316	G	P			S	0.2W	A	85	30	15	O	50	200						10M	B
2N1317	G	P			S	0.2W	A	85	20	12	O	45	180						10M	B
2N1318	G	P			S	0.2W	A	85	10	6.0	O	40	150						10M	B
2N1319	G	P	MP2372-1		S	120M	A	71	20	20	V	15		0.4A	0.3	0.4A			3.0M	T
2N1320	G	P	MP2372-2		AP	20W	C	85	35	30	S	40		0.5A	1.0	1.0A				
2N1321	G	N	MP2372-3		AP	25W	C	100	35	30	S	30		0.5A	1.0	1.0A				
2N1322	G	P	MP2372-4		AP	20W	C	85	60	60	S	40		0.5A	1.0	1.0A				
2N1323	G	N			AP	25W	C	100	60	45	S	30		0.5A	1.0	1.0A				
2N1324	G	P			AP	20W	C	85	80	80	S	40		0.5A	1.0	1.0A				
2N1325	G	N			AP	25W	C	100	80	60	S	30		0.5A	1.0	1.0A				
2N1326	G	P			AP	20W	C	85	100	100	S	40		0.5A	1.0	1.0A				
2N1327	G	N			AP	25W	C	100	100	80	S	30		0.5A	1.0	1.0A				
2N1328	G	P			AP	20W	C	85	35	30	S	40		0.5A	1.0	1.0A				
2N1329	G	N			AP	25W	C	100	35	30	S	30		0.5A	1.0	1.0A				
2N1330	G	N			AP	25W	C	100	60	45	S	30		0.5A	1.0	1.0A				
2N1331	G	P			AP	20W	C	85	80	80	S	40		0.5A	1.0	1.0A				
2N1332	G	N			AP	25W	C	100	80	60	S	30		0.5A	1.0	1.0A				
2N1333	G	P			AP	20W	C	85	100	100	S	40		0.5A	1.0	1.0A				
2N1334	G	N			AP	25W	C	100	100	80	S	30		0.5A	1.0	1.0A				
2N1335	S	N	2N3019	2N3019	AHP	0.8W	A	175	120	45	O	10	150	30M					70M	T
2N1336	S	N	2N3019	2N3019	AHP	0.8W	A	175	120	45	O	10	150	30M					70M	T
2N1337	S	N	2N3019	2N3019	AHP	0.8W	A	175	120	45	O	10	150	30M					70M	T
2N1338	S	N	2N2193	2N2192	AHP	0.8W	A	175	80	25	O	10	150	30M					70M	T
2N1339	S	N	2N3019	2N3019	AHP	0.8W	A	175	120	50	O	10	150	30M					70M	T
2N1340	S	N	2N3019	2N3019	AHP	0.8W	A	175	120	50	O	10	150	30M					70M	T
2N1341	S	N	2N3019	2N3019	AHP	0.8W	A	175	120	50	O	10	150	30M					70M	T
2N1342	S	N	2N3019	2N3019	AHP	0.8W	A	175	150	65	O	10	150	30M					70M	T
2N1343	G	P			S	0.15W	A	85	20	16	O	15		50M					4.0M	B
2N1344	G	P			S	0.15W	A	85	15	10	O	60		20M					7.0M	B
2N1345	G	P			S	0.15W	A	85	10	8.0	O	30	100	0.4A					10M	B
2N1346	G	P			S	0.15W	A	85	12	10	O	40	250	0.35M	0.13	12M			10M	B
2N1347	G	P			S	0.15W	A	85	20	12	O	30		10M	0.2	10M			5.0M	B
2N1352	G	P	2N651	2N650	A	0.15W	A	85	30	20	O	40	100							
2N1353	G	P			S	0.2W	A	85	15	10	O	25	150	10M	0.2	50M			1.5M	B
2N1354	G	P			S	0.2W	A	85	30	15	O	25	150	10M	0.2	50M			3.0M	B
2N1355	G	P			S	0.2W	A	85	30	20	O	30	150	10M	0.2	50M			5.0M	B
2N1356	G	P			S	0.2W	A	100	30	20	O	40	140	10M	0.2	50M			5.0M	B
2N1357	G	P			S	0.2W	A	85	30	15	O	40	150	10M	0.2	50M			10M	B
2N1358	G	P		2N173	SP	90W		95	80	40	O	40	80	1.2A	0.7	12A			100K	B
2N1358A	G	P		2N173	SP	150W	C	100	100	60	O	40	80	1.2A	0.7	12A			100K	B
2N1359	G	P		2N350A	AP	90W	J	100	50	40	S	35	90	1.0A	0.1	2.0A			5.0K	E
2N1360	G	P		2N350A	AP	90W	J	100	50	40	S	60	140	1.0A	1.0	2.0A			5.0K	E
2N1361	G	P			S	0.15W	A	100	25	20	O	40	100	25M					4.0M	B
2N1361A	G	P			S	0.2W	A	100	25	20	O	40	100	25M					4.0M	B
2N1362	G	P		2N350A	AP	90W	J	100	100	75	S	35	90	1.0A	1.0	2.0A			5.0K	E
2N1363	G	P		2N350A	AP	90W	J	100	100	75	S	60	140	1.0A	1.0	2.0A			5.0K	E
2N1364	G	P		2N350A	AP	90W	J	100	120	100	S	35	90	1.0A	1.0	2.0A			5.0K	E
2N1365	G	P		2N350A	AP	90W	J	100	120	100	S	60	140	1.0A	1.0	2.0A			5.0K	E
2N1366	G	N			A	100M	A	85	18	18	R	20		1.0M			10	E	5.0M	T
2N1367	G	N			A	100M	A	85	18	18	R	10		1.0M			5.0	E	2.5M	T
2N1370	G	P			A	250M	A	100	25	25	R	45	165	50M	1.0	100M	40	E		
2N1371	G	P			A	250M	A	100	45	45	R	45	165	50M	1.0	100M	40	E		
2N1372	G	P			A	250M	A	100	25	25	R	27	105	50M	1.0	100M	20	E		
2N1373	G	P			A	250M	A	100	45	45	R	27	105	50M	1.0	100M	20	E		
2N1374	G	P			A	250M	A	100	25	25	R	45	165	50M	1.0	100M	40	E		
2N1375	G	P			A	250M	A	100	45	45	R	45	165	50M	1.0	100M	40	E		
2N1376	G	P			A	250M	A	100	25	25	R	67	165	50M	1.0	100M	60	E		
2N1377	G	P			A	250M	A	100	45	45	R	67	165	50M	1.0	100M	60	E		
2N1378	G	P			A	250M	A	100	12	12	R	85	330	50M	1.0	100M	75	E		
2N1379	G	P			A	250M	A	100	25	25	R	85	330	50M	1.0	100M	75	E		
2N1380	G	P			A	250M	A	100	12	12	R	27	330	50M	1.0	100M	20	E		
2N1381	G	P			A	250M	A	100	25	25	R	27	330	50M	1.0	100M	20	E		
2N1382	G	P			A	250M	A	100	25	25	R	45	165	50M	1.0	100M	40	E		

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N1383	G	P			A	250M	A	100	25	25	R	27	165	50M	1.0	100M	20	E		
2N1384	G	P			SH	240M	A	85	30	30	O	20		200M					20M	T
2N1385	G	P			SH	750M	A	100	25	10	O	10		10M					250M	T
2N1386	S	N	2N2218	2N2218	S	300M	A	175	25	25	O	30	90	10M	0.6	5.0M				
2N1387	S	N	2N2218	2N2218	S	300M	A	175	30	30	O	20	40	10M	0.5	5.0M				
2N1388	S	N	2N2218	2N2218	AH	300M	A	175	45	25	O	15	55	10M			30	E	50M	B
2N1389	S	N	2N2218	2N2218	AH	300M	A	175	50	50	O				0.8	5.0M			24M	T
2N1390	S	N	2N2218	2N2218	AH	300M	A	175	20	20	O	30	150	10M			10	E	20M	B
2N1391	G	N			A	150M	A	100	25	18	O	40	160	20M			35	E	3.0M	E
2N1392	G	P			AL	50M	A	85	20	20	R									
2N1393	G	P			AL	50M	A	85	20	10	R									
2N1394	G	P			AL	50M	A	85	10	6.0	R									
2N1395	G	P	2N2955	2N2955	AH	120M	A	100	40	40	O	50	175	1.5M					30M	B
2N1396	G	P	2N3323	2N3323	AH	120M	A	100	40	40	O	50	175	1.5M					30M	B
2N1397	G	P	2N3323	2N3323	AH	120M	A	100	40	40	O	50	175	1.5M					120M	B
2N1398	G	P			AH	50M	A	85	30	20	O	10		0.5M	0.75	10M			140M	T
2N1399	G	P			AH	50M	A	85	30	20	O	3.5		0.5M	0.75	10M			140M	T
2N1400	G	P			AH	50M	A	85	30	20	O	5.0	12	0.5M	0.75	10M			100M	T
2N1401	G	P			AH	50M	A	85	30	20	O	5.0		0.5M	0.75	10M			120M	T
2N1402	G	P			AH	50M	A	85	30	20	O	3.5	12	1.5M	0.75	10M			100M	T
2N1403	G	P			AH	250M	A	100	15	12	O	25	250	7.0M	0.75	10M			200M	T
2N1404	G	P			S	150M	A	85	25						0.15	12M			4.0M	B
2N1404A	G	P			S	150M	A	85	25	15	O	30	200	12M	0.15	12M			3.0M	T
2N1405	G	P			AH	75M	A	100	30	20	O	10	200	2.0M			10	E	250M	T
2N1406	G	P			AH	75M	A	100	30	20	O	10	200	2.0M			10	E	250M	T
2N1407	G	P			AH	75M	A	100	30	20	O	10	200	2.0M			10	E	200M	T
2N1408	G	P			S	150M	A	100	50	50	S	10					10	E		
2N1409	S	N	2N2537	2N2537	SH	600M	A	200	30	25	O	15	45	150M					200M	T
2N1409A	S	N	2N2537	2N2537	SH	800M	A	200	30	25	O	15	45	150M					200M	T
2N1410	S	N	2N2537	2N2537	SH	600M	A	200	45	30	O	39	90	150M					130M	T
2N1410A	S	N	2N2537	2N2537	SH	800M	A	200	30	30	O	30	90	150M					130M	T
2N1411	G	P	2N962	2N956	S	25M	A	85	5.0	5.0	S	20		50M	0.45	10M			25M	T
2N1412	G	P		2N1412	SP	70W	C	95	100	65	O	25	50	5.0A	0.7	12A				
2N1413	G	P		2N1413	S	200M	A	85	35	25	R	25	42	20M			20	E	800K	B
2N1414	G	P		2N1413	S	200M	A	85	35	25	R	34	65	20M			30	E	1.0M	B
2N1415	G	P		2N1413	S	200M	A	85	35	25	R	53	90	20M			44	E	1.3M	B
2N1416	G	P	2N1193	2N1191	A	100M	A	65		18	U						39	E		
2N1417	S	N			A	0.15W	A	150	15	15	O						30	E		
2N1418	S	N			A	0.15W	A	150	30	30	O						30	E		
2N1419	G	P	2N1164	2N1162	SP	87W	C	95	80	40	O	40	100	25A	0.7	25A				
2N1420	S	N		2N718	AH	600M	A	175	60	30	R	100	300	150M	1.5	150M			50M	T
2N1420A	S	N	2N2219	2N2218	AH	800M	A	200	60	40	R	100	300	150M	1.5	150M			60M	T
2N1421	S	N			AHP	30W	C	200	60	60	S	20	80	1.0A	3.0	1.0A	20	E	10M	T
2N1422	S	N			AHP	30W	C	200	60	60	S	20	80	1.0A	3.0	1.0A	20	E	10M	T
2N1423	S	N			AHP	60W	C	200	60	60	S	20	80	2.0A	5.0	2.0A	20	E	10M	T
2N1424	S	N			AHP	60W	C	200	60	60	S	20	80	2.0A	5.0	2.0A	20	E	10M	T
2N1425	G	P			A	80M	A	85	24										10M	B
2N1426	G	P			A	80M	A	85	24								17	E	10M	B
2N1427	G	P	2N962	2N956	SH	25M	A	100	6.0	6.0	S	20		50M	0.2	50M	40	E	50M	T
2N1428	S	P			S	100M	A	140	6.0	6.0	O	12		5.0M	0.1	5.0M	25	E	16M	T
2N1429	S	P			S	100M	A	140	6.0	6.0	O	12		5.0M	0.1	5.0M	25	E	16M	T
2N1430	G	P			SP	70W	C	110	120	100	O	30	90	5.0A	0.4	10A			0.6M	T
2N1431	G	N			A	180M	A	75	20	15	R	75	150	35M					10K	E
2N1432	G	P			A	100M	A	100	45	45	R						30	E		
2N1433	G	P			AP			95	80	50	O	20	50	2.0A	1.5	2.0A			5.0K	E
2N1434	G	P			AP			95	80	50	O	45	115	2.0A	1.0	2.0A			5.0K	E
2N1435	G	P			AP			95	80	50	O	30	75	2.0A	0.6	2.0A			5.0K	E
2N1436	G	P			SH	50M	A	100	15	12	S	20		10M	0.2	10M				
2N1437	G	P			AP	23W	C	95	100	90	S	20		0.5A	1.0	1.0A			4.0K	E
2N1438	G	P			AP	23W	C	95	100	90	S	20		0.5A	1.0	1.0A			4.0K	E
2N1439	S	P	2N2907	2N2904	A	0.4W	A	200	50	50	O				0.25	5.0M	9.0	E	0.5M	B
2N1440	S	P	2N2907	2N2904	A	0.4W	A	200	60	50	O				0.25	5.0M	9.0	E	1.0M	B
2N1441	S	P	2N2907	2N2904	A	0.4W	A	200	50	35	O				0.25	5.0M	18	E	1.0M	B
2N1442	S	P	2N2907	2N2904	A	0.4W	A	200	50	30	O				0.25	5.0M	30	E	1.0M	B
2N1443	S	P			A	0.4W	A	200	50	15	O				0.25	5.0M	50	E	1.0M	B
2N1444	S	N			SH	0.5W	A	150	60	20	O	20		0.25A	1.5	0.25A				
2N1445	S	N			AP	4.0W	C	200	120	120	O	20	80	200M	4.0	200M			75K	E
2N1446	G	P	2N1191	2N1191	A	0.2W	A	85	45	25	O	16	45	20M			16	E	0.8M	B
2N1447	G	P	2N1191	2N1191	A	0.2W	A	85	45	25	O	35	65	20M			30	E	1.5M	B
2N1448	G	P	2N1192	2N1191	A	0.2W	A	85	45	25	O	50	90	20M			45	E	2.0M	B
2N1449	G	P	2N1189	2N1189	A	0.2W	A	85	45	25	O	70	125	20M			60	E	2.5M	B
2N1450	G	P	2N2955	2N2955	S	0.12W	A	85	30	20	O	20		10M	0.25	10M				
2N1451	G	P	2N464	2N464	A	0.2W	A	85	45	20	O	20	65	20M						
2N1452	G	P	2N1191	2N1191	A	0.2W	A	85	45	20	O	30	90	20M						
2N1453	G	P			AP			90	30	20	O	40	90	1.0A	1.0	3.0A			5.0K	E
2N1454	G	P			AP			90	30	20	O	70	150	1.0A	1.0	3.0A			5.0K	E
2N1455	G	P			AP			90	60	40	O	40	90	1.0A	1.0	3.0A			5.0K	E
2N1456	G	P			AP			90	60	40	O	70	150	1.0A	1.0	3.0A			5.0K	E
2N1457	G	P			AP			90	80	60	O	40	90	1.0A	1.0	3.0A			5.0K	E
2N1458	G	P			AP			90	80	60	O	70	150	1.0A	1.0	3.0A			5.0K	E
2N1461	G	P			AP			90	30	20	O	40	90	1.0A	1.0	3.0A			5.0K	E
2N1462	G	P			AP			90	30	20	O	70	150	1.0A	1.0	3.0A			5.0K	E
2N1463	G	P			AP			90	60	40	O	40	90	1.0A	1.0	3.0A			5.0K	E
2N1464	G	P			AP			90	60	40	O	70	150	1.0A	1.0	3.0A			5.0K	E
2N1465	G	P			AP	20W	C	85	120	70	O	20		0.5A	0.75	1.0A			4.0K	E
2N1466	G	P			AP	20W	C	85	120	70	O	20		0.5A	0.75	1.0A			4.0K	E
2N1469	S	P	2N2906	2N2904	A	0.25W	A	175	40	35	U						36	E	2.0M	B
2N1470	S	N			AP	55W	C	200	60	60	S	15		1.0A	3.0	1.0A				

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS									
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units	Subscript
2N1471	G	P			S	200M	A	85	12	15	R						100	E	3.0M		B
2N1472	S	N			SH	150M	A	150	25	25	O	20		10M	0.25	10M			75M		T
2N1473	G	N			S	167M	A	75	40	20	O	25	50	400M					4.0M		B
2N1474	S	P	2N2906A	2N2904	A	0.25W	A	175	60	60	U						12	E	1.0M		B
2N1474A	S	P	2N2906A	2N2904	A	0.25W	A	175	60	60	U						18	E	2.0M		B
2N1475	S	P	2N2906A	2N2904	A	0.25W	A	175	60	60	U						36	E	1.0M		B
2N1476	S	P	2N4928	2N4928	A	0.25W	A	175	100	100	U						12	E	1.0M		B
2N1477	S	P	2N4928	2N4928	A	0.25W	A	175	100	100	U						30	E	1.0M		B
2N1478	G	P	2N3427	2N3427	S	250M	A	100	30	20	S	40		100M	0.2	10M			3.0M		B
2N1479	S	N	2N4237	2N4237	SP	5.0W	C	200	60	60	V	20	60	200M	1.4	200M					
2N1480	S	N	2N4238	2N4237	SP	5.0W	C	200	100	100	V	20	60	200M	1.4	200M					
2N1481	S	N	2N4239	2N4237	SP	5.0W	C	200	60	60	V	35	100	200M	1.4	200M					
2N1482	S	N	2N4238	2N4237	SP	5.0W	C	200	100	100	V	35	100	200M	1.4	200M					
2N1483	S	N	2N3766	2N3766	SP	25W	C	200	60	60	V	20	60	750M	2.0	750M					
2N1484	S	N	2N3766	2N3766	SP	25W	C	200	100	100	V	20	60	750M	2.0	750M					
2N1485	S	N	2N3766	2N3766	SP	25W	C	200	60	60	V	35	100	750M	0.75	750M					
2N1486	S	N	2N3766	2N3766	SP	25W	C	200	100	100	V	35	100	750M	0.75	750M					
2N1487	S	N	2N4913	2N4913	SP	75W	C	200	60	60	V	15	45	200M	3.0	1.5A					
2N1488	S	N	2N4914	2N4913	SP	75W	C	200	100	100	V	15	45	200M	3.0	1.5A					
2N1489	S	N	2N4913	2N4913	SP	75W	C	200	60	60	V	25	75	1.5A	1.0	1.5A					
2N1490	S	N	2N4914	2N4913	SP	75W	C	200	100	100	V	25	75	1.5A	1.0	1.5A					
2N1491	S	N			AH	3.0W	C	175	30								15	E			
2N1492	S	N			AH	3.0W	C	175	60								15	E			
2N1493	S	N			AH	3.0W	C	175	100			4.0					15	E			
2N1494	G	P		2N1204	SH	400M	A	100	20	15	O	15		400M	0.5	200M			220M		T
2N1494A	G	P		2N1204	SH	400M	A	100	20	15	O	25		200M	0.4	200M			220M		T
2N1495	G	P		2N1204	SH	300M	A	100	40	25	O	25		200M	0.3	200M			150M		T
2N1495A	G	P			SH	0.25W	A	100	40	25	O	25		0.2A	0.3	0.2A			150M		T
2N1496	G	P		2N1204	SH	500M	A	100	40	25	O	25		200M	0.3	200M			150M		T
2N1499	G	P			SH	25M	A	85	20	15	S	20		10M	0.2	10M					
2N1499A	G	P			SH	60M	A	100	20	20	S	30		10M	0.2	10M			100M		T
2N1499B	G	P			SH	75M	A	100	30	20	O	40		10M	0.2	10M			150M		T
2N1500	G	P			SH	60M	A	100	15	12	S	20		10M	0.2	10M			120M		T
2N1501	G	P	2N2144	2N2137	SP	34W	J	95	60	40		25	100	2.0A	0.6	2.0A			200K		T
2N1502	G	P	2N2143	2N2137	SP	34W	J	95	40	40		25	100	2.0A	0.6	2.0A			200K		T
2N1504	G	P			AP	25W	C	95	80	60	O	21		0.5A	0.75	1.0A			4.0K		E
2N1505	S	N	2N2219A	2N2218	AHP	0.8W	A	175	50	20	O	7.0	100	0.1A	2.0	0.15A			70M		T
2N1506	S	N	2N2219A	2N2218	AHP	0.8W	A	175	60	20	O	10	100	0.1A	1.5	0.15A			140M		T
2N1506A	S	N	2N3444	2N3252	AHP	0.8W	A	200	80	50	O	10	100	0.1A	0.6	0.15A			140M		T
2N1507	S	N	2N2219	2N2218	S	600M	A	175	60	30	R	100	300	150M	1.5	150M			50M		T
2N1508	S	N	2N3019	2N3019	S	1.0W	A	175	100	55	O	20	60	600M	3.6	600M			50M		T
2N1509	S	N	2N3019	2N3019	S	1.0W	A	175	60	35	O	20	60	600M	3.6	600M			50M		T
2N1510	G	N			AL	75M	A	85	75	70	R	8.0	90	1.0M	0.8	4.0M					
2N1511	S	N	2N3445	2N3445	SP	75W	C	200	60	60	V	4.0		6.0A	7.2	6.0A			0.3M		T
2N1512	S	N	2N3445	2N3445	SP	75W	C	200	100	100	V	7.0		6.0A	6.0	6.0A			0.3M		T
2N1513	S	N	2N3445	2N3445	SP	75W	C	200	60	60	V	7.0		6.0A	6.0	6.0A			0.3M		T
2N1514	S	N	2N3445	2N3445	SP	75W	C	200	100	100	V								0.3M		T
2N1516	G	P			AH	83M	A	75	25			20		1.0M							
2N1518	G	P	MP943		SP	50W	C	95	50	40		15	60	15A	0.7	25A					
2N1519	G	P	MP943A		SP	50W	C	95	80	60		15	60	15A	0.7	25A					
2N1520	G	P	MP944		SP	50W	C	95	50	40		17	68	15A	0.6	35A					
2N1521	G	P	MP944A		SP	50W	C	95	80	60		17	68	15A	0.6	35A					
2N1522	G	P	MP945		SP	50W	C	95	50	40	B	25	100	15A	0.5	50A					
2N1523	G	P	MP945A		SP	50W	C	95	80	60	B	25	100	15A	0.5	50A					
2N1524	G	P	2N3325	2N3323	AH	80M	A	85	24								17	E			
2N1525	G	P	2N3325	2N3323	AH	80M	A	85	24								17	E			
2N1526	G	P	2N3325	2N3323	AH	80M	A	85	24								27	E			
2N1527	G	P	2N3325	2N3323	AH	80M	A	85	24								27	E			
2N1528	S	N	2N2218	2N2218	AH	150M	A	175	25	25	S						10	E			
2N1529	G	P		2N1529	AP	90W	C	100	40	30	S	20	40	3.0A	1.5	3.0A					
2N1529A	G	P		2N1529	AP	90W	C	100	40	20	O	20	40	3.0A	1.5	3.0A			5.0K		E
2N1530	G	P		2N1529	AP	90W	C	100	60	45	S	20	40	3.0A	1.5	3.0A					
2N1530A	G	P		2N1529	AP	90W	C	100	60	30	O	20	40	3.0A	1.5	3.0A			5.0K		E
2N1531	G	P		2N1529	AP	90W	C	100	80	60	S	20	40	3.0A	1.5	3.0A					
2N1531A	G	P		2N1529	AP	90W	C	100	80	40	O	20	40	3.0A	1.5	3.0A			5.0K		E
2N1532	G	P		2N1529	AP	90W	C	100	100	75	S	20	40	3.0A	1.5	3.0A					
2N1532A	G	P		2N1529	AP	90W	C	100	100	50	O	20	40	3.0A	1.5	3.0A			5.0K		E
2N1533	G	P		2N1529	AP	90W	C	100	120	90	S	20	40	3.0A	1.5	3.0A					
2N1534	G	P		2N1529	AP	90W	C	100	40	30	S	35	70	3.0A	1.2	3.0A					
2N1534A	G	P		2N1529	AP	90W	C	100	40	20	O	35	70	3.0A	1.2	3.0A			5.0K		E
2N1535	G	P		2N1529	AP	90W	C	100	60	45	S	35	70	3.0A	1.2	3.0A					
2N1535A	G	P		2N1529	AP	90W	C	100	60	30	O	35	70	3.0A	1.2	3.0A			5.0K		E
2N1536	G	P		2N1529	AP	90W	C	100	80	60	S	35	70	3.0A	1.2	3.0A					
2N1536A	G	P		2N1529	AP	90W	C	100	80	40	O	35	70	3.0A	1.2	3.0A			5.0K		E
2N1537	G	P		2N1529	AP	90W	C	100	100	75	S	35	70	3.0A	1.2	3.0A					
2N1537A	G	P		2N1529	AP	90W	C	100	100	50	O	35	70	3.0A	1.2	3.0A			5.0K		E
2N1538	G	P		2N1529	AP	90W	C	100	120	90	S	35	70	3.0A	1.2	3.0A					
2N1539	G	P		2N1539	AP	90W	C	100	40	30	S	50	100	3.0A	0.3	3.0A					
2N1539A	G	P		2N1539	AP	90W	C	100	40	20	O	50	100	3.0A	0.3	3.0A			3.0K		E
2N1540	G	P		2N1539	AP	90W	C	100	60	45	S	50	100	3.0A	0.3	3.0A					
2N1540A	G	P		2N1539	AP	90W	C	100	60	30	O	50	100	3.0A	0.3	3.0A			3.0K		E
2N1541	G	P		2N1539	AP	90W	C	100	80	60	S	50	100	3.0A	0.3	3.0A					
2N1541A	G	P		2N1539	AP	90W	C	100	80	40	O	50	100	3.0A	0.3	3.0A			3.0K		E
2N1542	G	P		2N1539	AP	90W	C	100	100	75	S	50	100	3.0A	0.3	3.0A					
2N1542A	G	P		2N1539	AP	90W	C	100	100	50	O	50	100	3.0A	0.3	3.0A			3.0K		E
2N1543	G	P		2N1539	AP	90W	C	100	120	90	S	50	100	3.0A	0.3	3.0A					
2N1544	G	P		2N1539	AP	90W	C	100	40	30	S	75	150	3.0A	0.2	3.0A			1.0K		E
2N1544A	G	P		2N1539	AP	90W	C	100	40	30	S	75		3.0A	0.2	3.0A			3.0K		E

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N1545	G	P		2N1539	AP	90W	C	100	60	45	S	75	150	3.0A	0.2	3.0A			1.0K	E
2N1545A	G	P		2N1539	AP	90W	C	100	60	45	S	75		3.0A	0.2	3.0A			3.0K	E
2N1546	G	P		2N1539	AP	90W	C	100	80	60	S	75	150	3.0A	0.2	3.0A			1.0K	E
2N1546A	G	P		2N1539	AP	90W	C	100	80	60	S	75		3.0A	0.2	3.0A			3.0K	E
2N1547	G	P		2N1539	AP	90W	C	100	100	75	S	75	150	3.0A	0.2	3.0A			1.0K	E
2N1547A	G	P		2N1539	AP	90W	C	100	100	75	S	75		3.0A	0.2	3.0A			3.0K	E
2N1548	G	P		2N1539	AP	90W	C	100	120	90	S	75	150	3.0A	0.2	3.0A			1.0K	E
2N1549	G	P		2N1539	AP	90W	C	100	40	30	S	10	30	10A	1.0	10A				
2N1549A	G	P		2N1539	AP	90W	C	100	40	30	S	10	30	10A	1.0	10A			5.0K	E
2N1550	G	P		2N1539	AP	90W	C	100	60	45	S	10	30	10A	1.0	10A				
2N1550A	G	P		2N1539	AP	90W	C	100	60	45	S	10	30	10A	1.0	10A			5.0K	E
2N1551	G	P		2N1539	AP	90W	C	100	80	60	S	10	30	10A	1.0	10A				
2N1551A	G	P		2N1539	AP	90W	C	100	80	60	S	10	30	10A	1.0	10A			5.0K	E
2N1552	G	P		2N1539	AP	90W	C	100	100	75	S	10	30	10A	1.0	10A				
2N1552A	G	P		2N1539	AP	90W	C	100	100	75	S	10	30	10A	1.0	10A			5.0K	E
2N1553	G	P		2N1539	AP	90W	C	100	40	30	S	30	60	10A	0.5	10A			1.0K	E
2N1553A	G	P		2N1539	AP	90W	C	100	40	20	O	30	60	10A	0.5	10A			3.0K	E
2N1554	G	P		2N1539	AP	90W	C	100	60	45	S	30	60	10A	0.5	10A			1.0K	E
2N1554A	G	P		2N1539	AP	90W	C	100	60	30	O	30	60	10A	0.5	10A			3.0K	E
2N1555	G	P		2N1539	AP	90W	C	100	80	60	S	30	60	10A	0.5	10A			1.0K	E
2N1555A	G	P		2N1539	AP	90W	C	100	80	40	O	30	60	10A	0.5	10A			3.0K	E
2N1556	G	P		2N1539	AP	90W	C	100	100	75	S	30	60	10A	0.5	10A			1.0K	E
2N1556A	G	P		2N1539	AP	90W	C	100	100	50	O	30	60	10A	0.5	10A			3.0K	E
2N1557	G	P		2N1539	AP	90W	C	100	40	30	S	50	100	10A	0.4	10A			1.0K	E
2N1557A	G	P		2N1539	AP	90W	C	100	40	20	O	50	100	10A	0.5	10A			3.0K	E
2N1558	G	P		2N1539	AP	90W	C	100	60	45	S	50	100	10A	0.4	10A			1.0K	E
2N1558A	G	P		2N1539	AP	90W	C	100	60	30	O	50	100	10A	0.5	10A			3.0K	E
2N1559	G	P		2N1539	AP	90W	C	100	80	60	S	50	100	10A	0.4	10A			1.0K	E
2N1559A	G	P		2N1539	AP	90W	C	100	80	40	O	50	100	10A	0.5	10A			3.0K	E
2N1560	G	P		2N1539	AP	90W	C	100	100	75	S	50	100	10A	0.4	10A			1.0K	E
2N1560A	G	P		2N1539	AP	90W	C	100	100	50	O	50	100	10A	0.5	10A			3.0K	E
2N1561	G	P		2N1561	AH	250M	A	100	25	15	O				3.0	200M				
2N1562	G	P		2N1561	AH	250M	A	100	25	15	O				4.0	200M				
2N1564	S	N	2N2218	2N2218	A	600M	A	175	80	60	O	15	50	5.0M	1.0	10M	20	E		
2N1565	S	N	2N2218	2N2218	A	600M	A	175	80	60	O	30	100	5.0M	1.0	10M	40	E		
2N1566	S	N	2N2219	2N2218	A	600M	A	175	80	60	O	60	200	5.0M	1.0	10M	80	E		
2N1566A	S	N	2N2219	2N2218	A	600M	A	175	80	60	O	60	200	5.0M	0.95	10M	80	E	100M	T
2N1572	S	N			A	600M	A	175	125	80	O	15	50	5.0M	1.0	10M	20	E		
2N1573	S	N			A	600M	A	175	125	80	O	30	100	5.0M	1.0	10M	40	E		
2N1574	S	N			A	600M	A	175	125	80	O	60	200	5.0M	1.0	10M	80	E		
2N1585	G	N			A	750M	A	100	25	10	O	20		10M						
2N1586	S	N			A	125M	A	85	15	10	O	5.0	27	1.0M	1.5	5.0M	9.0	E	5.0M	B
2N1587	S	N			A	125M	A	85	30	20	O	5.0	27	1.0M	1.5	5.0M	9.0	E	5.0M	B
2N1588	S	N			A	125M	A	85	60	40	O	5.0	27	1.0M	1.5	5.0M	9.0	E	5.0M	B
2N1589	S	N			A	125M	A	85	15	10	O	20	75	1.0M	1.5	5.0M	25	E	5.0M	B
2N1590	S	N			A	125M	A	85	30	20	O	20	75	1.0M	1.5	5.0M	25	E	5.0M	B
2N1591	S	N			A	125M	A	85	60	40	O	20	75	1.0M	1.5	5.0M	25	E	5.0M	B
2N1592	S	N			A	125M	A	85	15	10	O	40	210	1.0M	1.5	5.0M	70	E	5.0M	B
2N1593	S	N			A	125M	A	85	30	20	O	40	210	1.0M	1.5	5.0M	70	E	5.0M	B
2N1594	S	N			A	125M	A	85	60	40	O	40	210	1.0M	1.5	5.0M	70	E	5.0M	B
2N1595 thru 2N1604	Thyristors, see Table on Page 2-66																			
2N1605	G	N			S	150M	A	100	25	24	O	40		20M	0.15	12M			4.0M	B
2N1605A	G	N			S	0.2W	A	100	40	40		40		20M	0.15	12M			4.0M	B
2N1606	S	P			SH	100M	A	140	10	10	S	6.0	30	15M	0.15	5.0M			7.2M	T
2N1607	S	P			SH	100M	A	140	10	10	S	6.0	30	15M	0.15	5.0M			10M	T
2N1608	S	P			SH	100M	A	140	10	10	S	6.0	30	15M	0.15	5.0M			25M	T
2N1609	G	P	2N2140	2N2137	AP			95	80	60	O	30	75	100M	1.0	500M				
2N1610	G	P	2N2145	2N2137	AP			95	80	60	O	50	125	100M	0.6	500M				
2N1611	G	P	2N2138	2N2137	AP			95	60	40	O	30	75	100M	1.0	500M				
2N1612	G	P	2N2143	2N2137	AP			95	60	40	O	50	125	100M	0.6	500M				
2N1613	S	N		2N718A	S	800M	A	200	75	50	R	40	120	150M	1.5	150M	30	E	60M	T
2N1613A	S	N	2N2218	2N2218	S	1.0W	A	200	75	50	R	40	120	150M	1.0	150M	30	E	60M	T
2N1613B	S	N			S	1.0W	A	200	120	55	R	40	120	150M	0.2	150M	30	E	60M	T
2N1614	G	P	2N1924	2N1924	S	240M	A	100	65	40	R	18	43	20M	0.13	20M			500K	B
2N1615	S	N			AH	5.5M	A	200	100	100	O	25		5.0M	5.0	50M			2.0M	T
2N1616	S	N	2N3487	2N3485	AHP	60W	C	175	60	60	O	15	75	2.0A	2.0	2.0A			3.0M	T
2N1616A	S	N	2N3487	2N3485	AP	85W	C	200	60	60	O	20	60	2.0A	1.0	2.0A			3.0M	T
2N1617	S	N	2N3487	2N3485	AHP	60W	C	175	80	80	V	15	75	2.0A	2.0	2.0A			3.0M	T
2N1617A	S	N	2N3487	2N3485	AP	85W	C	200	80	70	O	20	60	2.0A	1.0	2.0A			3.0M	T
2N1618	S	N	2N3488	2N3485	AHP	60W	C	175	100	100	V	15	75	2.0A	2.0	2.0A			3.0M	T
2N1618A	S	N	2N3488	2N3485	AP	85W	C	200	100	80	O	20	60	2.0A	1.0	2.0A			3.0M	T
2N1620	S	N	2N3446	2N3445	AHP	60W	C	175	100	100	V	15	75	2.0A	2.0	2.0A			3.0M	T
2N1622	G	N			A	0.12W	A	85	90	90	S	40		5.0M		5.0M				
2N1623	S	P			A	250M	A	160	50	20	O	9.0	40	1.0M	0.3	5.0M			100K	B
2N1624	G	N			S	0.15W	A	100	25	20	R	60	180	30M					5.0M	B
2N1631	G	P	2N3325	2N3323	AH	80M	A	85	34								40	E		
2N1632	G	P	2N3325	2N3323	AH	80M	A	85	34								40	E		
2N1633	G	P			AH	80M	A	85	34								27	E		
2N1634	G	P			AH	80M	A	85	34								27	E		
2N1635	G	P			AH	80M	A	85	34								40	E		
2N1636	G	P			AH	80M	A	85	34								40	E		
2N1637	G	P	2N3325	2N3323	AH	80M	A	85	34								40	E		
2N1638	G	P	2N3325	2N3323	AH	80M	A	85	34								70	E		
2N1639	G	P	2N3325	2N3323	AH	80M	A	85	34								40	E		
2N1640	S	P			SC	250M	A	160	30	20	U	6.0		100*						
2N1641	S	P			SC	250M	A	160	30	10	U	10		100*						

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N1642	S	P			SC	250M	A	160	30	6.0	U	15		100*					
2N1643	S	P			A	250M	A	160	25	25	U	10	25	100*					
2N1644	S	N	2N2218	2N2218	S	2.0W	C	175	60	40	R	40	120	150M	1.5	150M			50M T
2N1645	G	P			AHP	1.0W	A	100	35	20	O	20		0.2A	4.0	0.2A	25	E	450M T
2N1646	G	N			SH	150M	A	100	15	12	S	20		10M					
2N1647	S	N	2N3445	2N3445	AHP	267M	C	175	80	80	V	15	45	0.5A	3.0	1.0A			3.0M T
2N1648	S	N	2N3446	2N3445	AHP	267M	C	175	120	80	O	15	45	0.5A	3.0	1.0A			2.0M T
2N1649	S	N	2N3447	2N3445	AHP	267M	C	175	80	80	V	30	90	0.5A	3.0	1.0A			3.0M T
2N1650	S	N	2N3448	2N3445	AHP	267M	C	175	120	80	O	30		0.5A	3.0	1.0A			2.0M T
2N1651	G	P		2N1651	AP	100W	C	110	60	60	S	35	140	10A	0.65	25A	20	E	
2N1652	G	P		2N1651	AP	100W	C	110	100	100	S	35	140	10A	0.65	25A	20	E	
2N1653	G	P		2N1651	AP	100W	C	110	120	120	S	35	140	10A	0.65	25A	20	E	
2N1654	S	N	MM3006	MM3005	AP	250M	A	160	100	80	O	20	45	1.0M	0.3	5.0M			100K B
2N1655	S	N	MM3007	MM3005	AP	250M	A	160	125	100	O	10	22	1.0M	0.3	5.0M			100K B
2N1656	S	N	MM3007	MM3005	AP	250M	A	160	125	100	O	20	45	1.0M	0.3	5.0M			100K B
2N1657	S	N	MM3005	MM3005	AP		C	200	60	60	S	7.5	30	0.85A	4.5	0.85A			2.0M H
2N1660	S	N			AP	85W	C	200	60	60	R	45	135	1.0A	4.0	1.0A			25M T
2N1661	S	N			AP	85W	C	200	80	80	R	45	135	1.0A	4.0	1.0A			25M T
2N1662	S	N			AP	85W	C	200	100	100	R	45	135	1.0A	4.0	1.0A			25M T
2N1663	S	N			SH	150M	A	150	20	15	O	30	150	20M	0.25	10M			100M T
2N1664	G	P			A	0.2W	A	100	45	40	R	45	120	10M	0.5	0.1A	50	E	0.1M B
2N1665	G	P			AH	150M	A	85	15	12	O	5.0	100	10M					300M T
2N1666	G	P	2N3616	2N3615	SP	30W	C	90	80	60	V	15	30	6.0A	0.5	6.0A			2.0K E
2N1667	G	P	2N3618	2N3615	SP	30W	C	90	60	48	X	35	80	6.0A	0.5	6.0A			2.0K E
2N1668	G	P	2N3616	2N3615	SP	30W	C	90	60	48	X	20	45	6.0A	0.5	6.0A			2.0K E
2N1669	G	P	2N3616	2N3615	SP	30W	C	90	80	60	X	20	65	6.0A	0.5	6.0A			2.0K E
2N1670	G	P			S	0.12W	A	85	100			15		10M					
2N1671	Unijunction Transistor, see Table on Page 2-86																		
2N1672	G	N			AL	120M	A	85	40	40	X	20		1.0M			15	E	2.0M H
2N1672A	G	N			AL	120M	A	85	40	40	X	20		1.0M			15	E	2.0M H
2N1673	G	P			AH	80M	A	85	35								20	E	
2N1674	S	N			A	0.2W	A	200	45	45	O				1.5	5.0M	50	E	20M T
2N1675	S	N			SHP	50W	C	150	100	100	S	25	100	1.0A	2.5	5.0A			120M T
2N1676	S	P			SC	100M	A	140	4.5	4.5	U				0.1	5.0M			16M T
2N1677	S	P			SC	100M	A	140	4.5	4.5	U				0.1	5.0M	25	E	16M T
2N1678	G	P			S	120M	A	85	60	60	S	25		20M		20M			25M B
2N1679	S	N			S	1.0W	A	175	100	55	O	40	120	600M	3.6	600M			50M T
2N1680	S	N			S	1.0W	A	175	60	35	O	40	120	600M	3.6	600M			50M T
2N1681	G	P			S	0.18W	C	100	30	15	O	30	120	10M	0.1	10M			5.0M H
2N1682	S	N			S	500M	A	175	25	20	R	20		10M	0.6	10M			200M T
2N1683	G	P			SH	150M	A	85	13	12	O	50		40M	12	1.0A			50M T
2N1684	G	P			S	100M	A	100	25	25	X				0.15	12M			4.0M H
2N1685	G	P			S	100M	A	100	25	20	R	60	180	30M		100M			8.0M B
2N1686 thru 2N1689	Thyristors, see Table on Page 2-66																		
2N1690	S	N	2N4912	2N4910	AP	40W	C	200	80	80	O	20	60	500M	7.5	500M			90K E
2N1691	S	N			AP	40W	C	200	120	120	O	20	60	500M	7.5				90K E
2N1692	G	P		2N1561	AH	350M	A	100	25	15	O				3.0	200M			
2N1693	G	P		2N1561	AH	350M	A	100	25	25	S				4.0	200M			
2N1694	G	N			S	75M	A	85	20	20	O	17	50	1.0M					3.0M B
2N1699	G	P			AH	100M	A	100	40	40	X	20	175	1.5M			20	E	
2N1700	S	N			S	5.0W	C	200	60	60	V	20	80	100M	12.5	2.5A			0.4M B
2N1701	S	N	2N3766	2N3766	S	25W	C	200	60	60	V	20	80	300M	20	5.0A			0.35M B
2N1702	S	N	2N4913	2N4913	S	75W	C	200	60	60	V	15	60	800M	20	5.0A			0.3M H
2N1703	S	N	2N4913	2N4913	S	75W	C	200	60	60	V	15	60	800M					0.3M B
2N1704	S	N	2N2218	2N2218	S	3.3M	J	175	45	45	O	50	200	1.0M	1.0	10M	40	E	5.0M B
2N1705	G	P		2N1692	A	0.2W	A	100	18	12	R						70	E	
2N1706	G	P		2N1692	A	0.2W	A	100	25	18	R	60	120	20M			50	E	
2N1707	G	P		2N1692	A	0.2W	A	100	30	25	R	30	150	10M			40	E	
2N1708	S	N		2N1708	SH	1.0W	C	175	25	12	O	20		10M	0.22	10M			200M T
2N1708A	S	N			SH	300M	A	175	40	20	R	30	120	10M	0.22	10M			300M T
2N1709	S	N			AHP	15W	C	175	75	30	O	7.5	75	0.35A	5.0	1.0A			175M T
2N1710	S	N			AHP	15W	C	175	60	30	O	4.0	100	0.35A	5.0	1.0A			140M T
2N1711	S	N	2N2219A	2N2218A	S	800M	A	200	75	50	R	100	300	150M	1.5	150M	50	E	70M T
2N1711A	S	N	2N2219A	2N2218A	AH	1.0W	A	200	75	50	R	100	300	150M	1.0	150M	50	E	70M T
2N1711B	S	N	2N2219A	2N2218A	AH	1.0W	A	200	120	55	R	100	300	150M	0.2	150M	50	E	70M T
2N1713	G	P				80M	A	85	30	12	O	20		1.5M			40	E	100M B
2N1714	S	N			AP	20W	C	175	90	60	O	20	60	200M	2.0	200M			16M T
2N1715	S	N			AP	20W	C	175	150	100	O	20	60	200M	2.0	200M			16M T
2N1716	S	N			AP	20W	C	175	90	60	O	40	120	200M	2.0	200M			16M T
2N1717	S	N			AP	20W	C	175	150	100	O	40	120	200M	2.0	200M			16M T
2N1718	S	N	2N3766	2N3766	AP	20W	C	175	90	60	O	20	60	200M	2.0	200M			16M T
2N1719	S	N	2N3767	2N3766	AP	20W	C	175	150	100	O	20	60	200M	2.0	200M			16M T
2N1720	S	N	2N3766	2N3766	AP	20W	C	175	90	60	O	40	120	200M	2.0	200M			16M T
2N1721	S	N	2N3767	2N3766	AP	20W	C	175	150	100	O	40	120	200M	2.0	200M			16M T
2N1722	S	N	2N3446	2N3445	AP	50W	C	175	120	80	O	20	90	2.0A	1.0	2.0A			10M T
2N1722A	S	N			AP	50W	C	175	180	120	O	30	90	2.0A	0.6	2.0A			10M T
2N1723	S	N	2N3448	2N3445	AP	50W	C	175	120	80	O	50	150	2.0A	1.0	2.0A			10M T
2N1724	S	N		2N1724	AP	50W	C	175	120	80	O	20	90	2.0A	1.0	2.0A			10M T
2N1724A	S	N			AP	50W	C	175	180	120	O	30	90	2.0A	0.6	2.0A			10M T
2N1725	S	N		2N1724	AP	50W	C	175	120	80	O	50	150	2.0A	1.0	2.0A			10M T
2N1726	G	P	2N3323	2N3323	AH	60M	A	100	20	20	S	50		1.0M					100M M
2N1727	G	P	2N3324	2N3323	AH	60M	A	100	20	20	S	20		1.0M					100M M
2N1728	G	P	2N3324	2N3323	AH	60M	A	100	20	20	S	20		1.0M					100M M
2N1729	G	P			S	150M	A	85	25	15	X	30		100M	0.35	200M			
2N1730	G	N			S	150M	A	85	20	15	X	30		100M	0.35	200M			
2N1731	G	P			A	150M	A	85	30	30	X	40		10M					5.0M B

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_{-} Units	Subscript
2N1732	G	N			A	150M	A	85	30	30	X	40		10M					5.0M	B
2N1742	G	P		2N499	AH	60M	A	125	20	20	S	10		2.0M						
2N1743	G	P	2N3284	2N3283	AH	60M	A	125	20	20	S	10		2.0M						
2N1744	G	P	2N3284	2N3283	AH	60M	A	125	20	20	S	10		2.0M						
2N1745	G	P	2N3285	2N3283	AH	60M	A	100	20	20	S	10		2.0M						
2N1746	G	P	2N3323	2N3323	AH	60M	A	100	20	20	S	10		1.0M					100M	M
2N1747	G	P	2N3324	2N3323	AH	60M	A	100	20	20	S	10		1.0M						
2N1748	G	P	2N3324	2N3323	AH	60M	A	100	25	25	S						30	E	80M	T
2N1748A	G	P	2N3323	2N3323	AH	60M	A	100	25	25	S						50	E	100M	T
2N1749	G	P	2N3323	2N3323	AH	75M	A	100	40	40	S						30	E	80M	T
2N1750	G	P			A	15M	A	75	14	6.0	S	18	40	500*					30M	M
2N1751	G	P		2N2832	AP			110	80	80	S	30	90	20A	0.5	20A	20	E	1.5M	B
2N1752	G	P	2N3325	2N3323	A	60M	A	100	12	12	S						50	E	50M	M
2N1753	G	P			AH	30M	A	85	30	18	O	50	220	100*						
2N1754	G	P			SH	50M	A	85	13	13	S	20		10M	0.2	10M				
2N1755	G	P	2N2137	2N2137	SP	28W	C	95	40	35	S	30	75	0.5A	0.7	3.0A			15K	E
2N1756	G	P	2N2138	2N2137	SP	28W	C	95	60	50	S	30	75	0.5A	0.7	3.0A				
2N1757	G	P	2N2139	2N2137	SP	28W	C	95	80	65	S	30	75	0.5A	0.7	3.0A			15K	E
2N1758	G	P	2N2140	2N2137	SP	28W	C	95	100	75	S	30	75	0.5A	0.7	3.0A			15K	E
2N1759	G	P	2N2142	2N2137	SP	28W	C	95	40	35	S	60	150	0.5A	0.5	3.0A			15K	E
2N1760	G	P	2N2143	2N2137	SP	28W	C	95	60	50	S	60	150	0.5A	0.5	3.0A			15K	E
2N1761	G	P	2N2144	2N2137	SP	28W	C	95	80	65	S	60	150	0.5A	0.5	3.0A			15K	E
2N1762	G	P	2N2145	2N2137	SP	28W	C	95	100	75	S	60	150	0.5A	0.5	3.0A			15K	E
2N1763	S	N			S	0.3W	A	175	40	25	O				1.5	10M				
2N1764	S	N			S	0.3W	A	175	20	15	O				1.5	10M				
2N1765	Thyristors, see Table on Page 2-66																			
2N1768	S	N	2N3445	2N3445	S	40W	C	200	60	40	O	35	100	750M	0.75	750M			600K	B
2N1769	S	N	2N3445	2N3445	S	40W	C	200	100	55	O	35	100	750M	0.75	750M			600K	B
2N1770 thru 2N1778	Thyristors, see Table on Page 2-66																			
2N1779	G	P			S	100M	A	100	25	20	R	20	60	30M						
2N1780	S	P	2N3798	2N3798	S	100M	A	100	25	25	R	30	110	30M					4.0M	B
2N1781	G	P			S	100M	A	100	25	25	X	40		20M	0.15	12M			4.0M	B
2N1782	G	P			S	100M	A	100	30	20	X	30	150	10M	0.20	50M			5.0M	B
2N1783	G	P			S	100M	A	100	30	15	O	20		10M	0.32	200M	30	E	5.0M	B
2N1784	G	P			S	100M	A	100	30	20	O	20		10M	0.32	200M			10M	B
2N1785	G	P	2N3324	2N3323	AH	45M	A	85	10	10	S	40		1.0M					50M	M
2N1786	G	P	2N3323	2N3323	AH	45M	A	85	10	10	S	15		1.0M					50M	M
2N1787	G	P	2N3324	2N3323	AH	45M	A	85	15	15	S	25		1.0M					50M	M
2N1788	G	P	2N3324	2N3323	AH	50M	A	100	35	35	S	50		1.0M					100M	M
2N1789	G	P	2N3325	2N3323	AH	60M	A	100	35	35	S	20		1.0M					100M	M
2N1790	G	P	2N3323	2N3323	AH	60M	A	100	35	35	S	40		1.0M					100M	M
2N1792 thru 2N1807	Thyristors, see Table on Page 2-66																			
2N1808	G	N			S	150M	A	85	25						0.15	12M			4.0M	B
2N1809	S	N			SP	250W	C	175	50	50	V	10		10A	1.5	10A				
2N1810	S	N			SP	250W	C	175	100	100	V	10		10A	1.5	10A				
2N1811	S	N			SP	250W	C	175	150	150	V	10		10A	1.5	10A				
2N1812	S	N			SP	250W	C	175	200	200	V	10		10A	1.5	10A				
2N1813	S	N			SP	250W	C	175	250	250	V	10		10A	1.5	10A				
2N1814	S	N			SP	250W	C	175	300	300	V	10		10A	1.5	10A				
2N1816	S	N			SP	250W	C	175	50	50	V	10		15A	1.5	15A				
2N1817	S	N			SP	250W	C	175	100	100	V	10		15A	1.5	15A				
2N1818	S	N			SP	250W	C	175	150	150	V	10		15A	1.5	15A				
2N1819	S	N			SP	250W	C	175	200	200	V	10		15A	1.5	15A				
2N1820	S	N			SP	250W	C	175	250	250	V	10		15A	1.5	15A				
2N1821	S	N			SP	250W	C	175	300	300	V	10		15A	1.5	15A				
2N1823	S	N			SP	250W	C	175	50	50	V	10		20A	1.5	20A				
2N1824	S	N			SP	250W	C	175	100	100	V	10		20A	1.5	20A				
2N1825	S	N			SP	250W	C	175	150	150	V	10		20A	1.5	20A				
2N1826	S	N			SP	250W	C	175	200	200	V	10		20A	1.5	20A				
2N1827	S	N			SP	250W	C	175	250	250	V	10		20A	1.5	20A				
2N1828	S	N			SP	250W	C	175	300	300	V	10		20A	1.5	20A				
2N1830	S	N			SP	250W	C	175	50	50	V	10		25A	1.5	25A				
2N1831	S	N			SP	250W	C	175	100	100	V	10		25A	1.5	25A				
2N1832	S	N			SP	250W	C	175	150	150	V	10		25A	1.5	25A				
2N1833	S	N			SP	250W	C	175	200	200	V	10		25A	1.5	25A				
2N1834	S	N			SP	250W	C	175	250	250	V	10		25A	1.5	25A				
2N1835	S	N			SP	250W	C	175	300	300	V	10		25A	1.5	25A				
2N1837	S	N	2N2218	2N2218	SH	800M	A	300	80	30	O	40	120	150M	0.8	150M			140M	T
2N1837A	S	N	2N2218	2N2218	SH	0.8W	A	175	80	30	O	40	120	0.15A	0.8	0.15A			140M	T
2N1837B	S	N			SH	0.8W	A	200	80	30	O	40	120	0.15A	0.8	0.15A			140M	T
2N1838	S	N	2N2218	2N2218	SH	0.6W	A	175	45	20	O	40	150	0.1A	1.4	0.1A			90M	T
2N1839	S	N	2N2218	2N2218	SH	0.6W	A	175	45	20	O	12	50	0.1A	1.4	0.15A			90M	T
2N1840	S	N	2N2218	2N2218	SH	0.6W	A	175	25	15	O	10	100	0.15A	1.4	0.15A			90M	T
2N1841	S	N			AHP	2.0W	A	150	100	50	O	15	50	15M	1.0	1.0A			60M	E
2N1842 thru 2N1850	Thyristors, see Table on Page 2-66																			
2N1853	G	P			SH	150M	A	85	18	6.0	O	30		6.0M	0.2	6.0M				
2N1854	G	P			SH	150M	A	85	18	6.0	O	40		20M	0.2	20M			40M	T
2N1864	G	P	2N3324	2N3323	AH	60M	A	100	20	20	S	10		1.0M			20	E	50M	M
2N1865	G	P	2N3325	2N3323	AH	60M	A	100	20	20	S	40		1.0M						
2N1866	G	P	2N3323	2N3323	AH	60M	A	100	35	35	S	40		1.0M						
2N1867	G	P	2N3324	2N3323	AH	60M	A	100	35	35	S	10		1.0M						
2N1868	G	P	2N3325	2N3323	AH	60M	A	100	20	20	S	10		2.0M						

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N1869 thru 2N1885	Thyristors, see Table on Page 2-66																		
2N1886	S	N	2N4914	2N4913	AHP	20W	C	175	60	60	O	20	80	0.5A	5.0	1.0A			2.0M	T
2N1889	S	N	2N3498	2N3498	AH	800M	A	200	100	80	R	40	120	150M	5.0	150M	30	E	50M	T
2N1890	S	N	2N3499	2N3498	AH	800M	A	200	100	80	R	100	300	150M	5.0	150M	50	E	60M	T
2N1891	G	N			SH	150M	A	85	25	15	O	25		100M	0.15	100M			5.0M	B
2N1892	G	P			S	150M	A	85	30	15	O	40	200	10M	0.2	10M	30	E	5.0M	B
2N1893	S	N	2N3498	2N3498	AH	800M	A	200	120	100	R	40	120	150M	5.0	150M	30	E	50M	T
2N1893A	S	N	2N3498	2N3498	AHP	0.8W	A	200	140	80	O	40	120	0.15A	2.0	0.15A	30	E	100M	T
2N1894	S	N			AP			200	60	60	R	12	60	1.0A	5.0	1.0A				
2N1895	S	N			AP			200	80	80	R	12	60	1.0A	10	1.0A				
2N1896	S	N			AP			200	60	60	R	45	135	1.0A	4.0	1.0A			25M	T
2N1897	S	N			AP			200	80	80	R	45	135	1.0A	4.0	1.0A			25M	T
2N1898	S	N			AP			200	100	100	R	45	135	1.0A	4.0	1.0A			25M	T
2N1899	S	N			SHP	125W	C	150	140	50	O	10	30	10A	1.0	10A			50M	T
2N1900	S	N			AHP	125W	C	150	140	50	O	8.0		10A	2.0	10A			50M	T
2N1901	S	N			SHP	125W	C	150	140	50	O	20	60	10A	1.0	10A			50M	T
2N1902	S	N			SHP	125W	C	150	140	50	O	10	30	10A	1.0	10A			50M	T
2N1903	S	N			AHP	125W	C	150	140	50	O	8.0		10A	2.0	10A			50M	T
2N1904	S	N			SHP	125W	C	150	140	50	O	20	60	10A	1.0	10A			50M	T
2N1905	G	P	2N2832	2N2832	AP	30W	C	100	100	50	O	50	150	1.0A	1.0	5.0A	30	E		
2N1906	G	P	2N2832	2N2832	AP	30W	C	100	130	60	O	75	250	1.0A	5.0	5.0A	50	E		
2N1907	G	P	MP1907		AHP	60W	C	100	100	40	O				1.0	15A			10M	T
2N1907A	G	P			AHP	60W	C		100	40	O	30	170	10A	0.7	10A	2.0	E		
2N1908	G	P	MP1910		AHP	60W	C	100	130	50	O				1.0	15A			10M	T
2N1908A	G	P			AHP	60W	C		130	50	O	30	170	10A	0.7	10A	2.0	E		
2N1909 thru 2N1916	Thyristors, see Table on Page 2-66																			
2N1917	S	P			SC	0.25W	A	175	25	8.0	O						25	E	16M	T
2N1918	S	P			SC	0.25W	A	175	25	8.0	O						25	E	10M	T
2N1919	S	P			SC	0.25W	A	175	40	18	O				0.003				1.0M	B
2N1920	S	P			SC	0.25W	A	175	40	18	O				0.004				1.0M	B
2N1921	S	P			SC	0.25W	A	175	50	50	O				0.005				1.0M	B
2N1922	S	P			SC	0.25W	A	175	80	80	O				0.005				1.0M	B
2N1923	S	N			A	750M	A	150	85	85	O	4.0	90		7.0	20M	28	E		
2N1924	G	P		2N1924	A	225M	A	100	60	40	R	34	65	20M	0.11	20M	30	E	1.0M	B
2N1925	G	P		2N1924	A	225M	A	100	60	40	R	53	90	20M	0.11	20M	44	E	1.3M	B
2N1926	G	P		2N1924	A	225M	A	100	60	40	R	72	121	20M	0.11	20M	60	E	1.5M	B
2N1929 thru 2N1935	Thyristors, see Table on Page 2-66																			
2N1936	S	N			AP	150W	C	175	125	60	O	7.0	50	10A	0.75	10A	15	E	4.0M	T
2N1937	S	N			AP	150W	C	175	125	80	O	7.0	50	10A	0.75	10A	15	E	4.0M	T
2N1940	G	P			AHP	3.5W	C	100	30	15	O	5.0		40M	1.8	200M				
2N1941	S	N			A	0.6W	A	175	45	30	R	30	150	10M	1.5	5.0M	40	E	60M	T
2N1942	G	P			S	0.2W	A	85	20	10	O	20	60	0.2A					5.0M	B
2N1943	S	N			A	800M	A	200	60	60	O	30	90	200M	5.0	200M	12	E		
2N1944	S	N			S	0.6W	A	175	20	20	R	150	450	1.0M			100	E	60M	T
2N1945	S	N			S	0.6W	A	175	30	30	R	150	450	1.0M			100	E	60M	T
2N1946	S	N			S	0.6W	A	175	40	40	R	150	450	1.0M			100	E	60M	T
2N1947	S	N			S	0.6W	A	175	20	20	R	500	800	0.1A			100	E	60M	T
2N1948	S	N			S	0.6W	A	175	30	30	R	500	800	0.1A			100	E	60M	T
2N1949	S	N			S	0.6W	A	175	40	40	R	500	800	0.1A			100	E	60M	T
2N1950	S	N			S	0.6W	A	175	20	20	R	250	500	0.1A			75	E	60M	T
2N1951	S	N			S	0.6W	A	175	30	30	R	250	500	0.1A			75	E	60M	T
2N1952	S	N			S	0.6W	A	175	40	40	R	250	500	0.1A			75	E	60M	T
2N1953	S	N			A	0.6W	A	175	20	20	S	15	150	10M			28	E	40M	T
2N1954	G	P	2N651	2N650	S	200M	A	100	60	20	O	30	120	20M	0.3	20M				
2N1955	G	P	2N1190	2N1189	S	200M	A	100	60	18	O	50	200	20M	0.175	20M				
2N1956	G	P	2N651	2N650	S	200M	A	100	60	16	O	30	120	20M	0.175	20M				
2N1957	G	P	2N1187	2N1175	S	200M	A	100	60	14	O	30	120	20M	0.175	20M				
2N1958	S	N	2N2537	2N2537	SH	600M	A	175	60	40	R	20	60	150M	0.45	150M			100M	T
2N1958A	S	N	2N2537	2N2537	SH	600M	A	175	60	40	R	20	60	150M	0.45	150M			100M	T
2N1959	S	N		2N1959	SH	600M	A	175	60	40	R	40	120	150M	0.45	150M	1.0	E		
2N1959A	S	N	2N2537	2N2537	SH	600M	A	175	60	40	R	40	120	150M	0.45	150M			100M	T
2N1960	G	P			SH	150M	A	100	15	15		25		10M	0.16	10M				
2N1961	G	P			SH	150M	A	100	12	12	S	20		10M	0.20	10M				
2N1962	S	N	2N834	2N834	SH	400M	A	175	40	20	R	20	60	10M	0.25	10M			200M	T
2N1963	S	N	2N834	2N834	SH	400M	A	175	30	15	R	25		10M	0.16	10M			200M	T
2N1964	S	N	2N2539	2N2537	SH	400M	A	175	60	40	R	20	60	150M	0.45	150M			100M	T
2N1965	S	N	2N2539	2N2537	SH	0.4W	A	175	60	40	R	40	120	0.15A	0.45	0.15A			100M	T
2N1966	G	P			AL	0.12W	A	75	35	15	R									
2N1967	G	P			AL	0.12W	A	75	35	15	R									
2N1968	G	P			AL	0.12W	A	75	35	18	R									
2N1969	G	P			S	150M	A	85	30	15	O	50	200	200*					10M	B
2N1970	G	P		2N1970	AP	150W	C	100	100	50	B	17	40	5.0A	1.0	12A			5.0K	E
2N1971	G	P	2N2140	2N2137	AP			100	80	40	O	25	60	0.5A	0.9	3.0A			15K	E
2N1972	S	N	2N2219	2N2218	AH	600M	A	175	60	30	R	110	350	50M	2.0	50M	40	E	50M	T
2N1973	S	N	2N2219	2N2218	A	800M	A	200	100	80	R	75		10M	1.2	50M	76	E	60M	T
2N1974	S	N	2N3498	2N3498	A	800M	A	200	100	80	R	35		10M	1.2	50M	36	E	50M	T
2N1975	S	N	2N3498	2N3498	A	800M	A	200	100	80	R	15		10M	1.2	50M	18	E	40M	T
2N1978	S	N			AHP	30W	C	200	60	40	R	20		500M	1.5	1.0A			40M	T
2N1980	G	P		2N1970	AP	170W	C	100	50	30	O	50	100	5.0A	0.5	5.0A			3.0K	E
2N1981	G	P		2N1970	AP	170W	C	100	70	40	O	50	100	5.0A	0.5	5.0A			3.0K	E
2N1982	G	P		2N1970	AP	170W	C	100	90	50	O	50	100	5.0A	0.5	5.0A			3.0K	E
2N1983	S	N	2N2218	2N2218	A	600M	A	150	50	25	O						70	E	40M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	h_{FE} @ I_C (max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	$V_{CE(SAT)}$ @ I_C Units	h_{f-}	Subscript	f_- Units	Subscript
2N1984	S	N	2N2218	2N2218	A	600M	A	150	50	25	0						35	E	40M	T
2N1985	S	N	2N2218	2N2218	A	600M	A	150	50	25	0						15	E	40M	T
2N1986	S	N	2N2218	2N2218	AH	600M	A	150	50	25	0	60	240	150M	1.5	150M			40M	T
2N1987	S	N	2N2218	2N2218	AH	600M	A	150	50	25	0	20	80	150M	1.5	150M			40M	T
2N1988	S	N	2N2218A	2N2218A	AH	600M	A	150	100	45	0	35	120	30M	2.0	30M	20	E	40M	T
2N1989	S	N	2N2218A	2N2218A	AH	600M	A	150	100	45	0	20	60	30M	2.0	30M	10	E	40M	T
2N1990	S	N		2N1990	SP	600M	A	150	100			20		30M	0.5	2.0M				
2N1991	S	P		2N1131	AH	600M	A	150	30	20	0	15	60	150M	1.5	150M			40M	T
2N1992	S	N			SH	0.35W	A	200	15	15	0	30	120	1.0M	0.25	10M			300M	T
2N1993	G	N			S	150M	A	100	30	18	0	50	300	10M	0.2	10M			3.0M	B
2N1994	G	N			S	150M	A	85	30	15	0	15		10M	0.25	200M			3.0M	B
2N1995	G	N			S	150M	A	85	25	15	0	25		10M	0.25	200M			5.0M	B
2N1996	G	N			S	150M	A	85	20	15	0	35		10M	0.25	200M			8.0M	B
2N1997	G	P			S	250M	A	100	45	15	0	40	200	100M	0.2	10M			3.0M	B
2N1998	G	P			S	250M	A	100	35	15	0	70	225	100M	0.2	10M			5.6M	T
2N1999	G	P			S	250M	A	100	30	15	0	100	350	100M	0.2	10M			10M	T
2N2000	G	P			S	300M	A	100	50	15	0	50	300	100M	0.35	500M			2.0M	B
2N2001	G	P			S	300M	A	100	30	15	0	100		100M	0.2	100M			6.0M	B
2N2002	S	P			SC	0.25W	A	200	30	5.0	0									
2N2003	S	P			SC	0.25W	A	200	30	5.0	0									
2N2004	S	P			SC	0.25W	A	175	50	15	0	12		1.0M			15	E	0.5M	B
2N2005	S	P			SC	0.25W	A	200	50	15	0									
2N2006	S	P			SC	0.25W	A	200	60	35	0									
2N2007	S	P			SC	0.25W	A	200	60	35	0									
2N2008	S	N	2N3500	2N3498	A	800M	A	200	175	110	0	30	90	10M	2.5	25M	20	E	40M	T
2N2009 thru 2N2014	Thyristors, see Table on Page 2-66																			
2N2015	S	N	2N3715	2N3713	A	150W	C	200	100	50	0	15	50	5.0A	1.25	5.0A	12	E	12K	E
2N2016	S	N	2N3715	2N3713	A	150W	C	200	130	65	0	15	50	5.0A	1.25	5.0A	12	E	12K	E
2N2017	S	N			A	1.0W	A	200	60	60	0	50	200	200M			30	E		
2N2018	S	N	2N3738	2N3738	AHP	20W	C	175	150	150	V	20	60	0.5A	6.0	1.0A			2.0M	T
2N2019	S	N	2N3738	2N3738	AHP	20W	C	175	200	200	V	20	60	0.5A	6.0	1.0A			2.0M	T
2N2020	S	N	2N3738	2N3738	AHP	20W	C	175	150	125	O	40	90	0.5A	6.0	1.0A			3.0M	T
2N2021	S	N	2N3738	2N3738	AHP	20W	C	175	200	140	O	40	90	0.5A	6.0	1.0A			3.0M	T
2N2022	G	P			SH	0.15W	A	100	15	12	S	25	150	10M	1.2	50M			250M	T
2N2023 thru 2N2031	Thyristors, see Table on Page 2-66																			
2N2032	S	N	2N4914	2N4913	AHP	45W	C	200	45	45	O	20		2.0A	5.0	2.0A			3.0M	T
2N2033	S	N			SP	5.0W	C	200	80	60	O	20	60	500M	0.4	500M			1.0M	T
2N2034	S	N	2N4238	2N4237	SP	14W	C	200	80	60	O	20	60	1.0A	0.3	1.0A			1.0M	T
2N2035	S	N	2N4911	2N4910	SP	17W	C	200	80	60	O	20	60	1.5A	0.45	1.5A			1.0M	T
2N2036	S	N	2N4914	2N4913	SP	17.5W	C	200	80	60	O	20	60	2.0A	1.0	2.0A			1.0M	T
2N2038	S	N			AH	0.6W	A	200	45	45	O	12	36	0.2A	6.0	0.2A			2.0M	T
2N2039	S	N			AH	0.6W	A	200	75	75	O	12	36	0.2A	6.0	0.2A			2.0M	T
2N2040	S	N			AH	0.6W	A	200	45	45	O	30	90	0.2A	6.0	0.2A			2.0M	T
2N2041	S	N			AH	0.6W	A	200	75	75	O	30	90	0.2A	6.0	0.2A			2.0M	T
2N2042A	G	P			A	200M	A	100	105	105	S	20	50	5.0M	0.75	100M	20	E	0.5M	B
2N2043A	G	P			A	200M	A	100	105	105	S	40	100	5.0M	0.75	100M	45	E	0.75M	B
2N2044 thru 2N2047	Thyristors, see Table on Page 2-66																			
2N2048	G	P	2N2955	2N2955	SH	150M	A	100	20	15	O	50	300	10M	0.14	10M			150M	T
2N2048A	G	P			SH	150M	A	100	30	20	O	50	300	10M	0.14	10M			7.5K	E
2N2049	S	N	2N2219A	2N2218A	A	800M	A	200	75	50	R	100	300	150M	0.4	10M	75	E	50M	T
2N2059	G	P			S	60M	A	100	10	8.0	S	20		10M	0.2	10M			50M	T
2N2060	S	N		2N2060	AM	500M	A	200	100	80	R	50	150	10M	1.2	50M	50	E	60M	T
2N2060A	S	N		2N2060	AM	0.5W	A	200	100	60	O	50	150	10M	0.6	50M	50	E	60M	T
2N2060B	S	N							100											
2N2061	G	P			S	40W	C	85	20	10	O	10	60	0.5A	2.0	0.5A			2.0K	E
2N2061A	G	P			SP	90W	C	100	20	15	O	20	60	2.0A	1.0	5.0A			5.0K	E
2N2062	G	P			S	40W	C	85	20	10	O	20	200	2.0A	1.0	2.0A			2.0K	E
2N2062A	G	P			SP	90W	C	100	20	15	O	50	140	2.0A	0.7	5.0A			1.0K	E
2N2063	G	P			S	35W	C	95	40	15	O	10	200	2.0A	2.0	2.0A			2.0K	E
2N2063A	G	P			SP	90W	C	100	40	20	O	20	60	2.0A	1.0	5.0A			5.0K	E
2N2064	G	P			S	35W	C	95	40	15	O	20	200	2.0A	1.0	2.0A			2.0K	E
2N2064A	G	P			SP	90W	C	100	40	20	O	50	140	2.0A	0.7	5.0A			1.0K	E
2N2065	G	P			S	35W	C	95	80	25	O	10	200	2.0A	2.0	2.0A			2.0K	E
2N2065A	G	P			SP	90W	C	100	80	40	O	20	60	2.0A	1.0	5.0A			5.0K	E
2N2066	G	P			S	35W	C	95	80	25	O	20	200	2.0A	1.0	2.0A			2.0K	E
2N2066A	G	P			SP	90W	C	100	80	40	O	50	140	2.0A	0.7	5.0A			1.0K	E
2N2067	G	P	2N1536	2N1529	S	28W	C	95	40	25	O	20	100	0.5A	0.7	1.0A			7.0K	E
2N2068	G	P	2N1531	2N1529	S	28W	C	95	80	55	O	20	100	0.5A	0.7	1.0A			7.0K	E
2N2069	G	P	2N1539	2N1539	S	70W	C	95	40	30	S	30	200	5.0A	1.5	12A			1.5K	E
2N2070	G	P	2N1541	2N1539	S	70W	C	95	80	60	S	30	200	5.0A	1.5	12A			1.5K	E
2N2071	G	P	MP1539		S	70W	C	95	40	30	S	30	200	5.0A	1.5	12A			1.5K	E
2N2072	G	P	MP1541		S	70W	C	95	80	60	S	30	200	5.0A	1.5	12A			1.5K	E
2N2074	Thyristors, see Table on Page 2-66																			
2N2075	G	P		2N2075	AP	170W	C	110	80	80	S	20	40	5.0A	0.7	12A			5.0K	E
2N2075A	G	P		2N2075	AP	170W	C	110	80	80	S	20	40	5.0A	0.7	12A			5.0K	E
2N2076	G	P		2N2075	AP	170W	C	110	70	70	S	20	40	5.0A	0.7	12A			5.0K	E
2N2076A	G	P		2N2075	AP	170W	C	110	70	70	S	20	40	5.0A	0.7	12A			5.0K	E
2N2077	G	P		2N2075	AP	170W	C	110	50	50	S	20	40	5.0A	0.9	12A			5.0K	E
2N2077A	G	P		2N2075	AP	170W	C	110	50	50	S	20	40	5.0A	0.9	12A			5.0K	E
2N2078	G	P		2N2075	AP	170W	C	110	40	40	S	20	40	5.0A	0.9	12A			5.0K	E
2N2078A	G	P		2N2075	AP	170W	C	110	40	40	S	20	40	5.0A	0.9	12A			5.0K	E
2N2079	G	P		2N2075	AP	170W	C	110	80	80	S	35	70	5.0A	0.7	12A			5.0K	E

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2079A	G	P		2N2075	AP	170W	C	110	80	80	S	35	70	5.0A	0.7	12A			5.0K	E
2N2080	G	P		2N2075	AP	170W	C	110	70	70	S	35	70	5.0A	0.7	12A			5.0K	E
2N2080A	G	P		2N2075	AP	170W	C	110	70	70	S	35	70	5.0A	0.7	12A			5.0K	E
2N2081	G	P		2N2075	AP	170W	C	110	50	50	S	35	70	5.0A	0.9	12A			5.0K	E
2N2081A	G	P		2N2075	AP	170W	C	110	50	50	S	35	70	5.0A	0 9	12A			5.0K	E
2N2082	G	P		2N2075	AP	170W	C	110	40	40	S	35	70	5.0A	0.9	12A			5.0K	E
2N2082A	G	P		2N2075	AP	170W		110	40	40	S	35	70	5.0A	0.9	12A			5.0K	E
2N2083	G	P			A	60M	A	85	30			25		1.0M					30M	T
2N2084	G	P			AH	125M	A	100	40	20	O	40	250	1.0M			40	E		
2N2085	G	N			A	150M	A	100	33	23	X	50	300	10M		10M	20	E	6.0M	B
2N2086	S	N			SH	600M	A	175	120	80	R	20		150M	0.7	150M			150M	T
2N2087	S	N			SH	600M	A	175	120	80	R	40	120	150M	0.5	150M			150M	T
2N2089	G	P			AH	0.1W	A	85	20	20	R	40		1.0M			40	E	44M	T
2N2090	G	P			AH	0.1W	A	85	20	20	R	40		1.0M			40	E	44M	T
2N2091	G	P			AH	0.1W	A	85	20	20	R	40		1.0M			40	E	44M	T
2N2092	G	P			AH	0.1W	A	85	20	20	R	40		1.0M			40	E	44M	T
2N2093	G	P			AH	0.1W	A	85	25	25	R	40		1.0M			40	E	30M	T
2N2095	G	P			AHP	1.0W	A	100	30	15	O								500M	T
2N2096	G	P		2N1204	SH	250M	A	100	25	12	O	15		400M	0.6	200M				
2N2097	G	P		2N1204	SH	250M	A	100	40	20	O	20		400M	0.5	200M				
2N2098	G	P			AH	1.0W	A	100	30	15	O								500M	T
2N2099	G	P		2N1204	SH	250M	A	100	25	12	O	15		400M	0.6	200M				
2N2100	G	P		2N1204	SH	250M	A	100	40	20	O	20		400M	0.5	200M				
2N2100A	G	P			SH	300M	A	100	40	20	O	20		400M	0 5	200M				
2N2101	S	N	2N3487	2N3485	AP	75W	C	200	60	40	O	15	60	1.0A	5.0	1.0A			25K	T
2N2102	S	N			SH	5.0W	C	200	120	80	R	35		10M	0.5	150M	35	E		
2N2102A	S	N			SH	1.0W	A	200	120	65	O	40	120	150M	0.3	150M	30	E		
2N2104	S	P			SH	3.5W	C	200	50	35	O	25	80	150M	1.5	150M			60M	T
2N2105	S	P			SH	3.5W	C	200	50	35	O	15	40	150M	1.5	150M			50M	T
2N2106	S	N	2N4238	2N2218	A	1.0W	A	150	60	60	R	12	36	200M	5.0	200M				
2N2107	S	N	2N4238	2N2218	A	1.0W	A	150	60	60	R	30	90	200M	2.0	200M				
2N2108	S	N	2N4238	2N2218	A	1.0W	A	150	60	60	R	75	200	200M	2.0	200M				
2N2109	S	N			SP	250W	C	175	50	50	V	10		10A	1.5	10A				
2N2110	S	N			SP	250W	C	175	100	100	V	10		10A	1.5	10A				
2N2111	S	N			SP	250W	C	175	150	150	V	10		10A	1.5	10A				
2N2112	S	N			SP	250W	C	175	200	200	V	10		10A	1.5	10A				
2N2113	S	N			SP	250W	C	175	250	250	V	10		10A	1.5	10A				
2N2114	S	N			SP	250W	C	175	300	300	V	10		10A	1.5	10A				
2N2116	S	N			SP	250W	C	175	50	50	V	10		15A	1.5	15A				
2N2117	S	N			SP	250W	C	175	100	100	V	10		15A	1.5	15A				
2N2118	S	N			SP	250W	C	175	150	150	V	10		15A	1.5	15A				
2N2119	S	N			SP	250W	C	175	200	200	V	10		15A	1.5	15A				
2N2120	S	N			SP	250W	C	175	250	250	V	10		15A	1.5	15A				
2N2121	S	N			SP	250W	C	175	300	300	V	10		15A	1.5	15A				
2N2123	S	N			SP	250W	C	175	50	50	V	10		20A	1.5	20A				
2N2124	S	N			SP	250W	C	175	100	100	V	10		20A	1.5	20A				
2N2125	S	N			SP	250W	C	175	150	150	V	10		20A	1.5	20A				
2N2126	S	N			SP	250W	C	175	200	200	V	10		20A	1.5	20A				
2N2127	S	N			SP	250W	C	175	250	250	V	10		20A	1.5	20A				
2N2128	S	N			SP	250W	C	175	300	300	V	10		20A	1.5	20A				
2N2130	S	N			SP	250W	C	175	50	50	V	10		25A	1.5	25A				
2N2131	S	N			SP	250W	C	175	100	100	V	10		25A	1.5	25A				
2N2132	S	N			SP	250W	C	175	150	150	V	10		25A	1.5	25A				
2N2133	S	N			SP	250W	C	175	200	200	V	10		25A	1.5	25A				
2N2134	S	N			SP	250W	C	175	250	250	V	10		25A	1.5	25A				
2N2135	S	N			SP	250W	C	175	300	300	V	10		25A	1.5	25A				
2N2137	G	P		2N2137	AP	62.5W	C	100	30	30	S	30	60	0.5A	0.5	2.0A			12K	E
2N2137A	G	P		2N2137	AP	62.5W	C	100	30	20	O	30	60	0.5A	0.5	2.0A			12K	E
2N2138	G	P		2N2137	AP	62.5W	C	100	45	45	S	30	60	0.5A	0.5	2.0A			12K	E
2N2138A	G	P		2N2137	AP	62.5W	C	100	45	30	O	30	60	0.5A	0.5	2.0A			12K	E
2N2139	G	P		2N2137	AP	62.5W	C	100	60	60	S	30	60	0.5A	0.5	2.0A			12K	E
2N2139A	G	P		2N2137	AP	62.5W	C	100	60	45	O	30	60	0.5A	0.5	2.0A			12K	E
2N2140	G	P		2N2137	AP	62.5W	C	100	75	75	S	30	60	0.5A	0.5	2.0A			12K	E
2N2140A	G	P		2N2137	AP	62.5W	C	100	75	60	O	30	60	0.5A	0.5	2.0A			12K	E
2N2141	G	P		2N2137	AP	62.5W	C	100	90	90	S	30	60	0.5A	0.5	2.0A			12K	E
2N2141A	G	P		2N2137	AP	62.5W	C	100	90	65	O	30	60	0.5A	0.5	2.0A			12K	E
2N2142	G	P		2N2137	AP	62.5W	C	100	30	30	S	50	100	0.5A	0.5	2.0A			12K	E
2N2142A	G	P		2N2137	AP	62.5W	C	100	30	20	O	50	100	0.5A	0.5	2.0A			12K	E
2N2143	G	P		2N2137	AP	62.5W	C	100	45	45	S	50	100	0.5A	0.5	2.0A			12K	E
2N2143A	G	P		2N2137	AP	62.5W	C	100	45	30	O	50	100	0.5A	0.5	2.0A			12K	E
2N2144	G	P		2N2137	AP	62.5W	C	100	60	60	S	50	100	0.5A	0.5	2.0A			12K	E
2N2144A	G	P		2N2137	AP	62.5W	C	100	60	45	O	50	100	0.5A	0.5	2.0A			12K	E
2N2145	G	P		2N2137	AP	62.5W	C	100	75	75	S	50	100	0.5A	0.5	2.0A			12K	E
2N2145A	G	P		2N2137	AP	62.5W	C	100	75	60	O	50	100	0.5A	0.5	2.0A			12K	E
2N2146	G	P		2N2137	AP	62.5W	C	100	90	90	S	50	100	0.5A	0.5	2.0A			12K	E
2N2146A	G	P		2N2137	AP	62.5W	C	100	90	65	O	50	100	0.5A	0.5	2.0A			12K	E
2N2147	G	P	2N2832	2N2832	AP	12.5W	C	100	75	50	O	100	300	1.0A	1.0	4.0A	75	E	3.0M	T
2N2148	G	P	2N2832	2N2800	AP	12.5W	C	100	60	40	O	40	160	1.0A	1.0	4.0A	30	E	2.0M	T
2N2150	S	N			AHP	30W	C	175	125	80	O	20	60	1.0A	1.0	1.0A	20	E	10M	T
2N2151	S	N			AHP	30W	C	175	125	80	O	40	120	1.0A	1.0	1.0A	40	E	10M	T
2N2152	G	P		2N2137	AP	170W	C	110	45	45	S	50	100	5.0A	0.1	5.0A			2.0K	E
2N2152A	G	P			AP	170W	C	110	45	30	O	50	100	5.0A	0.1	5.0A			2.0K	E
2N2153	G	P		2N2137	AP	170W	C	110	60	60	S	50	100	5.0A	0.1	5.0A			2.0K	E
2N2153A	G	P			AP	170W	C	110	60	45	O	50	100	5.0A	0.1	5.0A			2.0K	E
2N2154	G	P		2N2137	AP	170W	C	110	75	75	S	50	100	5.0A	0.1	5.0A			2.0K	E
2N2154A	G	P			AP	170W	C	110	75	60	O	50	100	5.0A	0.1	5.0A			2.0K	E
2N2155	G	P			AP	170W	C	110	90	90	S	50	100	5.0A	0.1	5.0A			2.0K	E
2N2155A	G	P			AP	170W	C	110	90	65	O	50	100	5.0A	0.1	5.0A			2.0K	E

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2156	G	P		2N2137	AP	170W	C	110	45	45	S	80	160	5.0A	0.1	5.0A			2.0K	E
2N2156A	G	P			AP	170W	C	110	45	30	O	80	160	5.0A	0.1	5.0A			2.0K	E
2N2157	G	P		2N2137	AP	170W	C	110	60	60	S	80	160	5.0A	0.1	5.0A			2.0K	E
2N2157A	G	P			AP	170W	C	110	60	45	O	80	160	5.0A	0.1	5.0A			2.0K	E
2N2158	G	P		2N2137	AP	170W	C	110	75	75	S	80	160	5.0A	0.1	5.0A			2.0K	E
2N2158A	G	P			AP	170W	C	110	75	60	O	80	160	5.0A	0.1	5.0A			2.0K	E
2N2159	G	P			AP	170W	C	110	90	90	S	80	160	5.0A	0.1	5.0A			2.0K	E
2N2159A	G	P			AP	170W	C	110	90	65	O	80	160	5.0A	0.1	5.0A			2.0K	E
2N2160	Unijunction Transistors, see Table on Page 2-66																			
2N2161	S	N			SH	200M	A	150	55	35	O	60	160	10M	1.5	10M	75	E		
2N2162	S	P			SC	150M	A	140	30	30	O								14M	T
2N2163	S	P			SC	150M	A	140	15	15	O								14M	T
2N2164	S	P			SC	150M	A	140	12	8.0	O								24M	T
2N2165	S	P			SC	150M	A	140	30	30	O								10M	T
2N2166	S	P			SC	150M	A	140	15	15	O								10M	T
2N2167	S	P			SC	150M	A	140	12	8.0	O								16M	T
2N2168	G	P			SH	60M	A	100	20	15	O	50		10M	0.125	10M				
2N2169	G	P			SH	60M	A	100	15	15	O	40		10M	0.15	10M				
2N2170	G	P			SH	60M	A	100	15	10	O	20		10M	0.18	10M				
2N2171	G	P		2N381	A	0.2W	A	100	50	25	R	110	250	20M			120	E		
2N2172	G	P			S	200M	A	85	20	15	O	30	150	10M	0.2	10M	0.97	B	5.0M	B
2N2173	G	P			SH	240M	A	100	25	15	O	30		200M	0.4	200M				
2N2175	S	P			A	0.1W	A	175	6.0	6.0	O	30		20*					10M	T
2N2176	S	P			A	0.1W	A	175	6.0	6.0	O	30		20*					10M	T
2N2177	S	P			A	0.1W	A	160	6.0	6.0	O	15		5.0*			50	E	8.0M	B
2N2178	S	P			A	0.1W	A	160	6.0	6.0	O	15		5.0*			50	E	8.0M	B
2N2180	G	P			SH	50M	A	100	15	6.0	O	100		10M	0.08	10M	120	E	60M	T
2N2181	S	P			SC	150M	A	140	25	25	O	10		5.0M					6.0M	T
2N2182	S	P			SC	150M	A	140	25	25	O	10		5.0M					6.0M	T
2N2183	S	P			SC	150M	A	140	15	10	O	10		5.0M					6.0M	T
2N2184	S	P			SC	150M	A	140	15	10	O	10		5.0M					6.0M	T
2N2185	S	P			SC	150M	A	140	30	30	O								6.5M	T
2N2186	S	P			SC	150M	A	140	30	30	O								6.5M	T
2N2187	S	P			SC	150M	A	140	30	30	O								6.5M	T
2N2188	G	P		2N3323	AH	125M	A	85	40	25	O	40	160	1.5M			40	E	60M	T
2N2189	G	P		2N3323	AH	125M	A	85	40	25	O	60	180	1.5M			40	E	102M	T
2N2190	G	P	2N3323	2N3323	AH	125M	A	85	60	25	O	40	160	1.5M			40	E	60M	T
2N2191	G	P	2N3323	2N3323	AH	125M	A	85	60	25	O	60	180	1.5M			60	E	102M	T
2N2192	S	N		2N2192	SH	800M	A	200	60	40	O	100	300	150M	0.35	150M				
2N2192A	S	N		2N2192	SH	800M	A	200	60	40	O	100	300	150M	0.25	150M				
2N2192B	S	N		2N2192	SH	800M	A	200	60	40	O	100	300	150M	0.18	150M				
2N2193	S	N		2N2192	SH	800M	A	200	80	50	O	40	120	150M	0.35	150M				
2N2193A	S	N		2N2192	SH	800M	A	200	80	50	O	40	120	150M	0.25	150M				
2N2193B	S	N		2N2192	SH	800M	A	200	80	50	O	40	120	150M	0.18	150M				
2N2194	S	N		2N2192	SH	800M	A	200	60	40	O	20	60	150M	0.35	150M				
2N2194A	S	N		2N2192	SH	800M	A	200	60	40	O	20	60	150M	0.25	150M				
2N2194B	S	N		2N2192	SH	800M	A	200	60	40	O	20	60	150M	0.18	150M				
2N2195	S	N		2N2192	SH	800M	A	200	45	25	O	20		150M	0.35	150M				
2N2195A	S	N		2N2192	SH	800M	A	200	45	25	O	20		150M	0.25	150M				
2N2195B	S	N		2N2192	SH	800M	A	200	45	25	O	20		150M	0.18	150M				
2N2196	S	N	2N3766	2N3766	AP	2.0W	A	175	80	60	R	30	90	0.2A	2.0	0.2A	30	E		
2N2197	S	N	2N3766	2N3766	AP	2.0W	A	175	80	60	R	75	200	0.2A	2.0	0.2A	30	E		
2N2198	S	N			AH	5.5M	A	200	80	80	O	35	55	0.1A	6.0	0.2A			4.0M	T
2N2199	G	P			AH	75M	A	100	15	10	O	9.0		3.0M			20	E	120M	T
2N2200	G	P			AH	75M	A	100	15	10	O	9.0		3.0M					120M	T
2N2201	S	N	2N4239	2N4237	A	1.0W	C	175	120	100	O	25	90	200M	1.7	200M	30	E		
2N2202	S	N	2N4239	2N4237	A	1.0W	C	175	120	100	O	25	90	200M	1.7	200M	30	E		
2N2203	S	N	2N4239	2N4237	A	1.0W	C	175	120	100	O	25	90	200M	1.7	200M	30	E		
2N2204	S	N	2N4239	2N4237	A	1.0W	C	175	120	100	O	25	90	200M	1.7	200M	30	E		
2N2205	S	N	2N835	2N834	SH	1.0W	C	175	25	12	O	20		10M	0.22	10M	2.0	E		
2N2206	S	N	2N835	2N834	SH	1.0W	C	175	25	12	O	40	120	10M	0.22	10M	2.0	E		
2N2207	G	P			AH	0.26W	A	75	70	50	R	36	370	10M					140M	B
2N2208	G	P			AH	120M	A	85	40	10	O	15		1.5M			30	E		
2N2209	G	P			S	150M	A	85	30	12	O	50		24M	0.15	12M			6.0M	B
2N2210	G	P	2N2075	2N2075	AP	75W	C	100	100	65		25	50	5.0A	0.6	12A			5.0K	E
2N2211	G	P			AP	90W	C	100	80	60	S	60	140	1.0A	0.8	2.0A			5.0K	E
2N2212	G	P		2N2212	AHP	100W	C	110	120	120	R	50	120	5.0A	1.0	5.0A	30	E	0.45M	T
2N2214	S	N			SH	0.25W	C	150	25	15	O	25		10M	0.2	10M			200M	T
2N2216	S	P	2N3498	2N3498	SH	3.0W	C	200	150	100	O	25	120	50M	5.0	50M			50M	T
2N2217	S	N	2N2218	2N2218	SH	0.8W	A	175	60	30	O	20	60	150M	0.4	150M			250M	T
2N2218	S	N		2N2218	SH	0.8W	A	175	60	30	O	40	120	150M	0.4	150M			250M	T
2N2218A	S	N		2N2218A	SH	0.8W	A	175	75	40	O	40	120	0.15A	0.3	0.15A	30	E	250M	T
2N2219	S	N		2N2218	SH	0.8W	A	175	60	30	O	100	300	150M	0.4	150M			250M	T
2N2219A	S	N		2N2218A	SH	0.8W	A	175	75	40	O	100	200	0.15A	0.3	0.15A	50	E	300M	T
2N2220	S	N	2N2222	2N2218	SH	0.5W	A	175	60	30	O	20	60	150M	9.4	150M			250M	T
2N2221	S	N		2N2218	SH	0.5W	A	175	60	30	O	40	120	150M	0.4	150M			250M	T
2N2221A	S	N		2N2218A	SH	0.5W	A	175	75	40	O	40	120	0.15A	0.3	0.15A	30	E	250M	T
2N2222	S	N		2N2218	SH	0.5W	A	175	60	30	O	100	300	150M	0.4	150M			250M	T
2N2222A	S	N		2N2218A	SH	0.5W	A	175	75	40	O	100	300	0.15A	0.3	0.15A	50	E	300M	T
2N2222B	S	N			SH	1.8W	C		75	40	O	100	300	150M	0.3	150M	50	E	300M	T
2N2223	S	N		2N2060	AM	500M	A	200	100	80	R	50	200	10M	1.2	50M	40	E	50M	T
2N2223A	S	N		2N2060	AM	500M	A	200	100	80	R	50	200	10M	1.2	50M	40	E	50M	T
2N2224	S	N		2N2224	SH	0.8W	A	175	65	40	O	35	115	10M	0.4	150M			250M	T
2N2225	G	P			S	200M	A	100	15	4.0	O	100	300	100M	0.2	50M			25M	B
2N2226	S	N			AP	150W	C	150	50	50	V	100	500	9.0A	3.5	9.0A	50	E	7.0K	E
2N2227	S	N			AP	150W	C	150	100	100	V	100	500	9.0A	3.5	9.0A	50	E	7.0K	E
2N2228	S	N			AP	150W	C	150	150	150	V	100	500	9.0A	3.5	9.0A	50	E	7.0K	E
2N2229	S	N			AP	150W	C	150	200	200	V	100	500	9.0A	3.5	9.0A	50	E	7.0K	E

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2230	S	N			AP	150W	C	150	50	50	V	350		9.0A	3.5	9.0A	100	E	4.0K	E
2N2231	S	N			AP	150W	C	150	100	100	V	350		9.0A	3.5	9.0A	100	E	4.0K	E
2N2232	S	N			AP	150W	C	150	150	150	V	350		9.0A	3.5	9.0A	100	E	4.0K	E
2N2233	S	N			AP	150W	C	150	200	200	V	350		9.0A	3.5	9.0A	100	E	4.0K	E
2N2234	S	N			SHP	12.5W	C	150	40	20	O	15	60	100M	0.25	100M			50M	T
2N2235	S	N			SHP	12.5W	C	150	40	20	O	40	125	100M	0.25	100M			100M	T
2N2236	S	N			SH	575M	A	150	40	20	O	15	60	100M	0.25	100M			50M	T
2N2237	S	N			SH	575M	A	150	40	20	O	40	125	100M	0.25	100M				
2N2238	G	P			AH	0.3W	A	100	30	30	S	10		10M			25	E	400M	T
2N2239	S	N	2N3766	2N3766	A	1.0W	A	150	60	50	R	30	200	200M	3.0	200M				
2N2240	S	N			SH	0.6W	A	200	25	20	O	40	100	1.0M	1.0	50M			50M	T
2N2241	S	N			SH	0.6W	A	200	25	20	O	100	200	1.0M	1.0	50M			50M	T
2N2242	S	N		2N2242	SH	360M	A	200	40	15	O	40	120	10M	0.7	100M			250M	T
2N2243	S	N	2N2219	2N2218	SH	0.8W	A	200	120	80	O	40	120	0.15A	0.35	0.15A			50M	T
2N2243A	S	N			SH	0.8W	A	200	120	80	O	40	120	0.15A	0.25	0.15A			50M	T
2N2244	S	N	2N835	2N834	A	0.5W	A	200	20	20	O	5.0	15	2.0*	0.2	1.0M	40	E	60M	T
2N2245	S	N	2N835	2N834	A	0.5W	A	200	20	20	O	10	30	2.0*	0.2	1.0M	80	E	60M	T
2N2246	S	N	2N835	2N834	A	0.5W	A	200	20	20	O	5.0	15	2.0*	0.2	1.0M	40	E	60M	T
2N2247	S	N	2N834	2N834	A	0.5W	A	200	45	45	O	5.0	15	2.0*	0.2	1.0M	40	E	60M	T
2N2248	S	N	2N834	2N834	A	0.5W	A	200	45	45	O	10	30	2.0*	0.2	1.0M	80	E	60M	T
2N2249	S	N	2N834	2N834	A	0.5W	A	200	45	45	O	20	60	2.0*	0.2	1.0M	150	E	60M	T
2N2250	S	N	2N835	2N834	A	0.5W	A	200	25	20	O	5.0	15	2.0*	0.2	1.0M	40	E	60M	T
2N2251	S	N	2N835	2N834	A	0.5W	A	200	25	20	O	10	30	2.0*	0.2	1.0M	80	E	60M	T
2N2252	S	N	2N834	2N834	A	0.5W	A	200	25	20	O	20	60	2.0*	0.2	1.0M	150	E	60M	T
2N2253	S	N	2N834	2N834	A	0.5W	A	200	45	50	O	5.0	15	2.0*	0.2	1.0M	40	E	60M	T
2N2254	S	N	2N834	2N834	A	0.5W	A	200	45	50	O	10	30	2.0*	0.2	1.0M	80	E	60M	T
2N2255	S	N	2N834	2N834	A	0.5W	A	200	45	50	O	20	60	2.0*	0.2	1.0M	150	E	60M	T
2N2256	S	N		2N2256	SH	300M	A	175	7.0	7.0	S	17		10M						
2N2257	S	N		2N2256	SH	300M	A	175	7.0	7.0	S	40		10M						
2N2258	G	P		2N2256	SH	150M	A	100	7.0	7.0	S	17		10M						
2N2259	G	P		2N2256	SH	150M	A	100	7.0	7.0	S	40		10M						
2N2260 thru 2N2262	Thyristors, see Table on Page 2-66																			
2N2266	G	P	2N2145	2N2137	SP	50W	J	125	100	55		40	120	500M	0.75	5.0A			200K	T
2N2267	G	P	2N2145	2N2137	SP	50W	J	125	120	55		40	120	500M	0.75	5.0A			200K	T
2N2268	G	P	2N2145	2N2137	SP	50W	J	125	100	55		40	120	500M	0.75	5.0A			200K	T
2N2269	G	P	2N2145	2N2137	SP	50W	J	125	120	55		40	120	500M	0.75	5.0A			200K	T
2N2270	S	N	2N2219	2N2218	A	5.0W	C	200	60	45	O	30		1.0M	0.9	150M	50	E		
2N2271		P			A	0.25W	A	100	20	15	R	50	100	35M					10K	E
2N2272	S	N			SH	360M	A	200	40	20	R	80	240	10M	0.7	200M	3.0	E		
2N2273	G	P		2N2273	AH	100M	A	100	25	15	O	20	150	1.0M						
2N2274	S	P			SC	150M	A	140	25	25	O	10		5.0M					6.0M	T
2N2275	S	P			SC	150M	A	140	25	25	O	10		5.0M					6.0M	T
2N2276	S	P			SC	150M	A	140	15	10	O	10		5.0M					6.0M	T
2N2277	S	P			SC	150M	A	140	15	10	O	10		5.0M					6.0M	T
2N2278	S	P			SC	150M	A	140	15	15	O								7.6M	T
2N2279	S	P			SC	150M	A	140	15	15	O								7.6M	T
2N2280	S	P			SC	150M	A	140	10	6.0	O				0.1	5.0M			16M	T
2N2281	S	P			SC	150M	A	140	10	6.0	O				0.1	5.0M			16M	T
2N2282	G	P			AHP	5.0W	C	110	60	30	O	15		3.0A	0.4	1.0A	40	E	20M	T
2N2283	G	P			AHP	5.0W	C	110	100	60	O	15		3.0A	0.4	1.0A	40	E	20M	T
2N2284	G	P			AHP	5.0W	C	110	200	100	O	15		3.0A	0.4	1.0A	40	E	20M	T
2N2285	G	P		2N1651	AP	100W	C	110	60	30	O	35	140	10A	0.65	25A			0.6M	T
2N2286	G	P		2N1651	AP	100W	C	110	100	60	O	35	140	10A	0.65	25A			0.6M	T
2N2287	G	P		2N1651	AP	100W	C	110	120	80	O	35	140	10A	0.65	25A			0.6M	T
2N2288	G	P		2N2288	AP	60W	C	110	40	40	R	20	60	5.0A	1.0	5.0A	25	E	0.45M	T
2N2289	G	P		2N2288	AP	60W	C	110	80	80	R	20	60	5.0A	1.0	5.0A	25	E	0.45M	T
2N2290	G	P		2N2288	AP	60W	C	110	120	120	R	20	60	5.0A	1.0	5.0A	25	E	0.45M	T
2N2291	G	P		2N2291	AP	60W	C	110	40	30	O	50	120	5.0A	1.0	5.0A	50	E	0.45M	T
2N2292	G	P		2N2291	AP	60W	C	110	80	70	O	50	120	5.0A	1.0	5.0A	50	E	0.45M	T
2N2293	G	P		2N2291	AP	60W	C	110	120	70	O	50	120	5.0A	1.0	5.0A	50	E	0.45M	T
2N2294	G	P			SP	70W	C	110	40	30	O	50	120	5.0A	1.0	5.0A	50	E	0.45M	T
2N2295	G	P			SP	70W	C	110	80	50	O	50	120	5.0A	1.0	5.0A	50	E	0.45M	T
2N2296	G	P			SP	70W	C	110	120	70	O	50	120	5.0A	1.0	5.0A	50	E	0.45M	T
2N2297	S	N	2N3252	2N3252	AH	800M	A	200	80	35	O	40	120	150M	0.2	150M			60M	T
2N2303	S	P	2N2801	2N2800	AH	600M	A	175	50	50	R	75	200	150M	1.5	150M	75	E	60M	T
2N2304	S	N	2N4910	2N4910	AP	25W	C	200	60	60	V	20	80	300M	0.9	300M				
2N2305	S	N	2N4913	2N4913	AP	75W	C	200	60	60	V	15	60	800M	1.2	600M				
2N2306	S	N			SHP	13W	C	175	75	50	O	12	75	0.35A	2.0	1.0A			175M	T
2N2307	Unijunction Transistors, see Table on Page 2-86																			
2N2308	S	N	2N4912	2N4910	AP	25W	C	200	100	80	O	20	60	1.0A	1.0	1.0A	15	E	30K	E
2N2309	S	N			A	600M	A	200	30	30	O	25	125	0.2M			40	E		
2N2310	S	N			A	350M	A	200	60	60	O	12	36	200M	5.0	200M				
2N2311	S	N			A	350M	A	200	100	100	O	12	36	200M	5.0	200M				
2N2312	S	N			A	350M	A	200	60	60	O	30	90	200M	5.0	200M				
2N2313	S	N			A	350M	A	200	100	100	O	30	90	200M	5.0	200M				
2N2314	S	N			A	350M	A	200	60	40	R	20	60	150M	5.0	150M	15	E	40M	T
2N2315	S	N			A	350M	A	200	60	40	R	40	120	150M	1.5	150M	25	E	50M	T
2N2316	S	N			A	350M	A	200	120	80	R	40	120	150M	5.0	150M	30	E	50M	T
2N2317	S	N			A	350M	A	200	75	50	R	40	120	150M	1.5	150M	30	E	60M	T
2N2318	S	N	2N834	2N834	SH	360M	A	200	30	25	S	15		0.1M	0.35	20M			300M	T
2N2319	S	N	2N834	2N834	SH	300M	A	200	30	25	S	15		0.1M	0.35	20M			300M	T
2N2320	S	N	2N834	2N834	SH	600M	A	200	30	25	S	15		0.1M	0.35	20M			300M	T
2N2322 thru 2N2329	Thyristors, see Table on Page 2-66																			
2N2330	S	N		2N2330	SC	0.8W	A	150	30	20	O	50		10M					100M	T

2N2331-2N2424

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2331	S	N		2N2330	SC	0.5W	A	150	30	20	O	50		10M					100M	T
2N2332	S	P			SC	0.15W	A	200	15	15	O									
2N2333	S	P			SC	0.15W	A	200	15	5.0	O									
2N2334	S	P			SC	0.15W	A	200	30	15	O									
2N2335	S	P			SC	0.15W	A	200	30	15	O									
2N2336	S	P			SC	0.15W	A	200	50	35	O									
2N2337	S	P			SC	0.15W	A	200	50	35	O									
2N2338	S	N	2N3713	2N3713	AP	150W	C	200	60	40	O	7.0		6.0A	1.5	3.0A	12	E	15K	E
2N2339	S	N	2N4910	2N4910	AP	40W	C	200	60	40	O	6.0		1.5A	1.5	0.3A	12	E	0.7M	T
2N2340	S	N			AHP	15W	C	175	50	40	O	10	40	750M	4.0	750M			550K	E
2N2341	S	N			AHP	15W	C	175	50	40	O	40	100	750M	4.0	750M			350K	E
2N2342	S	N			AHP	15W	C	175	100	40	O	10	40	750M	3.0	750M			550K	E
2N2343	S	N			AHP	15W	C	175	100	40	O	40	100	750M	2.5	750M			350K	E
2N2344 thru 2N2348	Thyristors, see Table on Page 2-66																			
2N2349	S	N			A	150M	A	200	40	24	O	120	250	10M	1.5	10M	60	E		
2N2350	S	N			SH	400M	A	200	60	40	O	100	300	150M	0.35	150M	2.5	E		
2N2350A	S	N			SH	400M	A	200	60	40	O	100	300	150M	0.25	150M	2.5	E		
2N2351	S	N			SH	400M	A	200	80	50	O	40	120	150M	0.35	150M	2.5	E		
2N2351A	S	N			SH	400M	A	200	80	50	O	40	120	150M	0.25	150M	2.5	E		
2N2352	S	N			SH	400M	A	200	60	40	O	20	60	150M	0.35	150M	2.5	E		
2N2352A	S	N			SH	400M	A	200	60	40	O	20	60	150M	0.25	150M	2.5	E		
2N2353	S	N			SH	400M	A	200	45	25	O	20		150M	0.35	150M	2.5	E		
2N2353A	S	N			SH	400M	A	200	45	25	O	20		150M	0.25	150M	2.5	E		
2N2354		N			A	0.18W	A	85	20	15	R	50	150	35M						
2N2356	S	N			SC	0.6W	A	200	25	7.0	O								50M	T
2N2356A	S	N			SC	0.6W	A	200	25	7.0	O								50M	T
2N2357	G	P		2N2357	SP	170W	C	110	60	30	O	30	90	20A	0.9	50A	20	E	0.6M	T
2N2358	G	P		2N2357	SP	170W	C	110	100	60	O	30	90	20A	0.9	50A	20	E	0.6M	T
2N2359	G	P		2N2357	SP	170W	C	110	120	80	O	30	90	20A	0.9	50A	20	E	0.6M	T
2N2360	G	P	2N3283	2N3283	AH	60M	A	125	20	20	O	10		2.0M						
2N2361	G	P	2N3284	2N3283	AH	60M	A	125	20	20	O	10		2.0M						
2N2362	G	P	2N3284	2N3283	AH	60M	A	100	20	20	S	10		2.0M						
2N2363	G	P			AH	75M	A	100	30	20	O	10	200	2.0M			10	E	250M	T
2N2364	S	N			SH	400M	A	200	120	80	O	40	120	150M	0.35	150M			50M	T
2N2364A	S	N			SH	400M	A	200	120	80	O	40	120	150M	0.25	150M			50M	T
2N2368	S	N	2N3227	2N2369	SH	360M	A	200	40	40	S	20	60	10M	0.25	10M			400M	T
2N2369	S	N	2N3227	2N2369	SH	360M	A	200	40	40	S	40	120	10M	0.25	10M			500M	T
2N2369A	S	N	2N3227	2N2369	SH	360M	A	200	40	40	S		120	10M	0.2	10M			500M	T
2N2370	S	P			L	0.2W	A	200	15	15	O	15		25*			15	E		
2N2371	S	P			L	0.2W	A	200	15	15	O	20		25*			20	E		
2N2372	S	P			L	0.15W	A	200	15	15	O	15		25*			15	E		
2N2373	S	P			L	0.15W	A	200	15	15	O	20		25*			20	E		
2N2374	G	P			A	250M	A	100	35	35	S	100	300	100M			100	E		
2N2375	G	P			A	250M	A	100	35	35	S	35	110	100M			35	E		
2N2376	G	P	2N1193	2N1191	A	250M	A	100	35	35	S	35	110	100M			35	E		
2N2377	S	P			AH	150M	A	140	25	25	O	10	100	5.0M			15	E	8.0M	T
2N2378	S	P			AH	150M	A	140	10	10	O	15		15M					7.2M	T
2N2379	G	P			SP	150W	C	95	100	80	S	25	37	5.0A	1.0	15A			4.0K	E
2N2380	S	N			SH	600M	A	175	80	40	O	20	120	150M	1.3	150M			100M	T
2N2380A	S	N			SH	600M	A	175	80	40	O	20	120	150M	1.3	150M	60	E	100M	T
2N2381	G	P		2N2381	SH	300M	A	100	30	15	O	40		200M	0.40	200M			300M	T
2N2382	G	P		2N2381	SH	300M	A	100	45	20	O	40		200M	0.40	200M			300M	T
2N2383	S	N	2N4914	2N4913	AP	85W	C	180	80	60	O	20	60	1.5A	1.0	1.5A	15	E	30K	E
2N2384	S	N	2N4914	2N4913	AP	85W	C	180	80	60	O	20	60	1.5A	1.0	1.5A	15	E	30K	E
2N2386,A	Field-Effect Transistors, see Table on Page 2-76																			
2N2387	S	N			A	300M	A	175	45	45	O	40	120	10*	1.0	10M	60	E	30M	T
2N2388	S	N			A	300M	A	175	45	45	O	100	300	10*	1.0	10M	150	E	30M	T
2N2389	S	N			A	450M	A	200	75	50	R	40	120	150M	1.5	150M	30	E	60M	T
2N2390	S	N			A	450M	A	200	75	50	R	100	300	150M	1.5	150M	50	E	70M	T
2N2391	S	P			A	300M	A	175	25	20	O	15	45	10M	0.6	10M	15	E	140M	T
2N2392	S	P			A	300M	A	175	25	20	O	30	90	10M	0.6	10M	30	E	140M	T
2N2393	S	P			A	450M	A	175	50	35	O	20	45	150M	1.5	150M	15	E	50M	T
2N2394	S	P			A	450M	A	175	50	35	O	30	90	150M	1.5	150M	25	E	60M	T
2N2395	S	N			A	450M	A	200	60	40	O	20	60	150M	1.0	150M			40M	T
2N2396	S	N			A	450M	A	200	60	40	O	40	120	150M	1.0	150M			50M	T
2N2397	S	N			SH	300M	A	200	35	15	O	25	120	10M	0.30	10M			200M	T
2N2398	G	P	2N3284	2N3283	AH	60M	A	100	20	20	S	10		2.0M						
2N2399	G	P	2N3284	2N3283	AH	60M	A	100	20	20	S	10		2.0M						
2N2400	G	P	2N964	2N960	SH	150M	A	100	12	7.0	O	30		10M	0.22	10M			150M	T
2N2401	G	P	2N964	2N960	SH	150M	A	100	15	10	O	50		10M	0.2	10M			200M	T
2N2402	G	P	2N2956	2N2955	SH	150M	A	100	18	12	O	60		10M	0.2	10M			250M	T
2N2403	S	N			S	1.0W	A	200	60	60	O	20	60	0.6A	1.5	0.6A			147M	T
2N2404	S	N			S	1.0W	A	200	60	60	O	40	120	0.6A	1.5	0.6A			147M	T
2N2405	S	N	2N3498	2N3498	A	5.0W	C		120	90	O	60	200	150M	0.5	150M	50	E		
2N2410	S	N		2N2405	SH	800M	A	200	60	30	O	30	120	10M					200M	T
2N2411	S	P		2N2411	SH	300M	A	200	25	20	O	20	60	10M	0.2	10M			140M	T
2N2412	S	P		2N2411	SH	300M	A	200	25	20	O	40	120	10M	0.2	10M			140M	T
2N2413	S	N			AH	300M	A	175	40	18	O	30	120	10M	0.4	10M			300M	T
2N2414	S	N			AL	500M	A	200	60	40	R	50	250	10M	1.2	50M	50	E	50M	T
2N2415	G	P		2N2415	AH	75M	A	100	15	10	O	10	200	2.0M			15	E	500M	T
2N2416	G	P		2N2415	AH	75M	A	100	15	10	O	8.0	20	2.0M			10	E	400M	T
2N2417 thru 2N2422	Unijunction Transistors, see Table on Page 2-86																			
2N2423	G	P			SP	90W	C	100	100	80	V	20	100	2.0A	1.5	5.0A			3.0K	E
2N2424	S	P			S	375M	A	160	40	5.0	O	30	200	5.0M	0.3	15M			15M	B

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2425	S	P			A	375M	A	160	50	10	O	25	110	5.0M	0.3	15M			10M	B
2N2426	G	N			A	150M	A	100	40	25	R				0.5	100M	35	E	25K	E
2N2427	S	N			AH	0.5W	A	200	40	40	O	20	60	10*			40	E	50M	T
2N2428	G	P	2N652	2N650	A	0.5W	A	75	32	32	S	50	150	2.0M			80	E	10K	E
2N2429	G	P	2N652	2N650	A	0.5W	A	75	32	32	S	65	300	2.0M			130	E	10K	E
2N2430	G	N			A	0.28W	A	75	32	32	R	60	210	0.1A					10K	E
2N2431	G	P			A	0.55W	A	90	32	32	R	60	175	0.3A					10K	E
2N2432	S	N			SC	300M	A	175	30	30	O	50		1.0M	0.15	10M			20M	T
2N2432A	S	N			SC	300M	A	175	45	45	O	50		1.0M					20M	T
2N2433	S	N			SH	500M	A	200	75	45	O	40	120	150M	1.5	150M	30	E	80M	T
2N2434	S	N			SH	500M	A	200	75	45	O	100	300	150M	1.5	150M	50	E	90M	T
2N2435	S	N			SH	500M	A	200	120	80	O	40	120	150M	3.0	150M	30	E	80M	T
2N2436	S	N			SH	500M	A	200	120	80	O	100	300	150M	3.0	150M	50	E	90M	T
2N2437	S	N			AH	500M	A	200	100	75	O	15		10M	0.2	10M	18	E	70M	T
2N2438	S	N			AH	500M	A	200	100	75	O	35		10M	0.4	50M	36	E	80M	T
2N2439	S	N			AH	500M	A	200	100	75	O	75		10M	0.4	50M	76	E	90M	T
2N2440	S	N			SH	300M	A	200	120	80	O	100	300	150M	0.4	50M	50	E	90M	T
2N2443	S	N			AH	800M	A	200	120	100	O	50	150	50M	1.2	50M	45	E	50M	T
2N2444	G	P			AP	85W	C	110	80	80	O	90	120	3.0A	1.0	5.0A	50	E	4.5M	T
2N2445	G	P			AP	90W	C	100	100	50	O	30	60	10A	1.0	10A	30	E	0.1M	T
2N2446	G	P			SP	90W	C	100	60	50	S	15	45	5.0A	1.5	7.0A			3.0K	E
2N2447	G	P	2N1187	2N1175	A	75M	A	85	45	24	O						25	E		
2N2448	G	P	2N1187	2N1175	A	75M	A	85	45	24	O						25	E		
2N2449	G	P	2N652	2N650	A	75M	A	85	35	20	O						50	E		
2N2450	G	P	2N652	2N650	A	75M	A	85	35	20	O						50	E		
2N2451	G	P			SH	25M	A	85	6.0	5.0	O	25		10M	0.1	10M	40	E	80M	T
2N2452	S	N			AL	500M	A	200	100	80	R									
2N2453	S	N		2N2453	AM	0.5W	A	200	60	30	O	150	600	1.0M	1.0	5.0M	150	E	60M	T
2N2453A	S	N		2N2453	AM	0.5W	A	200	80	50	O	150	600	1.0M	1.0	5.0M	150	E	60M	T
2N2454	Thyristors, see Table on Page 2-66																			
2N2455	G	P			SH	150M	A	100	15	15	S	20	100	2.0M	0.19	10M	30	E	600M	T
2N2456	G	P			SH	150M	A	100	15	15	S	20	100	2.0M	0.19	10M	30	E	1.0G	T
2N2459	S	N			A	0.4W	A	200	100	60	O	10		0.1M	0.3	10M	40	E	100M	T
2N2460	S	N			A	0.4W	A	200	100	60	O	20		0.1M	0.3	10M	70	E	120M	T
2N2461	S	N			A	0.4W	A	200	100	60	O	40		0.1M	0.3	10M	115	E	140M	T
2N2462	S	N			A	0.4W	A	200	100	60	O	60		0.1M	0.3	10M	160	E	160M	T
2N2463	S	N			A	0.5W	A	200	100	60	O	10		0.1M	0.3	10M	40	E	100M	T
2N2464	S	N			A	0.5W	A	200	100	60	O	20		0.1M	0.3	10M	70	E	120M	T
2N2465	S	N			A	0.5W	A	200	100	60	O	40		0.1M	0.3	10M	115	E	140M	T
2N2466	S	N			A	0.5W	A	200	100	60	O	60		0.1M	0.3	10M	160	E	160M	T
2N2467	G	P			AP	5.0W	C	110	60	30	O	30	90	0.5A	0.4	1.0A	40	E	20M	T
2N2468	G	P			AP	5.0W	C	110	100	60	O	30	90	0.5A	0.4	1.0A	40	E	20M	T
2N2469	G	P			AP	5.0W	C	110	200	100	O	30	90	0.5A	0.4	1.0A	40	E	20M	T
2N2472	S	N			AP	1.0W	A	175	120	100	O	30	90	0.2A	1.7	0.2A	30	E	10M	T
2N2473	S	N			AP	1.0W	A	175	120	100	O	30	90	0.2A	1.7	0.2A	30	E	10M	T
2N2474	S	P			AP	250M	A	160	30	15	O	8.0		100*	0.126	10M	8.0	E		
2N2475	S	N			SH	300M	A	200	15	6.0	O	20	20	50M			6.0	E		
2N2476	S	N		2N2476	SH	2.0W	C	200	60	20	O	20		150M	0.4	150M			250M	T
2N2477	S	N		2N2476	SH	2.0W	C	200	60	20	O	40		150M	0.4	150M			250M	T
2N2478	S	N	2N2218	2N2218	SH	600M	A	175	120	40	O	30		150M	0.7	150M			200M	T
2N2479	S	N	2N2218	2N2218	SH	600M	A	175	80	40	O	30	120	150M	0.85	150M	60	E	150M	T
2N2480	S	N		2N2060	AM	0.3W	A	200	75	40	O	30	350	1.0M	1.3	50M			50M	T
2N2480A	S	N		2N2060	AM	0.3W	A	200	80	40	O	50	200	1.0M	1.2	50M	50	E	50M	T
2N2481	S	N		2N2480	SH	1.2W	C	200	40	15	O	40	120	10M	0.25	10M			300M	T
2N2482	G	N			AH	150M	A		20	15	S	25	200	2.0M			15	E		
2N2483	S	N	MM2483	MM2483	A	360M	A	200	60	60	O	40	120	10*	0.35	1.0M	80	E	12M	T
2N2484	S	N	MM2484	MM2484	A	360M	A	200	60	60	O	100	500	10*	0.35	1.0M	150	E	15M	T
2N2484A	S	N			A	360M	A	200	60	60	O	100	500	10*	0.35	1.0M	150	E	60M	T
2N2485	S	N			AHP	8.8W	C	200	120	120	O	10		0.5A					100M	T
2N2486	S	N			AHP	8.8W	C	200	140	140	O	10		0.5A					100M	T
2N2487	G	P			SH	60M	A	100	15	10	O	20		10M	0.175	40M			360M	T
2N2488	G	P			SH	60M	A	100	15	10	O	20		50M	0.175	15M			360M	T
2N2489	G	P			SH	60M	A	100	20	15	O	20		10M	0.18	10M			300M	T
2N2490	G	P		2N2490	SP	170W	C	110	70	60	S	20	40	5.0A	0.7	12A			5.0K	E
2N2491	G	P		2N2490	SP	170W	C	110	60	50	S	35	70	5.0A	0.7	12A			5.0K	E
2N2492	G	P		2N2490	SP	170W	C	110	80	70	S	25	50	5.0A	0.5	12A			5.0K	E
2N2493	G	P		2N2490	SP	170W	C	110	100	85	S	25	50	5.0A	0.5	12A			5.0K	E
2N2494	G	P			AH	83M	A	75	20	20	V	25		1.0M						
2N2495	G	P			AH	125M	A	100	40	40	S	25		1.0M						
2N2496	G	P			AH	100M	A	100	40	20	V	25		1.0M						
2N2497 thru 2N2500	Field-Effect Transistors, see Table on Page 2-76																			
2N2501	S	N		2N2501	SH	0.36W	A	200	40	20	O	50	150	10M	0.2	10M			350M	T
2N2502 thru 2N2508	Thyristors, see Table on Page 2-66																			
2N2509	S	N			AH	1.2W	C	200	125	80	O	25		10*	1.0	5.0M			45M	T
2N2510	S	N			AH	1.2W	C	200	100	65	O	150	500	10M	1.0	5.0M			45M	T
2N2511	S	N	2N3444	2N3252	AH	1.2W	C	200	80	50	O	240	750	10M	1.0	5.0M			45M	T
2N2512	G	P			AH	0.15W	A	75	70	70	R	20		1.0M			40	E	140M	T
2N2514	S	N			A	0.4W	A	200	80	60	O	15	50	5.0M	0.5	10M	20	E	30M	T
2N2515	S	N			A	0.4W	A	200	80	60	O	30	100	5.0M	0.5	10M	40	E	60M	T
2N2516	S	N			A	0.4W	A	200	80	60	O	60	200	5.0M	0.5	10M	80	E	100M	T
2N2517	S	N			A	0.4W	A	200	125	80	O	15	50	5.0M	0.5	10M	20	E	30M	T
2N2518	S	N			A	0.4W	A	200	125	80	O	30	100	5.0M	0.5	10M	40	E	60M	T
2N2519	S	N			A	0.4W	A	200	125	80	O	60	200	5.0M	0.5	10M	80	E	100M	T
2N2520	S	N			A	0.4W	A	200	60	60	O	12		1.0M	0.5	10M	18	E	50M	B
2N2521	S	N			A	0.4W	A	200	60	60	O	25		1.0M	0.5	10M	36	E	50M	B

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2522	S	N			A	0.4W	A	200	60	60	O	50		1.0M	0.5	10M	76	E	50M	B
2N2523	S	N			A	0.4W	A	200	60	45	O	40	120	10*	0.5	10M	60	E	45M	T
2N2524	S	N			A	0.4W	A	200	60	45	O	100	300	10*	0.5	10M	150	E	45M	T
2N2525	S	N			AHP	25W	C	200	100	80	O	10		0.35A	0.8	1.0A			154M	T
2N2526	G	P		2N2526	SHP	85W	C	110	80	80	O	20	50	3.0A	0.8	10A			30K	T
2N2527	G	P		2N2526	SHP	85W	C	110	120	120	O	20	50	3.0A	0.8	10A			30K	T
2N2528	G	P		2N2526	SHP	85W	C	110	160	160	O	20	50	3.0A	0.8	10A			30K	T
2N2529	S	N			A	150M	A	175	45	40	O	10	20	1.0M	2.0	10M	12	E	6.0M	B
2N2530	S	N			A	150M	A	175	45	40	O	12	35	1.0M	2.0	10M	18	E	10M	B
2N2531	S	N			A	150M	A	175	45	40	O	20	80	1.0M	2.0	10M	36	E	12M	B
2N2532	S	N			A	150M	A	175	45	40	O	45	185	1.0M	2.0	10M	76	E	16M	B
2N2533	S	N			A	150M	A	175	45	40	O	20	55	10M	1.5	10M	19	E	10M	B
2N2534	S	N			A	150M	A	175	45	40	O	45	150	10M	1.5	10M	39	E	20M	B
2N2535	G	P			A	10W	C	100	60	30	O	40	120	0.4A	0.5	1.0A	15	E	8.0K	E
2N2536	G	P			A	10W	C	100	80	40	O	40	120	0.4A	0.5	1.0A	15	E	8.0K	E
2N2537	S	N		2N2537	SH	0.8W	A	200	60	30	O	50	150	150M	0.45	150M			250M	T
2N2538	S	N		2N2537	SH	0.8W	A	200	60	30	O	100	300	150M	0.45	150M			250M	T
2N2539	S	N		2N2537	SH	0.5W	A	200	60	30	O	50	150	150M	0.45	150M			250M	T
2N2540	S	N		2N2537	SH	0.5W	A	200	60	30	O	100	300	150M	0.45	150M			250M	T
2N2541	G	P			S	215M	A	100	30	14	O	60	250	50M	0.25	50M			10M	B
2N2542 thru 2N2550	Thyristors, see Table on Page 2-66																			
2N2551	S	P			A	0.4W	A	200	150	150	O	15	45	0.1A	1.2	0.1A				
2N2552	G	P			AP	20W	C	100	40	40	V	20	60	1.0A	0.25	1.0A	18	E	225K	T
2N2553	G	P			AP	20W	C	100	60	60	V	20	60	1.0A	0.25	1.0A	18	E	225K	T
2N2554	G	P			AP	20W	C	100	80	80	V	20	60	1.0A	0.25	1.0A	18	E	225K	T
2N2555	G	P			AP	20W	C	100	100	100	V	20	60	1.0A	0.25	1.0A	18	E	225K	T
2N2556	G	P			AP	20W	C	100	40	40	V	20	60	1.0A	0.25	1.0A	18	E	225K	T
2N2557	G	P			AP	20W	C	100	60	60	V	20	60	1.0A	0.25	1.0A	18	E	225K	T
2N2558	G	P			AP	20W	C	100	80	80	V	20	60	1.0A	0.25	1.0A	18	E	225K	T
2N2559	G	P			AP	20W	C	100	100	100	V	20	60	1.0A	0.25	1.0A	18	E	225K	T
2N2560	G	P			AP	20W	C	100	40	40	V	20	60	3.0A	0.75	3.0A	25	E	250K	T
2N2561	G	P			AP	20W	C	100	60	60	V	20	60	3.0A	0.75	3.0A	25	E	250K	T
2N2562	G	P			AP	20W	C	100	80	80	V	20	60	3.0A	0.75	3.0A	25	E	250K	T
2N2563	G	P			AP	20W	C	100	100	100	V	20	60	3.0A	0.75	3.0A	25	E	250K	T
2N2564	G	P			AP	20W	C	100	40	40	V	20	60	3.0A	0.75	3.0A	25	E	250K	T
2N2565	G	P			AP	20W	C	100	60	60	V	20	60	3.0A	0.75	3.0A	25	E	250K	T
2N2566	G	P			AP	20W	C	100	80	80	V	20	60	3.0A	0.75	3.0A	25	E	250K	T
2N2567	G	P			AP	20W	C	100	100	100	V	20	60	3.0A	0.75	3.0A	25	E	250K	T
2N2568	G	N			AHP	1.0W	C	100	32	32	S	10	60	40M	0.75	100M			600M	T
2N2569	S	N			SC	300M	A	200	20	5.0	O	50		100*					100M	T
2N2570	S	N			SC	300M	A	200	20	5.0	O	50		100*					100M	T
2N2571	S	N			SC	300M	A	200	20	15	O	50		100M					100M	T
2N2572	S	N			SC	300M	A	200	20	15	O	50		100M						
2N2573 thru 2N2579	Thyristors, see Table on Page 2-66																			
2N2580	S	N			SP	150W	C	150	400	400	O	10	40	5.0A	0.7	5.0A			30K	E
2N2581	S	N			SP	150W	C	150	400	400	O	25	65	5.0A	1.0	10A			30K	E
2N2582	S	N			SP	150W	C	150	500	500	O	10	40	5.0A	0.7	5.0A			30K	E
2N2583	S	N			SP	150W	C	150	500	500	O	25	65	5.0A	1.0	10A			30K	E
2N2584	S	N			SP	150W	C	150	600	600	O	10	40	5.0A	0.7	5.0A			30K	E
2N2585	S	N			SP	150W	C	150	600	600	O	25	65	5.0A	1.0	10A			30K	E
2N2586	S	N			A	300M	A	175	60	45	O	120	360	10*	0.5	10M	150	E	1.5K	T
2N2587	G	P			AH	150M	A	100	30	30	S	15	100	8.0M	0.5	50M	0.95	B	320M	T
2N2588	G	P			AH	150M	A	100	40	20	O	50	150	1.5M			50	E	75M	T
2N2589	S	N			SP	150W	C	200	150	150	O	17	51	7.0A	1.05	7.0A	5.0	E	0.25M	T
2N2590	S	P			AH	0.4W	A	200	100	60	O	10		0.1M	0.4	10M	40	E	50M	T
2N2591	S	P			AH	0.4W	A	200	100	60	O	20		0.1M	0.4	10M	70	E	70M	T
2N2592	S	P			AH	0.4W	A	200	100	60	O	40		0.1M	0.4	10M	115	E	90M	T
2N2593	S	P			AH	0.4W	A	200	100	60	O	60		0.1M	0.4	10M	160	E	110M	T
2N2594	S	N			A	5.0W	C	200	80	90	R	50	150	100M	1.0	200M	15	E	40M	T
2N2595	S	P			AH	0.4W	A	200	80	60	O	15	60	5.0M	0.5	10M	20	E	30M	T
2N2596	S	P			AH	0.4W	A	200	80	60	O	30	120	5.0M	0.5	10M	40	E	40M	T
2N2597	S	P			AH	0.4W	A	200	80	60	O	60	240	5.0M	0.5	10M	80	E	60M	T
2N2598	S	P			AH	0.4W	A	200	125	80	O	15	60	5.0M	0.5	10M	20	E	30M	T
2N2599	S	P			AH	0.4W	A	200	125	80	O	30	120	5.0M	0.5	10M	40	E	40M	T
2N2599A	S	P			AH	0.4W	A	200	125	100	O	30	120	5.0M	0.5	10M	40	E	40M	T
2N2600	S	P			AH	0.4W	A	200	125	80	O	60	240	5.0M	0.5	10M	80	E	60M	T
2N2600A	S	P			AH	0.4W	A	200	125	100	O	60	240	5.0M	0.5	10M	80	E	60M	T
2N2601	S	P			AH	0.4W	A	200	60	60	O	12		1.0M	0.5	10M	18	E	20M	T
2N2602	S	P			AH	0.4W	A	200	60	60	O	25		1.0M	0.5	10M	36	E	40M	T
2N2603	S	P			AH	0.4W	A	200	60	60	O	50		1.0M	0.5	10M	76	E	60M	T
2N2604	S	P		2N2604	AH	0.4W	A	200	60	45	O	40		10*	0.5	10M	60	E	30M	T
2N2605	S	P	2N3798	2N2798	AH	0.4W	A	200	60	45	O	100		10*	0.5	10M	150	E	30M	T
2N2605A	S	P			AH	0.4W	A	200	60	45	O	50	200	1.0*	0.25	10M	200	E	45M	T
2N2606 thru 2N2609	Field-Effect Transistors, see Table on Page 2-76																			
2N2610	S	N			A	0.15W	A	150	45	40	O				1.0	5.0M	4.5	E		
2N2611	S	N	2N3766	2N3766	AP	2.0W	A	175	120	100	O	7.0	36	0.2A	1.7	0.2A	12	E	4.0M	T
2N2612	G	P	2N1559	2N1539	AP	75W	C	100	65	65	V	85	250	10A	1.0	10A				
2N2613	G	P	2N1193	2N1191	A	120M	A	100	30	25	R						120	E	4.0M	B
2N2614	G	P	2N1193	2N1191	A	120M	A	100	40	35	R						100	E	4.0M	B
2N2615	S	N			AL	300M	A	200	30	15	O	20	200	3.0M	0.5	3.0M			500M	T
2N2616	S	N	2N1559	2N1539	AL	300M	A	200	30	15	O	20	200	3.0M	0.4	10M			600M	T
2N2617	S	P			A	0.25W	A	150	25			15	80	20M			25	E		

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2618	S	N			AH	0.6W	A	200	60	40	O	25		10M			30	E	200M	T
2N2619	Thyristors, see Table on Page 2-66																			
2N2620	Field-Effect Transistors, see Table on Page 2-76																			
2N2621	G	P			AH	150M	J	100	15	15	S	15		1.0M						
2N2622	G	P			AH	150M	J	100	24	24	S	15		1.0M						
2N2623	G	P			AH	150M	J	100	32	32	S	20		1.0M						
2N2624	G	P			AH	150M	J	100	15	15	S	20		1.0M						
2N2625	G	P			AH	150M	J	100	24	24	S	15		1.0M						
2N2626	G	P			AH	150M	J	100	32	32	S	20		1.0M						
2N2627	G	P			AH	150M	J	100	15	15	S	15		1.0M						
2N2628	G	P			AH	150M	J	100	24	24	S	15		1.0M						
2N2629	G	P			AH	150M	J	100	32	32	S	10		1.0M						
2N2630	G	P			SH	300M	A	100	18	10	O	25		100M	0.45	100M	3.0	E		
2N2631	S	N			A	8.75W	C	200	80	80	V	8.0		200M						
2N2632	S	N	2N3487	2N3485	AP	40W	C	175	90	60	O	40	120	1.0A	0.25	1.0A	40	E	20M	T
2N2633	S	N	2N3488	2N3485	AP	40W	C	175	120	80	O	40	120	1.0A	0.25	1.0A	40	E	20M	T
2N2634	S	N	2N3489	2N3485	AP	40W	C	175	150	100	O	40	120	1.0A	0.25	1.0A	40	E	20M	T
2N2635	G	P		2N2635	SH	150M	A	100	30	12	O	45	300	50M	0.2	10M			150M	T
2N2636	G	P			SP	100W	C	110	100	60	O	20	80	25A	0.65	25A			0.6M	T
2N2637	G	P			SP	100W	C	110	100	60	O	20	80	25A	0.65	25A			0.6M	T
2N2638	G	P			SP	100W	C	110	100	60	O	20	80	25A	0.65	25A			0.6M	T
2N2639	S	N		2N2639	AM	300M	A	200	45	45	O	50	300	10*	1.0	10M	65	E	35M	T
2N2640	S	N		2N2639	AM	300M	A	200	45	45	O	50	300	10*	1.0	10M	65	E	35M	T
2N2641	S	N		2N2639	AM	300M	A	200	45	45	O	50	300	10*	1.0	10M	65	E	35M	T
2N2642	S	N		2N2639	AM	300M	A	200	45	45	O	100	300	10*	1.0	10M	130	E	35M	T
2N2643	S	N		2N2639	AM	300M	A	200	45	45	O	100	300	10*	1.0	10M	130	E	35M	T
2N2644	S	N		2N2639	AM	300M	A	200	45	45	O	100	300	10*	1.0	10M	130	E	35M	T
2N2645	S	N			AM	500M	A	200	75	50	R	100	300	150M	0.4	10M	75	E	50M	T
2N2646	Unijunction Transistors, see Table on Page 2-86																			
2N2647																				
2N2648	G	P			S	5.0W	C	100	35	10	O	80	500	1.0A	0.4	1.0A			10M	T
2N2649	S	N			AHP	8.7W	C	200	65	65	O	10		0.5A					100M	T
2N2650	S	N			AHP	8.7W	C	200	140	140	O	10		0.5A					100M	T
2N2651	S	N	2N2501	2N2501	SH	360M	A	200	40	20	O	25		10M	0.25	10M			350M	T
2N2652	S	N		2N2652	AM	0.3W	A	200	100	60	O	50	200	1.0M	1.2	50M	50	E	60M	T
2N2652A	S	N		2N2652	AM	0.3W	A	200	100	60	O	50	200	1.0M	1.2	50M	50	E	60M	T
2N2653	Thyristors, see Table on Page 2-66																			
2N2654	G	P			AH	0.1W	A	75	25			25		1.0M						
2N2655	S	N			AP	15W	C	200	100	100	O	30	90	0.2A	2.0	0.2A	30	E	0.25M	E
2N2656	S	N			AH	0.36W	A	200	25	15	O	40	160	0.1M	0.5	10M			250M	T
2N2657	S	N	2N4238	2N4237	SP	1.25W	A	200	80	60	O	40	120	1.0A	0.5	1.0A			20M	T
2N2658	S	N	2N4239	2N4237	SP	1.25W	A	200	100	80	O	40	120	1.0A	0.5	1.0A			20M	T
2N2659	G	P			AP	15W	C	100	50	50	V	30	90	500M	0.2	500M	30	E	280K	T
2N2660	G	P			AP	15W	C	100	70	70	V	30	90	500M	0.2	500M	30	E	280K	T
2N2661	G	P			AP	15W	C	100	90	90	V	30	90	500M	0.2	500M	30	E	280K	T
2N2662	G	P			AP	15W	C	100	50	50	V	30	90	500M	0.2	500M	30	E	280K	T
2N2663	G	P			AP	15W	C	100	70	70	V	30	90	500M	0.2	500M	30	E	280K	T
2N2664	G	P			AP	15W	C	100	90	90	V	30	90	500M	0.2	500M	30	E	280K	T
2N2665	G	P			AP	15W	C	100	50	50	V	50	150	500M	0.2	500M	50	E	300K	T
2N2666	G	P			AP	15W	C	100	70	70	V	50	150	500M	0.2	500M	50	E	300K	T
2N2667	G	P			AP	15W	C	100	90	90	V	50	150	500M	0.2	500M	50	E	300K	T
2N2668	G	P			AP	15W	C	100	50	50	V	50	150	500M	0.2	500M	50	E	300K	T
2N2669	G	P			AP	15W	C	100	70	70	V	50	150	500M	0.2	500M	50	E	300K	T
2N2670	G	P			AP	15W	C	100	70	70	V	50	150	500M	0.2	500M	50	E	300K	T
2N2671	G	P			AH	0.1W	A	75	25			40		1.0M						
2N2672	G	P			AH	0.1W	A	90	25			40		1.0M						
2N2672A		P			AH	0.1W	A	90	32	32	S	40		1.0M						
2N2673	S	N			A	250M	A	200	60	45	O	8.0	22	1.0M	1.5	5.0M	9.0	E	2.5M	B
2N2674	S	N			A	250M	A	200	60	45	O	12	40	1.0M	1.5	5.0M	18	E	5.0M	B
2N2675	S	N			A	250M	A	200	60	45	O	22	76	1.0M	1.5	5.0M	37	E	10M	B
2N2676	S	N			A	250M	A	200	60	45	O	45	290	1.0M	1.5	5.0M	76	E	10M	B
2N2677	S	N			A	250M	A	200	45	35	O	20	55	1.0M	1.5	5.0M	19	E	10M	B
2N2678	S	N			A	250M	A	200	45	35	O	45	150	1.0M	1.5	5.0M	39	E	20M	B
2N2679 thru 2N2690	Thyristors, see Table on Page 2-66																			
2N2691	G	P			SP	100W	C	110	100	80	O	30	100	20A	0.65	20A			6.0M	T
2N2691A	G	P			SP	170W	C	125	120	80	O	50	100	20M						
2N2692	S	N			SH	300M	A	175	45	30	O	90	360	100*	0.12	100*			42M	T
2N2693	S	N			SH	300M	A	175	45	30	O	40		10*	0.12	100*			42M	T
2N2694	S	N			SH	300M	A	175	45	20	O	20		10*	0.12	100*			42M	T
2N2695	S	P			S	360M	A	200	25	25	O	30	130	50M	0.25	50M	25	E	100M	T
2N2696	S	P		2N2696	S	360M	A	200	25	25	O	30	130	50M	0.25	50M	25	E	100M	T
2N2697	S	N			SP	18W	C	200	80	60	O	40	120	1.0A	0.5	1.0A			20M	T
2N2698	S	N			SP	18W	C	200	100	80	O	40	120	1.0A	0.5	1.0A			20M	T
2N2699	G	P	2N964	2N960	SH	150M	A	100	15	8.0	O	40	200	10M	0.18	10M			300M	T
2N2706	G	P			A	0.5W	A	75	32	32	S	65	120	20M			80	E	1.3M	B
2N2707	G	N,P	Matched Pair: 2N2430 (NPN) and 2N2706 (PNP)																	
2N2708	S	N		2N2708	AH	200M	A	200	35	20	O	30	200	2.0M			30	E		
2N2709	S	P	2N2800	2N2800	A	240M	A	160	50	35	O	10	22	0.2M	0.4	8.0M			200K	B
2N2710	S	N		2N2710	SH	360M	A	200	40	20	O	40		10M	0.25	10M			500M	T
2N2711	S	N	MPS2711	MPS2711	A	0.2W	A	125	18	18	O	30	90	2.0M			30	E		
2N2712	S	N	MPS2712	MPS2711	A	0.2W	A	125	18	18	O	75	225	2.0M			80	E		
2N2713	S	N	MPS2713	MPS2713	A	0.2W	A	125	18	18	O	30	90	2.0M	0.3	50M	30	E		
2N2714	S	N	MPS2714	MPS2713	A	0.2W	A	125	18	18	O	75	225	2.0M	0.3	50M	80	E		
2N2715	S	N	MPS2715		A	0.2W	A	125	18	18	O	30	90	2.0M			30	E		
2N2716	S	N	MPS2716		A	0.2W	A	125	18	18	O	75	225	2.0M			80	E		
2N2717	G	P			SH	0.1W	A	75	20	15	O	50		30M	0.35	10M			300M	T

TYPE	MATERIAL	POLARITY	REPLACE-MENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2718	G	P			SH	240M	A	100	20	12	O	25		170M	0.27	170M			150M	T
2N2719	S	N			SH	300M	A	175	25	8.0	O	30		60M	0.40	60M			200M	T
2N2720	S	N		2N2720	AM	0.3W	A	200	80	60	O	30	120	0.1M	1.0	10M	30	E	80M	T
2N2721	S	N		2N2720	AM	0.3W	A	200	80	60	O	30	120	0.1M	1.0	10M	30	E	80M	T
2N2722	S	N		2N2722	AM	0.3W	A	200	45	45	O	50	250	1.0*	1.0	10M	100	E	100M	T
2N2723	S	N		2N2723	AL	0.5W	A	200	80	60	O	2K	10K	10M	1.0	10M	1500	E	100M	T
2N2724	S	N		2N2723	AL	0.5W	A	200	80	60	O	7K	50K	10M	1.0	10M	5000	E	100M	T
2N2725	S	N		2N2723	AL	0.5W	A	200	45	45	O	2K	10K	0.1M	1.0	10M	1500	E	100M	T
2N2726	S	N			AHP	1.0W	A	200	200	200	R	30	90	0.2A	2.0	0.2A	30	E	15M	T
2N2727	S	N			AHP	1.0W	A	200	200	200	R	75	150	0.2A	2.0	0.2A	75	E	15M	T
2N2728	G	P		2N2728	SHP	170W	C	110	15	5.0	O	40	130	20A	0.1	50A			3.0K	E
2N2729	S	N			AH	300M	A	200	30	15	O	20	200	3.0M	0.4	10M			600M	T
2N2730	G	P	MP506	MP500	SP	170W	C	110	80	60	O	30	120	25A	0.25	25A			200K	T
2N2731	G	P	MP505	MP500	SP	170W	C	110	60	45	O	30	120	25A	0.25	25A			200K	T
2N2732	G	P	MP504	MP500	SP	170W	C	110	40	30		30	120	25A	0.25	25A			200K	T
2N2733	G	P	MP506	MP500	SP	140W	C	110	80	60	O	30	120	25A	0.25	25A			200K	T
2N2734	G	P	MP505	MP500	SP	140W	C	110	60	45	O	30	120	25A	0.25	25A			200K	T
2N2735	G	P	MP504	MP500	SP	140W	C	110	40	30	O	30	120	25A	0.25	25A			200K	T
2N2736	G	P	MP506	MP500	SP	140W	C	110	80	60	O	30	120	25A	0.25	25A			200K	T
2N2737	G	P	MP505	MP500	SP	140W	C	110	60	45	O	30	120	25A	0.25	25A			200K	T
2N2738	G	P	MP504	MP500	SP	140W	C	110	40	30	O	30	120	25A	0.25	25A			200K	T
2N2739	S	N			SP	200W	C	175	50	50	V	10		10A	1.5	10A				
2N2740	S	N			SP	200W	C	175	100	100	V	10		10A	1.5	10A				
2N2741	S	N			SP	200W	C	175	150	150	V	10		10A	1.5	10A				
2N2742	S	N			SP	200W	C	175	200	200	V	10		10A	1.5	10A				
2N2743	S	N			SP	200W	C	175	250	250	V	10		10A	1.5	10A				
2N2744	S	N			SP	200W	C	175	300	300	V	10		10A	1.5	10A				
2N2745	S	N			SP	200W	C	175	50	50	V	10		15A	1.5	15A				
2N2746	S	N			SP	200W	C	175	100	100	V	10		15A	1.5	15A				
2N2747	S	N			SP	200W	C	175	150	150	V	10		15A	1.5	15A				
2N2748	S	N			SP	200W	C	175	200	200	V	10		15A	1.5	15A				
2N2749	S	N			SP	200W	C	175	250	250	V	10		15A	1.5	15A				
2N2750	S	N			SP	200W	C	175	300	300	V	10		15A	1.5	15A				
2N2751	S	N			SP	200W	C	175	50	50	V	10		20A	1.5	20A				
2N2752	S	N			SP	200W	C	175	100	100	V	10		20A	1.5	20A				
2N2753	S	N			SP	200W	C	175	150	150	V	10		20A	1.5	20A				
2N2754	S	N			SP	200W	C	175	200	200	V	10		20A	1.5	20A				
2N2755	S	N			SP	200W	C	175	250	250	V	10		20A	1.5	20A				
2N2756	S	N			SP	200W	C	175	300	300	V	10		20A	1.5	20A				
2N2757	S	N			SP	200W	C	175	50	50	V	10		10A	1.5	10A				
2N2758	S	N			SP	200W	C	175	100	100	V	10		10A	1.5	10A				
2N2759	S	N			SP	200W	C	175	150	150	V	10		10A	1.5	10A				
2N2760	S	N			SP	200W	C	175	200	200	V	10		10A	1.5	10A				
2N2761	S	N			SP	200W	C	175	250	250	V	10		10A	1.5	70A				
2N2762	S	N			SP	200W	C	175	300	300	V	10		10A	1.5	10A				
2N2763	S	N			SP	200W	C	175	50	50	V	10		15A	1.5	15A				
2N2764	S	N			SP	200W	C	175	100	100	V	10		15A	1.5	15A				
2N2765	S	N			SP	200W	C	175	150	150	V	10		15A	1.5	15A				
2N2766	S	N			SP	200W	C	175	200	200	V	10		15A	1.5	15A				
2N2767	S	N			SP	200W	C	175	250	250	V	10		15A	1.5	15A				
2N2768	S	N			SP	200W	C	175	300	300	V	10		15A	1.5	15A				
2N2769	S	N			SP	200W	C	175	50	50	V	10		20A	1.5	20A				
2N2770	S	N			SP	200W	C	175	100	100	V	10		20A	1.5	20A				
2N2771	S	N			SP	200W	C	175	150	150	V	10		20A	1.5	20A				
2N2772	S	N			SP	200W	C	175	200	200	V	10		20A	1.5	20A				
2N2773	S	N			SP	200W	C	175	250	250	V	10		20A	1.5	20A				
2N2774	S	N			SP	200W	C	175	300	300	V	10		20A	1.5	20A				
2N2775	S	N			SP	200W	C	175	50	50	V	10		25A	1.5	25A				
2N2776	S	N			SP	200W	C	175	100	100	V	10		25A	1.5	25A				
2N2777	S	N			SP	200W	C	175	150	150	V	10		25A	1.5	25A				
2N2778	S	N			SP	200W	C	175	200	200	V	10		25A	1.5	25A				
2N2779	S	N			SP	200W	C	175	250	250	V	10		25A	1.5	25A				
2N2780	S	N			SP	200W	C	175	300	300	V	10		25A	1.5	25A				
2N2781	S	N			AHP	200W	C	175	75	30	O	7.5	75	0.35A	5.0	1.0A			75M	T
2N2782	S	N			AHP	200W	C	175	100	40	O	7.5	75	0.35A	5.0	1.0A			75M	T
2N2783	S	N			AHP	200W	C	175	100	40	O	7.5	75	0.35A	5.0	1.0A			75M	T
2N2784	S	N			SH	200W	C	200	15	6.0	O	40		30M	0.26	3.0M			1.0G	T
2N2785	S	N		2N2785	AL	500M	A	175	60	40	O	2K	20K	0.1A	1.0	15M	600	E	10M	T
2N2786	G	P			AH	1.5W	C	90	35	20	O	33	200	0.1A						
2N2786A	G	P			AH	1.5W	C	90	35	20	O	33	200	0.1A						
2N2787	S	N	2N2218	2N2218	SH	800M	A	175	75	35	O	20	50	150M	0.4	150M	15	E	250M	T
2N2788	S	N	2N2218A	2N2218A	SH	800M	A	175	75	35	O	40	120	150M	0.4	150M	30	E	250M	T
2N2789	S	N	2N2219A	2N2218A	SH	800M	A	175	75	35	O	100	300	150M	0.4	150M	80	E	250M	T
2N2790	S	N	2N2218	2N2218	SH	500M	A	175	75	35	O	20	60	150M	0.4	150M	15	E	250M	T
2N2791	S	N	2N2221A	2N2218A	SH	500M	A	175	75	35	O	40	120	150M	0.4	150M	30	E	250E	T
2N2792	S	N	2N2222A	2N2218A	SH	500M	A	175	75	35	O	100	300	150M	0.4	150M	80	E	250E	T
2N2793	G	P			AHP	170W	C	110	75	60	O	50	100	15A	0.45	50A	20	E	2.0K	E
2N2794	Field-Effect Transistors, see Table on Page 2-76																			
2N2795	G	P			SH	75M	A	100	25	15	O	50		50M	0.125	50M			300M	T
2N2796	G	P			SH	75M	A	100	20	12	O	30		50M	0.25	50M			300M	T
2N2797	G	P			SH	75M	A	100	40	20	O	40		50M	0.2	50M			150M	T
2N2798	G	P			SH	75M	A	100	60	25	O	20		50M	0.25	50M			120M	T
2N2799	G	P			SH	75M	A	100	30	15	O	20		50M	0.25	50M			120M	T
2N2800	S	P		2N2800	SH	0.8W	A	200	50	35	O	30	90	150M	0.4	150M			120M	T
2N2801	S	P		2N2800	SH	0.8W	A	200	50	35	O	75	225	150M	0.4	150M			120M	T
2N2802	S	P		2N2802	AM	250M	A	200	25	20	O	20	120	100*	0.5	10M	20	E	60M	T
2N2803	S	P		2N2802	AM	250M	A	200	25	20	O	20	120	100*	0.5	10M	20	E	60M	T
2N2804	S	P		2N2802	AP	250M	A	200	25	20	O	20	120	100*	0.5	10M	20	E	60M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2805	S	P		2N2802	AM	250M	A	200	25	20	O	40	120	100*	0.5	10M	40	E	60M	T
2N2806	S	P		2N2802	AM	250M	A	200	25	20	O	40	120	100*	0.5	10M	40	E	60M	T
2N2807	S	P		2N2802	AP	250M	A	200	25	20	O	40	120	100*	0.5	10M	40	E	60M	T
2N2808	S	N			AH	300M	A	200	30	10	O	20	120	2.0M	0.25	4.0M	20	E	1.0G	T
2N2808A	S	N			AH	200M	A	200	30	10	O	20	120	2.0M	0.25	4.0M	7.0	E	1.5G	T
2N2809	S	N			AH	200M	A	200	30	15	O	20	120	2.0M	0.25	4.0M	20	E	600M	T
2N2809A	S	N			AH	200M	A	200	30	15	O	20	120	2.0M	0.25	4.0M	20	E	1.0G	T
2N2810	S	N			AH	200M	A	200	24	10	O	20	120	2.0M	0.25	4.0M	20	E	600M	T
2N2810A	S	N			AH	200M	A	200	24	10	O	20	120	2.0M	0.25	4.0M	20	E	1.0G	T
2N2811	S	N	2N3487	2N3485	AP	70W	J	200	80	60	O	20	60	5.0A	0.5	5.0A	20	E	15M	T
2N2812	S	N	2N3488	2N3485	AP	70W	J	200	80	60	O	40	120	5.0A	0.5	5.0A	40	E	15M	T
2N2813	S	N	2N3489	2N3485	AP	70W	J	200	120	80	O	20	60	5.0A	0.5	5.0A	20	E	15M	T
2N2814	S	N	2N3490	2N3485	AP	70W	J	200	120	80	O	40	120	5.0A	0.5	5.0A	40	E	15M	T
2N2815	S	N			SP	200W	C	200	80	80	O	10	50	10A	1.5	10A			0.6M	T
2N2816	S	N			SP	200W	C	200	100	100	O	10	50	10A	1.5	10A			0.6M	T
2N2817	S	N			SP	200W	C	200	150	150	O	10	50	10A	1.5	10A			0.6M	T
2N2818	S	N			SP	200W	C	200	200	200	O	10	50	10A	1.5	10A			0.6M	T
2N2819	S	N			SP	200W	C	200	80	80	O	10	50	15A	1.5	15A			0.6M	T
2N2820	S	N			SP	200W	C	200	100	100	O	10	50	15A	1.5	15A			0.6M	T
2N2821	S	N			SP	200W	C	200	150	150	O	10	50	15A	1.5	15A			0.6M	T
2N2822	S	N			SP	200W	C	200	200	200	O	10	50	15A	1.5	15A			0.6M	T
2N2823	S	N			SP	200W	C	200	80	80	O	10	40	20A	1.1	20A			0.6M	T
2N2824	S	N			SP	200W	C	200	100	100	O	10	40	20A	1.1	20A			0.6M	T
2N2825	S	N			SP	200W	C	200	150	150	O	10	40	20A	1.1	20A			0.6M	T
2N2826	G	P			AP	4.5W	C	95		15	O	75	200	100M	1.0	500M				
2N2827	G	P			AP	4.5W	C	95		30	O	75	200	100M	1.0	500M				
2N2828	S	N			SP	40W	C	200	80	60	O	20	60	0.5A	0.4	0.5A			1.0M	T
2N2829	S	N	2N4911	2N4910	SP	40W	C	200	80	60	O	20	60	1.0A	0.3	1.0A			1.0M	T
2N2831	S	N			AH	360M	A	200	40	12	O	25		10M	0.25	10M	40	E	250M	T
2N2832	G	P		2N2832	SP	85W	C	110	80	50	O	25	100	10A	0.5	20A			10M	T
2N2833	G	P		2N3832	SP	85W	C	110	120	75	O	25	100	10A	0.5	20A			10M	T
2N2834	G	P		2N2832	SP	85W	C	110	140	100	O	25	100	10A	0.5	20A				
2N2835	G	P			A	16W	C	90	32	32	R	30	100	1.0A	0.4	1.0A			0.3M	B
2N2836	G	P	2N3612	2N3611	AP	37.5W	C	100	55	55	R	30	100						250K	B
2N2837	S	P		2N2800	SH	0.5W	A	200	50	35	O	30	90	150M	0.4	150M			120M	T
2N2838	S	P		2N2800	SH	0.5W	A	200	50	35	O	75	225	150M	0.4	150M			120M	T
2N2840	Unijunction Transistors, see Table on Page 2-86																			
2N2841 thru 2N2844	Field-Effect Transistors, see Table on Page 2-76																			
2N2845	S	N		2N2845	S	360M	A	200	60	30	O	30	120	150M	0.4	150M			250M	T
2N2846	S	N		2N2845	S	800M	A	200	60	30	O	30	120	150M	0.4	150M			250M	T
2N2847	S	N		2N2845	S	360M	A	200	60	20	O	40	140	150M	0.4	150M			250M	T
2N2848	S	N		2N2845	S	800M	A	200	60	20	O	40	140	150M	0.4	150M			250M	T
2N2849	S	N			SH	850M	A	200	100	80	O	100	300	1.0A	0.4	1.0A			30M	T
2N2850	S	N			SH	850M	A	200	100	80	O	40	120	1.0A	0.25	1.0A			30M	T
2N2851	S	N			SH	850M	A	200	100	80	O	40	120	1.0A	0.4	1.0A			30M	T
2N2852	S	N			SH	850M	A	200	100	80	O	20	60	1.0A	0.4	1.0A			30M	T
2N2853	S	N			SH	850M	A	200	60	40	O	40		1.0A	1.5	5.0A			30M	T
2N2854	S	N			SH	850M	A	200	60	40	O	100	300	1.0A	0.4	1.0A			30M	T
2N2855	S	N			SH	850M	A	200	60	40	O	40	120	1.0A	0.4	1.0A			30M	T
2N2856	S	N			SH	850M	A	200	60	40	O	20	60	1.0A	0.4	1.0A			30M	T
2N2857	S	N		2N2857	AH	200M	A	200	30	15	O	30	150	3.0M			50	E	1.0G	T
2N2858	S	N			SP	0.6W	C	200	100	80	O	20	60	1.0A	0.3	1.0A			1.0M	T
2N2859	S	N			SP	0.6W	C	200	120	100	O	20	60	1.0A	0.3	1.0A			1.0M	T
2N2860	G	P			SH	150M	A	100	18	7.0	O	40		40M	0.4	36M			250M	T
2N2861	S	P			A	300M	A	200	25	20	O	30	120	10*	0.2	10M	50	E	60M	T
2N2862	S	P			A	300M	A	200	25	20	O	12	120	10*	0.2	10M	25	E	45M	T
2N2863	S	N			AH	800M	A	200	60	25	O	30	200	200M	1.0	500M			150M	T
2N2864	S	N			AH	800M	A	200	60	25	O	20	200	200M	1.0	500M			150M	T
2N2865	S	N			AH	200M	A	200	25	13	O	20	200	4.0M	0.4	10M	20	E	600M	T
2N2866	S	N			AHP	40W	C	175	120	80	O	20	60	0.5A	0.75	1.0A			10M	T
2N2867	S	N			AHP	40W	C	175	120	80	O	40	120	0.5A	0.75	1.0A			10M	T
2N2868	S	N	2N3252	2N3252	SH	0.8W	A	200	60	40	O	40	120	0.15A	0.25	0.15A			50M	T
2N2869	G	P	MP2015		AP	30W	C	100	60	50	O	50	165	1.0A	0.75	10A			200K	T
2N2870	G	P	MP2016		AP	30W	C	100	80	50	O	50	165	1.0A	0.5	10A			200K	T
2N2871	S	P			SC	0.4W	A	200	60	60	O	15		1.0M					0.2M	T
2N2872	S	P			SC	0.4W	A	200	110	110	O	15		1.0M					0.2M	T
2N2873	G	P			AH	115M	A	100	35	35	V	40		1.0M			40	E	300M	T
2N2874	S	N			AHP	2.0W	A	175	75	40	O	7.5	75	0.35A	5.0	1.0A			140M	T
2N2875	S	P			AHP	20W	C	200	60	50	O	15	60	50M	1.5	0.5A	20	E	25M	E
2N2876	S	N			AH	17.5W	C	200	80	60	O	5.0		2.5A	1.0	2.5A			150M	T
2N2877	S	N			AHP	53W	C	200	80	60	O	20	60	1.0A	0.25	1.0A	20	E	30M	T
2N2878	S	N			AHP	53W	C	200	80	60	O	40	120	1.0A	0.25	1.0A	40	E	50M	T
2N2879	S	N			AHP	53W	C	200	100	80	O	20	60	1.0A	0.25	1.0A	20	E	30M	T
2N2880	S	N			AHP	53W	C	200	100	80	O	40	120	1.0A	0.25	1.0A	40	E	50M	T
2N2881	S	P	2N4235	2N4234	AP	8.5W	C	200	60	60	O	20	60	0.5A	0.4	0.5A	10	E	25K	E
2N2882	S	P	2N4236	2N4234	AP	8.5W	C	200	100	100	O	20	60	0.5A	0.4	0.5A	10	E	25K	E
2N2883	S	N	2N3553	2N3375	AHP	800M	A	200	40	20	O	20		100M	0.5	100M			400M	T
2N2884	S	N	2N3553	2N3375	AHP	800M	A	200	40	20	O	20		100M	0.5	100M			400M	T
2N2885	S	N			SH	0.15W	A	175	40	15	O	30	120	10M	0.4	10M			300M	T
2N2886	S	N			A	800M	A	200	50	40	O	22	45	5.0M	1.2	8.0M				
2N2887	S	N			AHP	25W	C	200	100	80	O	15	80	0.35A	1.2	1.0A			140M	T
2N2888	Thyristors, see Table on Page 2-66																			
2N2889																				
2N2890	S	N	2N3507	2N3506	AP	800M	A	200	100	80	O	30	90	1.0A	0.5	1.0A	30	E	30M	T
2N2891	S	N	2N3507	2N3506	SP	800M	A	200	100	80	O	50	150	1.0A	0.5	1.0A	50	E	30M	T
2N2892	S	N			SP	30W	C	200	100	80	O	30	90	1.0A	0.5	1.0A	30	E	30M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2893	S	N			SP	30W	C	200	100	80	O	50	150	1.0A	0.5	1.0A	50	E	30M	T
2N2894	S	P		2N2894	S	360M	A	200	12	12	O	40	150	30M	0.15	10M			400M	T
2N2894A	S	P			SP	360M	A	200	12	12	S	40		30M					800M	T
2N2895	S	N		2N2895	S	500M	A	200	120	65	O	40	120	150M	0.6	150M	50	E	120M	T
2N2896	S	N		2N2895	S	500M	A	200	140	90	O	60	200	150M	0.6	150M	50	E	120M	T
2N2897	S	N		2N2895	S	500M	A	200	60	45	O	50	200	150M	1.0	150M	50	E	120M	T
2N2898	S	N			S	500M	A	200	120	65	O	40	120	150M	0.6	150M	50	E	120M	T
2N2899	S	N			S	500M	A	200	140	90	O	60	200	150M	0.6	150M	50	E	120M	T
2N2900	S	N			S	500M	A	200	60	45	O	50	200	150M	1.0	150M	50	E	120M	T
2N2901	S	N			SC	0.36W	A	200	20	10	O	30		10M	0.15	10M			300M	T
2N2902	S	N			AP	40W	C	200	120	120	O	30	90	500M	7.5	500M	30	E	2.0M	T
2N2903	S	N		2N2903	AM	600M	C	200	60	30	O	125	625	1.0M	1.0	5.0M	150	E	60M	T
2N2903A	S	N		2N2903	AM	600M	C	200	60	30	O	125	625	1.0M	1.0	5.0M	150	E	60M	T
2N2904	S	P		2N2904	SH	3.0W	C	200	60	40	O	40	120	150M	0.4	150M			200M	T
2N2904A	S	P		2N2904	SH	3.0W	C	200	60	60	O	40	120	150M	0.4	150M			200M	T
2N2905	S	P		2N2904	SH	3.0W	C	200	60	40	O	100	300	150M	0.4	150M			200M	T
2N2905A	S	P		2N2904	SH	3.0W	C	200	60	60	O	100	300	150M	0.4	150M			200M	T
2N2906	S	P		2N2904	SH	1.8W	C	200	60	40	O	40	120	150M	0.4	150M			200M	T
2N2906A	S	P		2N2904	SH	1.8W	C	200	60	60	O	40	120	150M	0.4	150M			200M	T
2N2907	S	P		2N2904	SH	1.8W	C	200	60	40	O	100	300	150M	0.4	150M			200M	T
2N2907A	S	P		2N2904	SH	1.8W	C	200	60	60	O	100	300	150M	0.4	150M			200M	T
2N2908	S	N			AP	75W	C	200	80	80	R	12	60	1.0A	10	1.0A	10	E	1.0M	E
2N2909	S	N			SH	0.4W	A	200	60	40	O	40	120	0.15A	0.25	0.15A			50M	T
2N2910	S	N	2N3409	2N3409	AM	0.3W	A	200	45	25	O	70		0.1M	1.0	10M	50	E	11M	T
2N2911	S	N	2N3766	2N3766	SP	5.0W	C	200	150	125	O	20	60	1.0A	0.3	1.0A			1.0M	T
2N2912	G	P		2N2912	SP	75W	C	110	15	6.0	O	75		10A	0.5	25A			20M	T
2N2913	S	N		2N2913	AM	300M	A	200	45	45	O	60	240	10*	0.35	1.0M			60M	T
2N2914	S	N		2N2913	AM	300M	A	200	45	45	O	150	600	10*	0.35	1.0M			60M	T
2N2915	S	N		2N2213	AM	300M	A	200	45	45	O	60	240	10*	0.35	1.0M			60M	T
2N2915A	S	N			A	300M	A	200	45	45	O						240	E	60M	T
2N2916	S	N		2N2913	AM	300M	A	200	45	45	O	150	600	10*	0.35	1.0M			60M	T
2N2916A	S	N			A	300M	A	200	45	45	O						600	E	60M	T
2N2917	S	N		2N2913	AM	0.3W	A	200	45	45	O	60	240	10*	0.35	1.0M			60M	T
2N2918	S	N		2N2913	AM	0.3W	A	200	45	45	O	150	600	10*	0.35	1.0M			60M	T
2N2919	S	N		2N2913	AM	0.3W	A	200	60	60	O	60	240	10*	0.35	1.0M			60M	T
2N2919A	S	N			A	300M	A	200	60	60	O						240	E	60M	T
2N2920	S	N		2N2913	AM	0.3W	A	200	60	60	O	150	600	10*	0.35	1.0M			60M	T
2N2920A	S	N			A	300M	A	200	60	60	O						600	E	60M	T
2N2921	S	N			A	0.2W	A	125	25	25	O						35	E		
2N2922	S	N	MPS6512	MPS6512	A	0.2W	A	125	25	25	O						55	E		
2N2923	S	N	MPS2923	MPS2923	A	0.2W	A	125	25	25	O						90	E		
2N2924	S	N	MPS2924	MPS2923	A	0.2W	A	125	25	25	O						150	E		
2N2925	S	N	MPS2925	MPS2923	A	0.2W	A	125	25	25	O						235	E		
2N2926	S	N	MPS2926	MPS2926	A	0.2W	A	125	18	18	O						35	E		
2N2927	S	P			S	800M	A	200	25	25	O	30	130	50M	0.25	50M	25	E	100M	T
2N2928	G	P			AH	150M	A	100	15	13	O	0.8	200	2.0M			0.10		400M	T
2N2929	G	P		2N2929	AH	750M	C	100	25	10	O	10	100	10M	0.5	50M	10	E	800M	T
2N2930	G	P	2N3427	2N3427	S	250M	A	100	30	12	O	60	420	10M	0.25	100M			4.0M	B
2N2931	S	N			A	50M	A	125	5.0	5.0	O	50		50M	0.45	50M	30	E	20M	T
2N2932	S	N			A	50M	A	125	5.0	5.0	O	70		50M	0.45	50M	70	E	20M	T
2N2933	S	N			A	50M	A	125	5.0	5.0	O	50		50M	0.45	50M	45	E	20M	T
2N2934	S	N			A	50M	A	125	45	30	O	50		50M	0.45	50M	30	E	20M	T
2N2935	S	N			A	50M	A	125	45	30	O	70		50M	0.45	50M	70	E	20M	T
2N2936	S	N			AP	300M	A	175	60	55	O	100	300	10*	0.3	2.0M	150	E	30M	T
2N2937	S	N			AP	300M	A	175	60	55	O	100	300	10*	0.3	2.0M	150	E	30M	T
2N2938	S	N			SH	300M	A	200	25	13	O	30		50M	0.4	50M			500M	T
2N2939	S	N			AHP	0.8W	A	300	75	60	O	60	240	0.15A	0.75	0.15A			150M	T
2N2940	S	N			AHP	0.8W	A	300	120	80	O	60	240	0.15A	0.75	0.15A			150M	T
2N2941	S	N			AHP	0.8W	A	200	150	100	O	60	240	0.15A					150M	T
2N2942	G	P			SH	150M	A	100	50	25	O	50		10M	0.15	10M			150M	T
2N2943	G	P			SH	150M	A	100	30	15	O	30		10M	0.2	10M			120M	T
2N2944	S	P		2N2944	SC	400M	A	175	15	10	O	80		1.0M					10M	T
2N2944A	S	P			SC	400M	A	200	15	10	O	100		1.0M					15M	T
2N2945	S	P		2N2944	SC	400M	A	175	25	20	O	40		1.0M					5.0M	T
2N2945A	S	P			SC	400M	A	200	25	20	O	100		1.0M					10M	T
2N2946	S	P		2N2944	SC	400M	A	175	40	35	O	30		1.0M					3.0M	T
2N2946A	S	P			SC	400M	A	200	40	35	O	50		1.0M					5.0M	T
2N2947	S	N		2N2947	AP	25W	C	175	60	60	S	2.5	55	0.4A	0.5	1.0A			100M	T
2N2948	S	N		2N2947	AP	25W	C	175	40	40	S	2.5	100	0.4A	0.5	1.0A			100M	T
2N2949	S	N		2N2949	AP	6.0W	C	175	60	60	S	5.0	100	40M	0.5	0.4A			100M	T
2N2950	S	N		2N2949	AP	6.0W	C	175	60	60	S	5.0	100	40M	0.5	0.4A			100M	T
2N2951	S	N		2N2951	AP	3.0W	C	175	60	60	S	20	150	10M	0.5	0.15A			200M	T
2N2952	S	N		2N2951	AP	1.8W	C	175	60	60	S	20	150	10M	0.5	0.15A			200M	T
2N2953	G	P	2N1194	2N1191	A	120M	A	100	30	25	R	100		50M			200	E		
2N2954	S	N			SH	200M	A	200	30	20	O	25	300	2.0M			25	E	300M	T
2N2955	G	P		2N2955	SH	0.15W	A	100	40			20	60	50M	0.2	10M			200M	T
2N2956	G	P		2N2955	SH	0.15W	A	100	40			40	120	50M	0.18	10M			250M	T
2N2957	G	P		2N2955	SH	0.15W	A	100	40			60		10M	0.15	10M			300M	T
2N2958	S	N		2N2958	SH	3.0W	C	200	60	20	O	40	120	150M	0.5	150M			250M	T
2N2959	S	N		2N2958	SH	3.0W	C	200	60	20	O	100	300	150M	0.5	150M			250M	T
2N2960	S	N			SH	3.0W	C	200	60	30	O	100	300	150M	0.5	150M			250M	T
2N2961	S	N			SH	3.0W	C	200	60	30	O	100	300	150M	0.5	150M			250M	T
2N2962	G	P			AP	350M	A	100	40	18	O								660M	T
2N2963	G	P			AP	350M	A	100	40	18	O								660M	T
2N2964	G	P			AP	350M	A	100	30	15	O								660M	T
2N2965	G	P			AHP	350M	A	100	30	15	O								660M	T
2N2966	G	P	2N3283	2N3283	AH	60M	A	100	20	20	O	8.0	100	3.0M					500M	T
2N2967	S	N			SH	300M	A	200	12	6.0	O	20	120	10M	0.3	3.0M			400M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2968	S	P			S	150M	A	140	30	10	O	15		100*	0.6	10M			8.0M	T
2N2969	S	P			S	150M	A	140	30	10	O	15		100*	0.6	10M			8.0M	T
2N2970	S	P			S	150M	A	140	30	20	O	10		100*	0.8	10M			4.0M	T
2N2971	S	P			S	150M	A	140	30	20	O	10		100*	0.8	10M			4.0M	T
2N2972	S	N		2N2913	AM	0.25W	A	200	45	45	O	60	240	10*	0.35	1.0M			60M	T
2N2973	S	N		2N2913	AM	0.25W	A	200	45	45	O	150	600	10*	0.35	1.0M			60M	T
2N2974	S	N		2N2913	AM	0.25W	A	200	45	45	O	60	240	10*	0.35	1.0M			60M	T
2N2975	S	N		2N2913	AM	0.25W	A	200	45	45	O	150	600	10*	0.35	1.0M			60M	T
2N2976	S	N		2N2913	AM	250M	A	200	45	45	O	60	240	10*	0.35	1.0M			60M	T
2N2977	S	N		2N2913	AM	250M	A	200	45	45	O	150	600	10*	0.35	1.0M			60M	T
2N2978	S	N		2N2913	AM	250M	A	200	60	60	O	60	240	10*	0.35	1.0M			60M	T
2N2979	S	N		2N2913	AM	0.25W	A	200	60	60	O	150	600	10*	0.35	1.0M			60M	T
2N2980	S	N	2N2060A	2N2060	AM	0.25W	A	200	100	60	O	25	75	10*	1.2	50M	50	E	60M	T
2N2981	S	N	2N2223	2N2060	AM	0.25W	A	200	100	60	O	50	200	10M	1.2	50M	40	E	50M	T
2N2982	S	N	2N2223A	2N2060	AM	0.25W	A	200	100	60	O	50	200	10M	1.2	50M	40	E	50M	T
2N2983	S	N			AP	1.0W	A	175	155	80	O	20	60	500M	0.6	1.0A	20	E	60M	T
2N2984	S	N			AP	1.0W	A	175	185	120	O	20	60	500M	0.8	200M	20	E	60M	T
2N2985	S	N			AP	1.0W	A	175	155	80	O	40	120	500M	0.8	200M	40	E	60M	T
2N2986	S	N			AP	1.0W	A	175	185	120	O	40	120	500M	0.8	200M	40	E	60M	T
2N2987	S	N			AP	1.0W	A	200	95	80	O	25	75	200M	0.8	200M	25	E	30M	T
2N2988	S	N			AP	1.0W	A	200	155	100	O	25	75	200M	0.8	200M	25	E	30M	T
2N2989	S	N			AP	1.0W	A	200	95	80	O	60	120	200M	0.8	200M	50	E	30M	T
2N2990	S	N			AP	1.0W	A	200	155	100	O	60	120	200M	0.8	200M	50	E	30M	T
2N2991	S	N			AP	2.0W	A	200	95	80	O	25	75	200M	0.8	200M	25	E	30M	T
2N2992	S	N			AP	2.0W	A	200	155	100	O	20		1.0M	0.8	200M	25	E	30M	T
2N2993	S	N			AP	2.0W	A	200	95	80	O	60	120	200M	0.8	200M	50	E	30M	T
2N2994	S	N			AP	2.0W	A	200	155	100	O	60	120	200M	0.8	200M	50	E	30M	T
2N2995	S	N			AHP	1.5W	A	175	120	100	O	25	90	0.2A	1.7	0.2A	30	E	10M	T
2N2996	G	P			AH	75M	A	100	15	10	O	25	500	4.0M			35	E	400M	T
2N2997	G	P			AH	75M	A	100	30	15	O	40	500	4.0M			50	E	400M	T
2N2998	G	P			AH	75M	A	100	15	12	O	15	300	3.0M			20	E	600M	T
2N2999	G	P	2N3283	2N3283	AH	75M	A	100	15	10	O	10		3.0M			15	E	1.4G	T
2N3001 thru 2N3008	Thyristors, see Table on Page 2-66																			
2N3009	S	N		2N3009	SH	360M	A	200	40	15	O	30	120	30M	0.18	30M			350M	T
2N3010	S	N		2N3010	SH	300M	A	200	15	6.0	O	25	125	10M	0.25	10M			600M	T
2N3011	S	N		2N3011	SH	360M	A	200	30	12	O	30	120	10M	0.2	10M			400M	T
2N3013	S	N		2N3009	SH	360M	A	200	40	15	O	30	120	30M	0.18	30M			350M	T
2N3014	S	N		2N3009	SH	360M	A	200	40	20	O	30	120	30M	0.18	10M			350M	T
2N3015	S	N		2N3013	SH	800M	A	200	60	30	O	30	120	150M	0.4	150M			250M	T
2N3016	S	N			AHP	3.33W	C	150	100	50	O	60	150	1.0A	0.75	1.0A			200M	T
2N3017	S	N			AHP	3.33W	C	150	100	50	O	60	150	1.0A	0.75	5.0A			200M	T
2N3018	S	N			AHP	25W	C	150	100	50	O	60	150	1.0A	0.75	5.0A			200M	T
2N3019	S	N		2N3019	AH	0.8W	A	200	140	80	O	100	300	0.15A	0.2	0.15A	80	E	100M	T
2N3020	S	N		2N3019	AH	0.8W	A	200	140	80	O	40	120	0.15A	0.2	0.15A	30	E	80M	T
2N3021	S	P		2N3021	SHP	25W	C	175	30	30	O	20	60	1.0A	1.5	3.0A			60M	T
2N3022	S	P		2N3021	SHP	25W	C	175	45	45	O	20	60	1.0A	1.5	3.0A			60M	T
2N3023	S	P		2N3021	SHP	25W	C	175	60	60	O	20	60	1.0A	1.5	3.0A			60M	T
2N3024	S	P		2N3021	SHP	25W	C	175	30	30	O	50	180	1.0A	1.0	3.0A			60M	T
2N3025	S	P		2N3021	SHP	25W	C	175	45	45	O	50	180	1.0A	1.0	3.0A			60M	T
2N3026	S	P		2N3021	SHP	25W	C	175	60	60	O	50	180	1.0A	1.0	3.0A			60M	T
2N3027 thru 2N3032	Thyristors, see Table on Page 2-66																			
2N3033	S	N			AL	300M	A	175	100	100	R				1.0	100M				
2N3034	S	N			AL	300M	A	175	70	70	R				1.0	100M				
2N3035	S	N			AL	300M	A	175	50	50	R				1.0	100M				
2N3036	S	N			A	800M	A	200	120	80	O	50	150	150M	0.25	150M	40	E	50M	T
2N3037	S	N			A	360M	A	175	120	70	O	40	120	150M	0.2	10M	30	E	50M	T
2N3038	S	N			A	360M	A	175	100	60	O	80	240	150M	0.2	10M	60	E	50M	T
2N3039	S	P			A	360M	A	175	50	35	O	20	80	150M			20	E	50M	T
2N3040	S	P			A	360M	A	175	40	30	O	40	160	150M	0.2	10M	40	E	50M	T
2N3043	S	N		2N3043	AM	250M	A	200	45	45	O	100	300	10*	1.0	10M	130	E	30M	T
2N3044	S	N		2N3043	AM	250M	A	200	45	45	O	100	300	10*	1.0	10M	130	E	30M	T
2N3045	S	N		2N3043	A	250M	A	200	45	45	O	100	300	10*	1.0	10M	130	E	30M	T
2N3046	S	N		2N3043	AM	250M	A	200	45	45	O	50	200	10*	1.0	10M	65	E	30M	T
2N3047	S	N		2N3043	AM	250M	A	200	45	45	O	50	200	10*	1.0	10M	65	E	30M	T
2N3048	S	N		2N3043	A	250M	A	200	45	45	O	50	200	10*	1.0	10M	65	E	30M	T
2N3049	S	P		2N3049	AM	250M	A	200	25	20	O	20	120	10*	0.2	10M	30	E	60M	T
2N3050	S	P		2N3049	AM	250M	A	200	25	20	O	20	120	10*	0.2	10M	30	E	60M	T
2N3051	S	P			A	250M	A	175	25	20	O	20	120	10*	0.2	10M	30	E	60M	T
2N3052	S	N			SH	250M	A	175	35	15	O	25	130	10M	0.25	10M			200M	T
2N3053	S	N		2N3053	SH	5.0W	C	200	60	40	O	50	250	0.15A	1.4	0.15A			100M	T
2N3054	S	N			AP	25W	C	200	90	60	R	25	100	0.5A	1.0	0.5A	25	E	30K	E
2N3055	S	N		2N3055	AP	115W	C	200	100	70	R	20	70	4.0A	1.1	4.0A	15	E	20K	E
2N3055A	S	N			AP	175W	C	200	100	70	R	20	70	4.0A	0.8	4.0A	30	E		
2N3056	S	N			AH	0.4W	A	200	100	60	O	40	120	0.15A	0.25	0.15A	30	E	80M	T
2N3056A	S	N			AH	0.4W	A	200	140	80	O	40	120	0.15A	0.2	0.15A	30	E	80M	T
2N3057	S	N			AH	0.4W	A	200	100	60	O	100	300	0.15A	0.25	0.15A	80	E	100M	T
2N3057A	S	N			AH	0.4W	A	200	140	80	O	100	300	0.15A	0.2	0.15A	80	E	100M	T
2N3058	S	P			A	400M	A	200	6.0	6.0	O	40	120	100N			40	E		
2N3059	S	P			A	400M	A	200	10	10	O	100	300	10*			100	E		
2N3060	S	P			A	400M	A	200	70	60	O	30	90	1.0M			30	E		
2N3061	S	P			A	400M	A	200	70	60	O	60	180	1.0M			60	E		
2N3062	S	P			A	400M	A	200	90	80	O	20	80	1.0M			20	E		
2N3063	S	P			A	400M	A	200	90	80	O	50	150	1.0M			50	E		
2N3064	S	P			A	400M	A	200	110	100	O	15	45	1.0M			15	E		

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N3065	S	P			A	400M	A	200	110	100	O	30	90	1.0M			30	E		
2N3066,A thru 2N3071	Field-Effect Transistors, see Table on Page 2-76																			
2N3072	S	P		2N3072	S	800M	A	200	60	60	O	30	130	50M	0.25	50M	25	E	130M	T
2N3073	S	P			S	360M	A	200	60	60	O	30	130	50M	0.25	50M	25	E	130M	T
2N3074	G	P			AH	0.14W	A	85	30	25	S	25	300	3.5M						
2N3075	G	P			AH	0.14W	A	85	35	25	S	20	250	3.0M						
2N3076	S	N			SHP	125W	C	175	140	50	O	30	90	7.0A	1.0	10A	60	E	50M	T
2N3077	S	N			A	0.36W	A	200	80	60	O	100	400	10*	0.35	1.0M	120	E	15M	T
2N3078	S	N			A	0.36W	A	200	80	60	O	40	120	10*	0.35	1.0M	50	E	15M	T
2N3079	S	N			SP	178W	C	150	200	200	O	7.0	40	5.0A	0.7	5.0A			30K	E
2N3080	S	N			SP	178W	C	150	300	300	O	7.0	40	5.0A	0.7	5.0A			30K	E
2N3081	S	P			SH	600M	A	200	70	50	O	20		500M	0.3	150M			150M	T
2N3082	S	N			SC	0.5W	A	200	25	7.0	O	100		0.25M					100M	T
2N3083	S	N			SC	0.5W	A	200	25	7.0	O	100		0.25M					100M	T
2N3084 thru 2N3089,A	Field-Effect Transistors, see Table on Page 2-76																			
2N3091 thru 2N3106	Thyristors, see Table on Page 164																			
2N3107	S	N			S	0.8W	A	200	100	60	O	100	300	0.15A	1.0	1.0A	60	E	70M	T
2N3108	S	N			S	800M	A	200	100	60	O	40	120	150M	0.25	150M			60M	T
2N3109	S	N			S	0.8W	A	200	80	40	O	100	300	0.15A	1.0	1.0A	60	E	70M	T
2N3110	S	N	2N2218A	2N2218A	S	800M	A	200	80	40	O	40	120	150M	0.25	150M			60M	T
2N3112 2N3113	Field-Effect Transistors, see Table on Page 2-76																			
2N3114	S	N		2N3114	AH	800M	A	200	150	150	O	30	120	30M	1.0	50M	25	E	40M	T
2N3115	S	N		2N2958	SH	0.4W	A	200	60	20	O	40	120	0.15A	0.5	0.15A			250M	T
2N3116	S	N		2N2958	SH	0.4W	A	200	60	20	O	100	300	0.15A	0.5	0.15A			250M	T
2N3117	S	N			A	360M	A	200	60	60	O	250	500	10*	0.35	1.0M	400	E	60M	T
2N3118	S	N			AH	1.0W	A	200	85	60	O	50	275	25M					250M	T
2N3119	S	N			SH	1.0W	A	200	100	80	O	50	200	100M	0.5	100M			250M	T
2N3120	S	P	2N3120	2N2800	S	800M	A	200	45	45	O	30	130	50M	0.25	50M	25	E	130M	T
2N3121	S	P	2N3120	2N2800	S	360M	A	200	45	45	O	30	130	50M	0.25	50M	25	E	130M	T
2N3122	S	N			A	800M	A	200	50	30	O	25	100	300M	1.5	300M			60M	T
2N3123	S	N			SH	0.8W	A	175	60	30	O	100	300	0.15A	0.4	0.15A			400M	T
2N3124	G	P			AP	90W	C	100	40	30	S	50	100	10A	0.5	10A	20	E	2.5K	E
2N3125	G	P			AP	90W	C	100	80	80	S	30	75	3.0A	1.5	3.0A	10	E	5.0K	E
2N3126	G	P			AP	90W	C	100	100	75	S	10	30	10A	1.0	10A	10	E	6.0K	E
2N3127	G	P		2N3127	AH	0.1W	A	100	30	20	O	20	75	3.0M	0.3	5.0M	20	E	400M	T
2N3128	S	N			A	0.15W	A	150	20	20	O	50	150	0.1M	0.25	1.0M	75	E	60M	T
2N3129	S	N			A	0.15W	A	150	45	45	O	100	300	10N	0.25	1.0M	160	E	60M	T
2N3130	S	N			A	0.15W	A	150	60	60	O	60	180	10N	0.25	1.0M	110	E	60M	T
2N3131	S	N			SH	0.15W	A	150	40	15	O	30	120	10M	0.25	10M			250M	T
2N3132	G	P			SP	90W	C	100	100	70	S	40	200	2.0A	1.5	5.0A			3.0K	E
2N3133	S	P		2N3133	SH	0.6W	A	200	50	35	O	40	120	0.15A	0.6	0.15A			200M	T
2N3134	S	P		2N3133	SH	0.6W	A	200	50	35	O	100	300	0.15A	0.6	0.15A			200M	T
2N3135	S	P		2N3133	SH	0.4W	A	200	50	35	O	40	120	0.15A	0.6	0.15A			200M	T
2N3136	S	P		2N3133	SH	0.4W	A	200	50	35	O	100	300	0.15A	0.6	0.15A			200M	T
2N3137	S	N		2N3137	AH	600M	A	200	40	20	O				0.3	50M			500M	T
2N3138	S	N	2N3766	2N3766	AHP	20W	C	200	65	65	O	10		1.0A					100M	T
2N3139	S	N			AHP	20W	C	200	140	140	O	10		1.0A					100M	T
2N3140	S	N			AHP	20W	C	200	65	65	O	10		1.0A					100M	T
2N3141	S	N			AHP	20W	C	200	140	140	O	10		1.0A					100M	T
2N3142	S	N			AHP	25W	C	200	65	65	O	10		1.0A					100M	T
2N3143	S	N			AHP	25W	C	200	140	140	O	10		1.0A					100M	T
2N3144	S	N			AHP	25W	C	200	65	65	O	10		1.0A					100M	T
2N3145	S	N			AHP	25W	C	200	140	140	O	10		1.0A					100M	T
2N3146	G	P	2N3616	2N3615	AP	150W	C	100	150	140	V	30	90	5.0A	0.4	5.0A	20	E	200K	T
2N3147	G	P	2N3616	2N3615	AP	150W	C	100	180	160	V	30	90	5.0A	0.4	5.0A	20	E	200K	T
2N3148	G	P			S	0.45M	A	100	11	6.0	O	70		20M	0.2	50M	80	E	25M	T
2N3149	S	N			SP	300W	C	200	80	80	O	10		50A	1.5	50A			0.1M	T
2N3150	S	N			SP	300W	C	200	100	100	O	10		50A	1.5	50A			0.1M	T
2N3151	S	N			SP	300W	C	200	150	150	O	10		50A	1.5	50A			0.1M	T
2N3152	S	N			SH	25M	C	200	120	120	O	40		30M			20	E	200M	T
2N3153	S	N			SC	0.3W	A	200	15	15	O								30M	T
2N3154	G	P			SP	37.5W	C	100	40	25	O	60	180	0.5A	1.1	3.0A			15K	E
2N3155	G	P			SP	37.5W	C	100	60	40	O	60	180	0.5A	1.1	3.0A			15K	E
2N3156	G	P			SP	37.5W	C	100	80	55	O	60	180	0.5A	1.1	3.0A			15K	E
2N3157	G	P			SP	37.5W	C	100	100	65	O	60	180	0.5A	1.1	3.0A			15K	E
2N3158	G	P			SP	37.5W	C	100	40	25	O	30	75	0.5A	1.4	3.0A			10K	E
2N3159	G	P			SP	37.5W	C	100	60	40	O	30	75	0.5A	1.4	3.0A			10K	E
2N3160	G	P			SP	37.5W	C	100	80	55	O	30	75	0.5A	1.4	3.0A			10K	E
2N3161	G	P			SP	37.5W	C	100	100	65	O	30	75	0.5A	1.4	3.0A			10K	E
2N3162	S	N	2N3411	2N3409	AM	300M	A	200	45	25	O	50	200	10M	0.5	10M			300M	T
2N3163	S	P			AHP	85W	C	200	40	40	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T
2N3164	S	P			AHP	85W	C	200	60	60	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T
2N3165	S	P			AHP	85W	C	200	80	80	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T
2N3166	S	P			AHP	85W	C	200	100	100	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T
2N3167	S	P	MJ2267	MJ2267	AHP	85W	C	200	40	40	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T
2N3168	S	P	2N3789	2N3789	AHP	85W	C	200	60	60	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T
2N3169	S	P	2N3790	2N3789	AHP	85W	C	200	80	80	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T
2N3170	S	P	2N3790	2N3789	AHP	85W	C	200	100	100	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T
2N3171	S	P			AHP	75W	C	200	40	40	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T
2N3172	S	P			AHP	75W	C	200	60	60	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T
2N3173	S	P			AHP	75W	C	200	80	80	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N3174	S	P			AHP	75W	C	200	100	100	O	12	36	1.0A	0.75	1.0A	10	E	1.0M	T
2N3175	S	P	MJ2267	MJ2267	AHP	85W	C	200	40	40	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3176	S	P	2N3789	2N3789	AHP	85W	C	200	60	60	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3177	S	P	2N3790	2N3789	AHP	85W	C	200	80	80	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3178	S	P	2N3790	2N3789	AHP	85W	C	200	100	100	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3179	S	P	MJ2267	MJ2267	AHP	85W	C	200	40	40	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3180	S	P	2N3789	2N3789	AHP	85W	C	200	60	60	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3181	S	P	2N3790	2N3789	AHP	85W	C	200	80	80	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3182	S	P	2N3790	2N3789	AHP	85W	C	200	100	100	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3183	S	P			AHP	75W	C	200	40	40	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3184	S	P			AHP	75W	C	200	60	60	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3185	S	P			AHP	75W	C	200	80	80	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3186	S	P			AHP	75W	C	200	100	100	O	10	30	2.0A	1.0	2.0A	10	E	1.0M	T
2N3187	S	P	MJ2267	MJ2267	AHP	85W	C	200	40	40	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3188	S	P	2N3789	2N3789	AHP	85W	C	200	60	60	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3189	S	P	2N3790	2N3789	AHP	85W	C	200	80	80	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3190	S	P	2N3790	2N3789	AHP	85W	C	200	100	100	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3191	S	P			AHP	85W	C	200	40	40	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3192	S	P	2N3789	2N3789	AHP	85W	C	200	60	60	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3193	S	P	2N3790	2N3789	AHP	85W	C	200	80	80	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3194	S	P	2N3790	2N3789	AHP	85W	C	200	100	100	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3195	S	P			AHP	75W	C	200	40	40	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3196	S	P			AHP	75W	C	200	60	60	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3197	S	P			AHP	75W	C	200	80	80	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3198	S	P			AHP	75W	C	200	100	100	O	10	30	3.0A	0.9	3.0A	10	E	1.0M	T
2N3199	S	P			AHP	40W	C	200	40	40	O	20	60	1.0A	0.3	1.0A	10	E	1.0M	T
2N3200	S	P	2N3740	2N3740	AHP	40W	C	200	60	60	O	20	60	1.0A	0.3	1.0A	10	E	1.0M	T
2N3201	S	P	2N3741	2N3740	AHP	40W	C	200	80	80	O	20	60	1.0A	0.3	1.0A	10	E	1.0M	T
2N3202	S	P			AHP	8.8W	C	200	40	40	O	20	60	1.0A	0.3	1.0A	10	E	1.0M	T
2N3203	S	P	2N3740	2N3740	AHP	8.8W	C	200	60	60	O	20	60	1.0A	0.3	1.0A	10	E	1.0M	T
2N3204	S	P	2N3741	2N3740	AHP	8.8W	C	200	80	80	O	20	60	1.0A	0.3	1.0A	10	E	1.0M	T
2N3205	S	P			AHP	40W	C	200	40	40	O	20	60	0.5A	0.4	0.5A	10	E	1.0M	T
2N3206	S	P	2N3740	2N3740	AHP	40W	C	200	60	60	O	20	60	0.5A	0.4	0.5A	10	E	1.0M	T
2N3207	S	P	2N3741	2N3740	AHP	40W	C	200	100	100	O	20	60	0.5A	0.4	0.5A	10	E	1.0M	T
2N3208	S	P	2N3740	2N3740	AHP	8.8W	C	200	40	40	O	20	60	0.5A	0.4	0.5A	10	E	1.0M	T
2N3209	S	P		2N3209	S	0.36W	A	200	20	20	O	30	120	30M	0.2	30M			400M	T
2N3210	S	N		2N3210	SH	0.36W	A	200	40	15	O	30	120	10M	0.75	0.2A			300M	T
2N3211	S	N		2N3211	SH	0.36W	A	200	40	15	O	50	150	10M	0.2	10M			350M	T
2N3212	G	P			AP	14W	C	110	100	80	O	30	90	3.0A	0.5	5.0A	3.0	E		
2N3213	G	P			AP	14W	C	110	80	60	O	30	90	3.0A	0.5	5.0A	3.0	E		
2N3214	G	P			AP	14W	C	110	60	40	O	30	90	3.0A	0.5	5.0A	3.0	E		
2N3215	G	P			AP	14W	C	110	40	30	O	25	100	3.0A	0.5	5.0A	3.0	E		
2N3216	G	P			S	150M	A	100	20	10	O	60		200M	0.22	200M			10M	T
2N3217	S	P			SC	400M	A	200	15	10	O								1.0M	T
2N3218	S	P			SC	400M	A	200	25	20	O								1.0M	T
2N3219	S	P			SC	400M	A	200	40	35	O								1.0M	T
2N3220	S	N	2N3767	2N3766	AHP	6.0W	C	175	100	80	O	20	60	1.0A	1.25	1.0A	20	E	10M	T
2N3221	S	N	2N3767	2N3766	AHP	6.0W	C	175	100	80	O	40	120	1.0A	1.25	1.0A	40	E	10M	T
2N3222	S	N	2N3766	2N3766	AHP	6.0W	C	175	80	60	O	20	60	1.0A	1.25	1.0A	20	E	10M	T
2N3223	S	N	2N3766	2N3766	AHP	6.0W	C	175	80	60	O	40	120	1.0A	1.25	1.0A	40	E	10M	T
2N3224	S	P	2N3498	2N3498	AH	0.7W	A	200	100	100	O	20	60	50M			20	E	60M	T
2N3225	S	P	2N3498	2N3498	AH	0.7W	A	200	100	100	O	40	120	50M			40	E	80M	T
2N3226	S	N	2N4913	2N4913	AP	75W	C	200	35	35	O	20	50	2.0A	1.2	2.7A	20	E	30K	E
2N3227	S	N		2N2369	SH	0.36W	A	200	40	20	O	100	300	10M	0.25	10M			500M	T
2N3228	Thyristors, see Table on Page 2-66																			
2N3229	S	N			AHP	17.5W	C	200	105	60	O	5.0		2.5A	1.0	2.5A			150M	T
2N3230	S	N			SHP	25W	C	200	80	60	O	2K	20K	2.0A	1.4	2.0A			40M	T
2N3231	S	N			SHP	25W	C	200	100	80	O	2K	20K	2.0A	1.4	2.0A			40M	T
2N3232	S	N		2N3232	AHP	117W	C	200	80	60	O	18	55	3.0A	2.5	3.0A	10	E	1.0M	E
2N3233	S	N			AHP	117W	C	200	110	100	O	18	55	3.0A	2.5	3.0A	10	E	1.0M	E
2N3234	S	N			AHP	117W	C	200	160	160	O	18	55	3.0A	2.5	3.0A	10	E	1.0M	E
2N3235	S	N		2N3232	AHP	117W	C	200	65	55	O	20	70	4.0A	1.1	4.0A	10	E	1.0M	E
2N3236	S	N	2N3716	2N3713	AHP	150W	C	200	90	90	O	17	60	5.0A	1.1	5.0A	10	E	1.0M	E
2N3237	S	N			AHP	200W	C	200	90	75	O	12	36	10A	2.0	10A	10	E	1.0M	E
2N3238	S	N	2N3716	2N3713	AHP	150W	C	200	80	80	O	8.5	25	10A	3.0	10A	10	E	1.0M	E
2N3239	S	N	2N3716	2N3713	AHP	150W	C	200	80	80	O	8.5	25	10A	1.0	10A	10	E	1.0M	E
2N3240	S	N			AHP	150W	C	200	160	160	O	8.5	25	10A	1.0	10A	10	E	1.0M	E
2N3241	S	N			A	0.5W	A	175	30	25	O	50	300	10M			70	E	50M	T
2N3241A	S	N			A	500M	A	175	30	25	O						175	E	100M	T
2N3242	S	N			A	0.5W	A	175	30	25	O	75		10M			100	E	50M	T
2N3242A	S	N			A	500M	A	175	40	40	O						200	E	100M	T
2N3244	S	P		2N3227	SH	1.0W	A	200	40	40	O	50	150	0.5A	0.3	0.15A			175M	T
2N3245	S	P		2N3227	SH	1.0W	A	200	50	50	O	30	90	0.5A	0.35	0.15A			150M	T
2N3246	S	N			SH	0.35W	A	200	60	45	O	200	600	10*	0.5	5.0M	200	E	60M	T
2N3247	S	N			SH	0.15W	A	150	60	45	O	200	600	10*	0.5	5.0M	200	E	60M	T
2N3248	S	P		2N3248	SH	0.36W	A	200	15	12	O	50	150	0.1M	0.125	10M			250M	T
2N3249	S	P		2N3248	SH	0.36W	A	200	15	12	O	100	300	0.1M	0.125	10M			300M	T
2N3250	S	P		2N3250	SH	0.36W	A	200	50	40	O	50	150	10M	0.25	10M	50	E	250M	T
2N3250A	S	P		2N3250	SH	0.36W	A	200	60	60	O	50	150	10M	0.25	10M	50	E	250M	T
2N3251	S	P		2N3250	SH	0.36W	A	200	50	40	O	100	300	10M	0.25	10M	100	E	300M	T
2N3251A	S	P		2N3250	SH	0.36W	A	200	60	60	O	100	300	10M	0.25	10M	100	E	300M	T
2N3252	S	N		2N3252	SH	1.0W	A	200	60	30	O	30	90	0.5A	0.3	0.15A			200M	T
2N3253	S	N		2N3252	SH	1.0W	A	200	75	40	O	25	75	375M	0.35	0.15A			175M	T
2N3254 thru 2N3259	Thyristors, see Table on Page 2-66																			
2N3260	S	N			SP	200W	C	200	200	200	O	10	40	20A	1.5	20A			0.6M	T
2N3261	S	N			SH	0.3W	A	175	40	15	O	40	150	10M	0.35	0.1A			600M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N3262	S	N			SH	8.75W	C	200	100	80	O	40		0.5A	0.6	1.0A			150M	T
2N3263	S	N			SP	75W	C	200	150	90	O	20	55	15A	1.0	20A			20M	T
2N3264	S	N			SP	75W	C	200	120	60	O	20	80	15A	1.6	20A			20M	T
2N3265	S	N			SP	125W	C	200	150	90	O	20	55	15A	1.0	20A			20M	T
2N3266	S	N			SP	125W	C	200	120	60	O	20	80	15A	1.6	20A			20M	T
2N3267	G	P			AH	75M	A	100	15	8.0	O	10	500	3.0M			15	E	900M	T
2N3268	S	N			A	0.15W	A	200	45	45	O	12	80	10M	1.0	5.0M	40	E	2.5M	B
2N3269 thru 2N3276	Thyristors, see Table on Page 2-66																			
2N3277 2N3278	Field-Effect Transistors, see Table on Page 2-76																			
2N3279	G	P		2N3279	AH	0.1W	A	100	30	20	O	10	70	3.0M	0.3	5.0M	10	E	400M	T
2N3280	G	P		2N3279	AH	0.1W	A	100	30	20	O	10	70	3.0M	0.3	5.0M	10	E	400M	T
2N3281	G	P		2N3279	AH	0.1W	A	100	30	15	O	10	100	3.0M	0.5	5.0M	10	E	300M	T
2N3282	G	P		2N3279	AH	0.1W	A	100	30	15	O	10	100	3.0M	0.5	5.0M	10	E	300M	T
2N3283	G	P		2N3283	AH	0.1W	A	100	25	25	S	10		3.0M			10	E	250M	T
2N3284	G	P		2N3283	AH	0.1W	A	100	25	25	S	10		3.0M			10	E	250M	T
2N3285	G	P		2N3283	AH	0.1W	A	100	20	20	S	5.0		3.0M			5.0	E	250M	T
2N3286	G	P		2N3283	AH	0.1W	A	100	20	20	S	5.0		3.0M			5.0	E	250M	T
2N3287	S	N		2N3287	AH	0.2W	A	200	40	20	O	15	100	2.0M	0.3	5.0M	15	E	350M	T
2N3288	S	N		2N3287	AH	0.2W	A	200	40	20	O	15	100	2.0M	0.3	5.0M	15	E	350M	T
2N3289	S	N		2N3287	AH	0.2W	A	200	30	15	O	10	150	2.0M	0.4	5.0M	10	E	300M	T
2N3290	S	N		2N3287	AH	0.2W	A	200	30	15	O	10	150	2.0M	0.4	5.0M	10	E	300M	T
2N3291	S	N		2N3291	AH	0.2W	A	200	25	25	S	10		2.0M			10	E	250M	T
2N3292	S	N		2N3291	AH	0.2W	A	200	25	25	S	10		2.0M			10	E	250M	T
2N3293	S	N		2N3291	AH	0.2W	A	200	20	20	S	10		2.0M			10	E	250M	T
2N3294	S	N		2N3291	AH	0.2W	A	200	20	20	S	10		2.0M			10	E	250M	T
2N3295	S	N		2N3295	AHP	800M	A	175	60	60	S	20	60	10M	0.5	0.15A			200M	T
2N3296	S	N		2N3296	AHP	700M	A	175	60	60	S	5.0	50	40M	0.5	0.4A			100M	T
2N3297	S	N		2N3297	AHP	25W	C	175	60	60	S	2.5	35	0.4A	0.5	1.0A			100M	T
2N3298	S	N		2N3298	AHP	1.0W	C	175	25	15	O	80	240	10M					200M	T
2N3299	S	N		2N3299	SH	0.8W	A	200	60	30	O	40	120	0.15A	0.22	0.15A			250M	T
2N3300	S	N		2N3299	SH	0.8W	A	200	60	30	O	100	300	0.15A	0.22	0.15A			250M	T
2N3301	S	N		2N3299	SH	0.36W	A	200	60	30	O	40	120	0.15A	0.22	0.15A			250M	T
2N3302	S	N		2N3299	SH	0.36W	A	200	60	30	O	100	300	0.15A	0.22	0.15A			250M	T
2N3303	S	N		2N3303	SH	0.6W	A	200	25	12	O	30	120	0.3A	0.33	0.3A			450M	T
2N3304	S	P		2N3304	S	0.3W	A	200	6.0	6.0	O	30	120	10M	0.16	10M			500M	T
2N3305	S	P			A	0.6W	A	200	50	40	O	40	120	0.1M	0.2	10M	40	E	20M	T
2N3306	S	P			A	0.6W	A	200	50	40	O	100	300	0.1M	0.2	10M	70	E	20M	T
2N3307	S	P		2N3307	AH	0.2W	A	200	40	35	O	40	250	2.0M	0.4	3.0M	40	E	300M	T
2N3308	S	P		2N3307	AH	0.2W	A	200	30	25	O	25	250	2.0M	0.4	3.0M	25	E	300M	T
2N3309	S	N	2N3553	2N3375	AHP	3.5W	C	175	50	50	S	5.0	100	30M	0.5	0.25A			300M	T
2N3309A	S	N	2N3553	2N3375	AHP	5.0W	C	200	60	60	S	8.0	80	50M	0.5	0.25A			300M	T
2N3310	S	N			AHP	0.3W	A	200	35	15	O	10		20M	0.5	20M			300M	T
2N3311	G	P		2N3311	AP	170W	C	110	30	30	S	60	120	3.0A	0.1	3.0A	30	E	1.0K	E
2N3312	G	P		2N3311	AP	170W	C	110	45	45	S	60	120	3.0A	0.1	3.0A	30	E	1.0K	E
2N3313	G	P		2N3311	AP	170W	C	110	60	60	S	60	120	3.0A	0.1	3.0A	30	E	1.0K	E
2N3314	G	P		2N3311	AP	170W	C	110	30	30	S	100	200	3.0A	0.1	3.0A	40	E	1.0K	E
2N3315	G	P		2N3311	AP	170W	C	110	45	45	S	100	200	3.0A	0.1	3.0A	40	E	1.0K	E
2N3316	G	P		2N3311	AP	170W	C	110	60	60	S	100	200	3.0A	0.1	3.0A	40	E	1.0K	E
2N3317	S	P			SC	0.15W	A	140	30	30	O								6.4M	T
2N3318	S	P			SC	0.15W	A	140	15	15	O								7.6M	T
2N3319	S	P			SC	0.15W	A	140	10	6.0	O								12M	T
2N3320	G	P			SH	60M	A	100	15	10	O	50		20M	0.19	40M			600M	T
2N3321	G	P			SH	60M	A	100	12	7.0	O	100		10M	0.12	10M			600M	T
2N3322	G	P			SH	60M	A	100	12	7.0	O	30		40M	0.25	20M			600M	T
2N3323	G	P		2N3323	AH	0.15W	A	100	35	35	S	30	200	3.0M			30	E	200M	T
2N3324	G	P		2N3323	AH	0.15W	A	100	35	35	S	30	200	3.0M			30	E	200M	T
2N3325	G	P		2N3323	AH	0.15W	A	100	35	35	S	30	200	3.0M			30	E	200M	T
2N3326	S	N	2N2218A	2N2218A	SH	0.8W	A	175	60	45	O	40	120	0.15A	0.4	0.15A			250M	T
2N3327	S	N			AHP	20W	C	200	65	65	O	10		0.5A					100M	T
2N3328 thru 2N3336	Field-Effect Transistors, see Table on Page 2-76																			
2N3337	S	N	2N3287	2N3287	AH	0.3W	A	200	40	40	O	30	300	4.0M			30	E	400M	T
2N3338	S	N	2N3289	2N3287	AH	0.3W	A	200	40	40	O	30	300	4.0M			30	E	400M	T
2N3339	S	N	2N3288	2N3287	AH	0.3W	A	200	40	40	O	30	300	4.0M			30	E	400M	T
2N3340	S	N			S	0.4W	A	175	30	20	O	40		10*	0.2	10*			70M	T
2N3341	S	P			S	0.4W	A	175	30	20	O	40		10*	0.25	10*			50M	T
2N3342	S	P			S	0.25W	A	175	20	8.0	O	30		5.0M	0.1	5.0M				
2N3343	S	P			SC	0.25W	A	175	25	8.0	O	20		0.25M					2.0M	T
2N3344	S	P			SC	0.25W	A	175	30	30	O	25		1.0M					2.0M	T
2N3345	S	P			SC	0.25W	A	175	50	50	O	15		1.0M					2.0M	T
2N3346	S	P			SC	0.25W	A	175	50	50	O	25		1.0M					2.0M	T
2N3347	S	P			AM	300M	A	175	60	45	O	40	300	10*	0.5	10M	60	E	60M	T
2N3348	S	P			AM	300M	A	175	60	45	O	40	300	10*	0.5	10M	60	E	60M	T
2N3349	S	P			AM	300M	A	175	60	45	O	40	300	10*	0.5	10M	60	E	60M	T
2N3350	S	P			AM	300M	A	175	60	45	O	100	300	10*	0.5	10M	150	E	60M	T
2N3351	S	P			AM	300M	A	175	60	45	O	100	300	10*	0.5	10M	150	E	60M	T
2N3352	S	P			AM	300M	A	175	60	45	O	100	300	10*	0.5	10M	150	E	60M	T
2N3353 thru 2N3364	Thyristors, see Table on Page 2-66																			
2N3365 thru 2N3370	Field-Effect Transistors, see Table on Page 2-76																			
2N3371	G	P			AH	150M	A	100	25	10	O	20	300	12M			25	E	320M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N3374	S	N			AHP	5.0W	C	200	80	80	O	10		0.17A	0.3	0.15A			230M	T
2N3375	S	N		2N3375	AHP	11.6W	C	200	65	40	O	10	100	0.25A	1.0	0.25A			400M	T
2N3376 thru 2N3387	Field-Effect Transistors, see Table on Page 2-76																			
2N3388	S	N			S	0.6W	A	175	125	100	O	60		2.5M	1.0	2.5M			36M	T
2N3389	S	N			S	0.6W	A	175	195	160	O	60		7.0M	1.0	7.0M			36M	T
2N3390	S	N	MPS6521	MPS6512	A	0.2W	A	125	25	25	O	400	800	2.0M			400	E		
2N3391	S	N	MPS6515	MPS6512	A	0.2W	A	125	25	25	O	250	500	2.0M			250	E		
2N3391A	S	N	MPS6520	MPS6512	A	0.2W	A	125	25	25	O	250	500	2.0M			250	E		
2N3392	S	N	MPS3392	MPS3392	A	0.2W	A	125	25	25	O	150	300	2.0M			150	E		
2N3393	S	N	MPS3393	MPS3392	A	0.2W	A	125	25	25	O	90	180	2.0M			90	E		
2N3394	S	N	MPS3394	MPS3392	A	0.2W	A	125	25	25	O	55	110	2.0M			55	E		
2N3395	S	N	MPS3395	MPS3392	A	0.2W	A	125	25	25	O	150	500	2.0M			150	E		
2N3396	S	N	MPS3396		A	0.2W	A	125	25	25	O	90	500	2.0M			90	E		
2N3397	S	N	MPS3397		A	0.2W	A	125	25	25	O	55	500	2.0M			55	E		
2N3398	S	N	MPS3398		A	0.2W	A	125	25	25	O	55	800	2.0M			55	E		
2N3399	G	P			AH	80M	A	100	20			10		1.5M					400M	T
2N3400	G	P			SH	0.15W	A	100	20	20	O	50	300	10M	0.15	10M			150M	T
2N3401	S	P			SC	0.25W	A	150	25	25	O				0.25	5.0M	4.0	E	0.1M	B
2N3402	S	N	MPS6513	MPS6512	A	0.56W	A	150	25	25	O	75	225	2.0M	0.3	50M	75	E		
2N3403	S	N	MPS6515	MPS6512	A	0.56W	A	150	25	25	O	180	540	2.0M	0.3	50M	180	E		
2N3404	S	N			A	0.56W	A	150	50	50	O	75	225	2.0M	0.3	50M	75	E		
2N3405	S	N			A	0.56W	A	150	50	50	O	180	540	2.0M	0.3	50M	100	E		
2N3406	Unijunction Transistors, see Table on Page 2-86																			
2N3407	S	N			AH	0.2W	A	200	35	18	O	10	100	10M			10	E	300M	T
2N3408	S	P			AH	4.0W	A	200	40	25	O	10	100	40M			10	E	200M	T
2N3409	S	N		2N3409	AM	0.5W	A	200	60	30	O	30	120	0.1M	0.15	10M			250M	T
2N3410	S	N		2N3409	AM	0.5W	A	200	60	30	O	20	100	10*	0.15	10M			250M	T
2N3411	S	N		2N3409	AM	0.5W	A	200	60	30	O	20	100	10*	0.15	10M			250M	T
2N3412	G	P			A	60M	A	100	20	20	S	30	200	10M	0.2	10M	25	E	100M	T
2N3413	S	P			A	0.4W	A	200	150	150	O	10	45	50M	1.2	0.1A			0.25M	T
2N3414	S	N	MPS6513	MPS6512	A	0.36W	A	160	25	25	O	75	225	2.0M	0.3	50M	75	E		
2N3415	S	N	MPS6515	MPS6512	A	0.36W	A	160	25	25	O	180	540	2.0M	0.3	50M	180	E		
2N3416	S	N	MPS6515	MPS6512	A	0.36W	A	160	50	50	O	75	225	2.0M	0.3	50M	75	E		
2N3417	S	N	MPS6515	MPS6512	A	0.36W	A	160	50	50	O	180	540	2.0M	0.3	50M	100	E		
2N3418	S	N			SP	0.8W	A	175	85	60	O	20	60	1.0A	0.25	1.0A			40M	T
2N3419	S	N			SP	0.8W	A	175	125	80	O	20	60	1.0A	0.25	1.0A			40M	T
2N3420	S	N			SP	0.8W	A	175	85	60	O	40	120	1.0A	0.25	1.0A			40M	T
2N3421	S	N			SP	0.8W	A	175	125	80	O	40	120	1.0A	0.25	1.0A			40M	T
2N3422	Thyristors, see Table on Page 2-66																			
2N3423	S	N		2N3423	AM	0.3W	A	200	30	15	O	20	200	3.0M	0.4	10M			600M	T
2N3424	S	N		2N3423	AM	0.3W	A	200	30	15	O	20	200	3.0M	0.4	10M			600M	T
2N3425	S	N		2N3425	AHP	0.3W	A	200	40	15	O	30	120	10M	0.4	10M	20	E	300M	T
2N3426	S	N			SH	0.6W	A	200	25	12	O	30	120	0.3A	0.33	0.3A			450M	T
2N3427	G	P		2N3427	A	0.2W	A	100	45	30	R	100	350	0.1A	0.2	0.1A	200	E	4.0M	T
2N3428	G	P		2N3427	A	0.2W	A	100	45	30	R	150	400	0.1A	0.19	0.1A	350	E	5.0M	T
2N3429	S	N	2N3713	2N3713	SP	150W	C	175	50	50	O	10	35	5.0A	1.0	5.0A			20K	E
2N3430	S	N	2N3714	2N3713	SP	150W	C	175	100	100	O	10	35	5.0A	1.0	5.0A			20K	E
2N3431	S	N			SP	150W	C	175	150	150	O	10	35	5.0A	1.0	5.0A			20K	E
2N3432	S	N			SP	150W	C	175	200	200	O	10	35	5.0A	1.0	5.0A			20K	E
2N3433	S	N			SP	150W	C	175	250	250	O	10	35	5.0A	1.0	5.0A			20K	E
2N3434	S	N			SP	150W	C	175	300	300	O	10	35	5.0A	1.0	5.0A				
2N3435	S	N			AHP	1.0W	A	200	80	60	O	50	200	10M					140M	T
2N3436 thru 2N3438	Field-Effect Transistors, see Table on Page 2-76																			
2N3439	S	N		MJ3201	AH	1.0W	A	200	450	350	O	40	160	20M			25	E	15M	T
2N3440	S	N		MJ3201	AH	1.0W	A	200	300	250	O	40	160	20M			25	E	15M	T
2N3441	S	N		2N3738	AP	25W	C	200	160	140	O	20	80	0.5A	6.0	2.7A	15	E	0.2M	T
2N3442	S	N			AP	100W	C	200	160	140	O	20	70	3.0A	5.0	10A	12	E	80K	T
2N3443	G	P			AH	0.3W	A	100	20	15	O	20	150	10M			20	E	750M	T
2N3444	S	N		2N3252	SH	1.0W	A	200	80	50	O	20	60	0.5A	0.35	0.15A			150M	T
2N3445	S	N		2N3445	AP	115W	C	200	80	60	O	20	60	3.0A	1.5	3.0A	20	E	10M	T
2N3446	S	N		2N3445	AP	115W	C	200	100	80	O	20	60	3.0A	1.5	3.0A	20	E	10M	T
2N3447	S	N		2N3445	AP	115W	C	200	80	60	O	40	120	5.0A	1.5	5.0A	40	E	10M	T
2N3448	S	N		2N3445	AP	115W	C	200	100	80	O	40	120	5.0A	1.5	5.0A	40	E	10M	T
2N3449	G	P			SH	150M	A	100	15	6.0	O	20		10M	0.2	2.0M			300M	T
2N3450	S	N			SH	0.6W	A	200	120	60	O	40	120	0.15A	0.5	0.15A			100M	T
2N3451	S	P			SH	0.3W	A	200	6.0	6.0	O	30	120	10M	0.16	10M			500M	T
2N3452 thru 2N3460	Field-Effect Transistors, see Table on Page 2-76																			
2N3461	G	P			AP	5.0W	C	110	60	30	O	90	150	0.5A	0.4	1.0A	40	E	10K	E
2N3462	S	N			A	0.3W	A	200	50	35	O	100	300	10*	0.35	5.0M	150	E	10M	T
2N3463	S	N			A	0.3W	A	200	60	45	O	120	360	10*	0.35	1.0M	150	E	45M	T
2N3464	S	N			AHP	5.0W	C	200	60	40	O	35	100	0.2A	1.0	0.2A	30	E	50M	T
2N3465 2N3466	Field-Effect Transistors, see Table on Page 2-76																			
2N3467	S	P		2N3467	SH	1.0W	A	200	40	40	O	40	120	0.5A	0.3	0.15A			175M	T
2N3468	S	P		2N3467	SH	1.0W	A	200	50	50	O	25	75	0.5A	0.35	0.15A			150M	T
2N3469	S	N			AHP	1.25W	A	200	35	25	O	100	350	0.5A	0.5	1.0A	100	E	20M	T
2N3470	S	N			AP	150W	C	150	50	50	O	100	500	9.0A	3.5	9.0A	50	E	7.0K	E
2N3471	S	N			AP	150W	C	150	100	100	O	100	500	9.0A	3.5	9.0A	50	E	7.0K	E
2N3472	S	N			AP	150W	C	150	150	150	O	100	500	9.0A	3.5	9.0A	50	E	7.0K	E
2N3473	S	N			AP	150W	C	150	200	200	O	100	500	9.0A	3.5	9.0A	50	E	7.0K	E
2N3474	S	N			AP	150W	C	150	50	50	O	700	10K	4.0A	3.5	9.0A	100	E	4.0K	E
2N3475	S	N			AP	150W	C	150	100	100	O	700	10K	4.0A	3.5	9.0A	100	E	4.0K	E

2N3476–2N3581

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	h_{FE} @ I_C (max)	h_{FE} @ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	$V_{CE(SAT)}$ @ I_C Units	h_{f-}	h_{f-} Subscript	f_- Units	f_- Subscript
2N3476	S	N			AP	150W	C	150	150	150	O	700	10K	4.0A	3.5	9.0A	100	E	4.0K	E
2N3477	S	N			AP	150W	C	150	200	200	O	700	10K	4.0A	3.5	9.0A	100	E	4.0K	E
2N3478	S	N			AH	0.2W	A	200	30	15	O	25	150	2.0M			25	E	750M	T
2N3479 thru 2N3484	Unijunction Transistors, see Table on Page 2-86																			
2N3485	S	P		2N2904	SH	2.0W	C	200	60	40	O	40	120	0.15A	0.4	0.15A			200M	T
2N3485A	S	P		2N2904	SH	2.0W	C	200	60	60	O	40	120	0.15A	0.4	0.15A			200M	T
2N3486	S	P		2N2904	SH	2.0W	C	200	60	40	O	100	300	0.15A	0.4	0.15A			200M	T
2N3486A	S	P		2N2904	SH	2.0W	C	200	60	60	O	100	300	0.15A	0.4	0.15A			200M	T
2N3487	S	N		2N3485	AP	115W	C	200	80	60	O	20	60	3.0A	0.3	1.0A	20	E	10M	T
2N3488	S	N		2N3485	AP	115W	C	200	100	80	O	20	60	3.0A	0.3	1.0A	20	E	10M	T
2N3489	S	N		2N3485	AP	115W	C	200	120	100	O	15	45	3.0A	0.3	1.0A	20	E	10M	T
2N3490	S	N		2N3485	AP	115W	C	200	80	60	O	40	120	5.0A	0.3	1.0A	40	E	10M	T
2N3491	S	N		2N3485	AP	115W	C	200	100	80	O	40	120	5.0A	0.3	1.0A	40	E	10M	T
2N3492	S	N		2N3485	AP	115W	C	200	120	100	O	30	90	5.0A	0.3	1.0A	40	E	10M	T
2N3493	S	N			SH	0.15W	A	200	12	8.0	O	40	120	0.5M	0.15	10*			400M	T
2N3494	S	P		2N3494	AH	0.6W	A	200	80	80	O	35		0.1A	0.3	10M	40	E	200M	T
2N3495	S	P		2N3494	AH	0.6W	A	200	120	120	O	35		0.1M	0.35	10M	40	E	150M	T
2N3496	S	P		2N3494	AH	0.4W	A	200	80	80	O	35		0.1A	0.3	10M	40	E	200M	T
2N3497	S	P		2N3494	AH	0.4W	A	200	120	120	O	35		0.1M	0.35	10M	40	E	150M	T
2N3498	S	N		2N3498	AH	1.0W	A	200	100	100	O	40	120	0.15A	0.2	10M	50	E	150M	T
2N3499	S	N		2N3498	AH	1.0W	A	200	100	100	O	100	300	0.15A	0.2	10M	75	E	150M	T
2N3500	S	N		2N3498	AH	1.0W	A	200	150	150	O	40	120	0.15A	0.2	10M	50	E	150M	T
2N3501	S	N		2N3498	AH	1.0W	A	200	150	150	O	100	300	0.15A	0.2	10M	75	E	150M	T
2N3502	S	P	2N2905	2N2904	SH	0.7W	A	200	45	45	O	115	300	50M	0.25	50M	135	E	200M	T
2N3503	S	P	2N2905A	2N2904	SH	0.7W	A	200	60	60	O	115	300	50M	0.25	50M	135	E	200M	T
2N3504	S	P	2N2907	2N2904	SH	0.4W	A	200	45	45	O	115	300	50M	0.25	50M	135	E	200M	T
2N3505	S	P	2N2907A	2N2904	SH	0.4W	A	200	60	60	O	115	300	50M	0.25	50M	135	E	200M	T
2N3506	S	N		2N3506	SH	1.0W	A	200	60	40	O	40	200	1.5A	1.0	1.5A			60M	T
2N3507	S	N		2N3506	SH	1.0W	A	200	80	50	O	30	150	1.5A	1.0	1.5A			60M	T
2N3508	S	N		2N3506	SH	0.4W	A	200	40	20	O	40	120	10M	0.25	10M			500M	T
2N3509	S	N		2N3506	SH	0.4W	A	200	40	20	O	100	300	10M	0.25	10M			500M	T
2N3510	S	N		2N3510	SH	0.36W	A	200	40	10	O	25	150	0.15A	0.25	10M	20	E	350M	T
2N3511	S	N		2N3510	SH	0.36W	A	200	40	15	O	30	120	0.15A	0.25	10M	20	E	450M	T
2N3512	S	N	2N2537	2N2537	SH	0.8W	A	200	60	35	O	10		0.5A	1.0	0.5A			250M	T
2N3513	S	N	2N2480A	2N2060	AM	0.25W	A	200	80	40	O	50	200	1.0M	1.2	50M	50	E	50M	T
2N3514	S	N			AM	0.25W	A	175	80	40	O	50	200	1.0M	1.2	50M	50	E	50M	T
2N3515	S	N		2N3515	AM	0.25W	A	175	80	40	O	50	200	1.0M	1.2	50M	50	E	50M	T
2N3516	S	N			AM	0.25W	A	200	100	60	O	50	200	1.0M	1.2	50M	50	E	60M	T
2N3517	S	N			AM	0.25W	A	175	100	60	O	50	200	1.0M	1.2	50M	50	E	60M	T
2N3518	S	N		2N3515	AM	0.25W	A	175	100	60	O	50	200	1.0M	1.2	50M	50	E	60M	T
2N3519	S	N			AM	0.25W	A	175	60	30	O	150	600	1.0M	1.0	5.0M	150	E	60M	T
2N3520	S	N			AM	0.25W	A	175	60	30	O	150	600	1.0M	1.0	5.0M	150	E	60M	T
2N3521	S	N			AM	0.3W	A	200	70	55	O	100	300	10*	1.0	10M			30M	T
2N3522	S	N			AM	0.25W	A	200	70	55	O	100	300	10*	1.0	10M			30M	T
2N3523	S	N			AM	0.25W	A	175	70	55	O	100	300	10*	1.0	10M			30M	T
2N3524	S	N			AM	0.25W	A	175	70	55	O	100	300	10*	1.0	10M			30M	T
2N3525	Thyristors, see Table on Page 2-66																			
2N3526	S	N			AH	0.8W	A	200	130	120	O	30	120	30M	1.0	50M	25	E	40M	T
2N3527	S	P			A	0.4W	A	200	30	30	O	25	75	0.1N		0.1N	100	E	5.0M	T
2N3528 thru 2N3541	Thyristors, see Table on Page 2-66																			
2N3543	S	N			AHP	60W	C	200	65	60	O	10	80	4.5A	1.0	4.5A			150M	T
2N3544	S	N		2N3544	AH	0.3W	A	175	25	25	S	25		10M					600M	T
2N3545	S	P			SH	0.36W	A	200	20	20	O	40	120	10M	0.2	10M			250M	T
2N3546	S	P		2N3546	SH	0.36W	A	200	15	12	O	30	120	10M	0.15	10M			700M	T
2N3547	S	P			A	0.36W	A	200	60	60	O	100	500	1.0M	1.0	10M	120	E	45M	T
2N3548	S	P			A	0.4W	A	200	60	45	O	100	300	10*	1.0	10M	150	E	60M	T
2N3549	S	P			A	0.4W	A	200	60	60	O	100	500	10*	1.0	10M	150	E	60M	T
2N3550	S	P			A	0.4W	A	200	60	45	O	200	600	10*	0.9	5.0M	300	E	60M	T
2N3551	S	N			SHP	40W	C	175	115	60	O	20	90	10A	1.0	10A			40M	T
2N3552	S	N			SHP	40W	C	175	140	80	O	20	90	10A	1.0	10A			40M	T
2N3553	S	N		2N3375	AHP	7.0W	C	200	65	40	O	10	100	0.25A	1.0	0.25A			400M	T
2N3554	S	N			SH	0.8W	A	200	60	30	O	25	100	0.75A	0.7	0.75A			150M	T
2N3555 thru 2N3562	Thyristors, see Table on Page 2-66																			
2N3563	S	N			AH	0.2W	A	125	30	12	O	20	200	8.0M			20	E	600M	T
2N3564	S	N			AH	0.2W	A	125	30	15	O	20	500	15M	0.3	20M	20	E	400M	T
2N3565	S	N	MPS6514	MPS6512	A	0.2W	A	125	30	25	O	150	600	1.0M			120	E	40M	T
2N3566	S	N	MPS6514	MPS6512	A	0.3W	A	125	40	30	O	150	600	10M	1.0	0.1A			40M	T
2N3567	S	N	MPS6530	MPS6530	A	0.3W	A	125	80	40	O	40	120	0.15A	0.25	0.15A			60M	T
2N3568	S	N			A	0.3W	A	125	80	60	O	40	120	0.15A	0.25	0.15A			60M	T
2N3569	S	N	MPS6531	MPS6530	A	0.3W	A	125	80	40	O	100	300	0.15A	0.25	0.15A			60M	T
2N3570	S	N			AH	0.2W	A	200	30	15	O	20	150	5.0M			20	E	1.5G	T
2N3571	S	N			AH	0.2W	A	200	25	15	O	20	200	5.0M			20	E	1.5G	T
2N3572	S	N			AH	0.2W	A	200	25	13	O	20	300	5.0M			20	E	1.0G	T
2N3573 thru 2N3575	Field-Effect Transistors, see Table on Page 2-76																			
2N3576	S	P			SH	0.36W	A	200	20	15	O	40	120	10M	0.15	10M			400M	T
2N3577	S	N			AHP	85W	C	175	100	80	O	12	60	1.0A	5.25	1.0A	12	E	10M	T
2N3578	Field-Effect Transistors, see Table on Page 2-76																			
2N3579	S	P			AH	0.4W	A	200	60	60	O	30	120	1.0M	0.5	5.0M	30	E	80M	T
2N3580	S	P			AH	0.4W	A	200	60	60	O	60	240	1.0M	0.5	5.0M	60	E	80M	T
2N3581	S	P			AH	0.4W	A	200	50	40	O	50	150	0.1M	0.5	5.0M	50	E	30M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N3582	S	P			AH	0.4W	A	200	50	40	O	100	300	0.1M	0.5	5.0M	100	E	30M	T
2N3583	S	N			AHP	35W	C	200	250	175	O	40	200	0.5A	5.0	1.0A	25	E	10M	T
2N3584	S	N			SP	35W	C	200	330	250	O	8.0	140	1.0A	0.75	1.0A			10M	T
2N3585	S	N	2N3767	2N3766	SP	35W	C	200	440	300	O	8.0	140	1.0A	0.75	1.0A			10M	T
2N3586	S	P			SC	125M	A	200	45	45	O								0.1M	T
2N3587	S	N			AM	0.3W	A	200	60	45	O	80	500	1.0M	1.0	10M			80M	T
2N3588	G	P			AM	0.1W	A	85	25			20		1.0M					200M	T
2N3589	S	N			AHP	2.0W	A	175	200	200	R	30	90	0.2A	2.0	0.2A	30	E	15M	T
2N3590	S	N			AHP	2.0W	A	175	200	200	R	75	150	0.2A	2.0	0.2A	75	E	15M	T
2N3591	S	N			AHP	1.0W	A	175	200	200	R	30	90	0.2A	2.0	0.2A	30	E	15M	T
2N3592	S	N			AHP	1.0W	A	175	200	200	R	75	150	0.2A	2.0	0.2A	75	E	15M	T
2N3593	S	N			AHP	1.0W	A	175	200	200	R	30	90	0.2A	2.0	0.2A	30	E	15M	T
2N3594	S	N			AHP	1.0W	A	175	200	200	R	75	150	0.2A	2.0	0.2A	75	E	15M	T
2N3595	S	N			AHP	1.5W	A	175	200	200	R	30	90	0.2A	2.0	0.2A	30	E	15M	T
2N3596	S	N			AHP	1.5W	A	175	200	200	R	75	150	0.2A	2.0	0.2A	75	E	15M	T
2N3597	S	N	2N3767	2N3766	SHP	100W	C	200	60	40	O	40	120	10A	0.5	10A	75	E	30M	T
2N3598	S	N	2N3446	2N3445	SHP	100W	C	200	80	60	O	40	120	10A	0.5	10A	75	E	30M	T
2N3599	S	N	2N3447	2N3445	SHP	100W	C	200	100	80	O	40	120	10A	0.5	10A	75	E	30M	T
2N3600	S	N			AH	0.2W	A	200	30	15	O	20	150	3.0M			40	E	850M	T
2N3601	G	P			SP	0.286W	C	100	100	40	O	60	180	1.0A	0.2	0.1A	50	E	20M	T
2N3602	G	P			SP	0.286W	C	100	100	40	O	60	180	1.0A	0.2	0.1A	50	E	20M	T
2N3603	G	P			SP	0.286W	C	100	130	55	O	60	180	1.0A	0.2	0.1A	50	E	20M	T
2N3604	G	P			SP	0.286W	C	100	130	55	O	60	180	1.0A	0.2	0.1A	50	E	20M	T
2N3605	S	N	MPS3646	MPS3646	S	0.2W	A	150	18	14	O	30		10M	0.25	10M			300M	T
2N3605A	S	N			S	320M	A	120	40	15	O	30	120	10M	0.25	10M			300M	T
2N3606	S	N	MPS3646	MPS3646	S	0.2W	A	150	18	14	O	30		10M	0.25	10M			300M	T
2N3606A	S	N			S	320M	A	120	40	15	O	30	120	10M	0.25	10M			300M	T
2N3607	S	N	MPS3646	MPS3646	S	0.2W	A	150	18	14	O	30		10M	0.25	10M			300M	T
2N3608 thru 2N3610	Field-Effect Transistors, see Table on Page 2-76																			
2N3611	G	P		2N3611	AP	85W	C	110	40	30	S	35	70	3.0A	0.25	3.0A	40	E	0.3M	T
2N3612	G	P		2N3611	AP	85W	C	110	60	45	S	35	70	3.0A	0.25	3.0A	40	E	0.3M	T
2N3613	G	P		2N3611	AP	85W	C	110	40	30	S	60	120	3.0A	0.25	3.0A	60	E	0.3M	T
2N3614	G	P		2N3611	AP	85W	C	110	60	45	S	60	120	3.0A	0.25	3.0A	60	E	0.3M	T
2N3615	G	P		2N3615	AP	85W	C	110	80	60	S	30	60	3.0A	0.25	3.0A	40	E	0.3M	T
2N3616	G	P		2N3615	AP	85W	C	110	100	75	S	30	60	3.0A	0.25	3.0A	40	E	0.3M	T
2N3617	G	P		2N3615	AP	85W	C	110	80	60	S	45	90	3.0A	0.25	3.0A	60	E	0.3M	T
2N3618	G	P		2N3615	AP	85W	C	110	100	75	S	45	90	3.0A	0.25	3.0A	60	E	0.3M	T
2N3619	S	N			AHP	7.5W	C	175	75	40	O	40		1.0A	0.75	1.0A			200M	T
2N3620	S	N			AHP	7.5W	C	175	75	40	O	40		1.0A	1.0	3.0A			200M	T
2N3621	S	N			AHP	30W	C	175	75	40	O	40		1.0A	1.25	5.0A			200M	T
2N3622	S	N			AHP	30W	C	175	75	40	O	40		1.0A	1.25	5.0A			200M	T
2N3623	S	N			AHP	7.5W	C	175	75	40	O	40		1.0A	0.75	1.0A			200M	T
2N3624	S	N			AHP	7.5W	C	175	75	40	O	40		1.0A	1.0	3.0A			200M	T
2N3625	S	N			AHP	30W	C	175	75	40	O	40		1.0A	1.25	5.0A			200M	T
2N3626	S	N			AHP	30W	C	175	75	40	O	40		1.0A	1.25	5.0A			200M	T
2N3627	S	N			AHP	7.5W	C	175	100	50	O	40		1.0A	0.75	1.0A			200M	T
2N3628	S	N			AHP	7.5W	C	175	100	50	O	40		1.0A	1.0	3.0A			200M	T
2N3629	S	N			AHP	30W	C	175	100	50	O	40		1.0A	1.25	5.0A			200M	T
2N3630	S	N			AHP	30W	C	175	100	50	O	40		1.0A	1.25	5.0A			200M	T
2N3631	Field-Effect Transistors, see Table on Page 2-76																			
2N3632	S	N		2N3375	AHP	23W	C	200	65	40	O	10	150	0.25A	1.0	1.0A			250M	T
2N3633	S	N			SH	0.3W	A	200	15	6.0	O	50	150	10M	0.21	3.0M			1.3G	T
2N3634	S	P		2N3634	AH	1.0W	A	200	140	140	O	50	150	50M			40	E	150M	T
2N3635	S	P		2N3634	AH	1.0W	A	200	140	140	O	100	300	50M			80	E	200M	T
2N3636	S	P		2N3634	AH	1.0W	A	200	175	175	O	50	150	50M			40	E	150M	T
2N3637	S	P		2N3634	AH	1.0W	A	200	175	175	O	100	300	50M			80	E	200M	T
2N3638	S	P			SH	0.3W	A	125	25	25	O	30		50M	0.25	50M	25	E	100M	T
2N3638A	S	P			SH	0.3W	A	125	25	25	O	100		50M	0.25	50M	100	E	150M	T
2N3639	S	P	MPS3639	MPS3639	SH	0.2W	A	125	6.0	6.0	O	30	120	10M	0.16	10M			500M	T
2N3640	S	P	MPS3640	MPS3640	SH	0.2W	A	125	12	12	O	30	120	10M	0.2	10M			500M	T
2N3641	S	N	MPS6530	MPS6530	AHP	0.35W	A	125	60	30	O	40	120	0.15A	0.22	0.15A			250M	T
2N3642	S	N	MPS6530	MPS6530	AHP	0.35W	A	125	60	45	O	40	120	0.15A	0.22	0.15A			250M	T
2N3643	S	N	MPS6531	MPS6530	AHP	0.35W	A	125	60	30	O	100	300	0.15A	0.22	0.15A			250M	T
2N3644	S	P			SH	0.3W	A	125	45	45	O	115	300	50M	0.25	50M			200M	T
2N3645	S	P			SH	0.3W	A	125	60	60	O	115	300	50M	0.25	50M			200M	T
2N3646	S	N	MPS3646	MPS3646	SH	0.2W	A	125	40	15	O	30	120	30M	0.2	30M			350M	T
2N3647	S	N		2N3510	SH	0.4W	A	200	40	10	O	25	150	0.15A	0.25	10M	20	E	350M	T
2N3548	S	N		2N3510	SH	0.4W	A	200	40	15	O	30	120	0.15A	0.25	10M	20	E	450M	T
2N3649 thru 2N3658	Thyristors, see Table on Page 2-66																			
2N3659	S	N			AH	4.0W	C	200	220	170	O	20		10M			20	E	50M	T
2N3660	S	P	2N3719		AHP	5.0W	C	200	40	30	O	25	100	0.5A	1.2	0.5A			25M	T
2N3661	S	P	2N3720		AHP	5.0W	C	200	60	50	O	25	100	0.5A	1.2	0.5A			25M	T
2N3662	S	N			AH	0.2W	A	125	18	12	O	20		8.0M					700M	T
2N3663	S	N			AH	0.2W	A	125	30	12	O	20		8.0M					700M	T
2N3664	S	N		2N3664	AHP	5.0W	C	200	60	60	S	8.0	80	50M	0.75	0.25A			300M	T
2N3665	S	N			S	5.0W	C	200	120	80	O	40	120	0.15A	0.5	0.15A			60M	T
2N3666	S	N			S	5.0W	C	200	120	80	O	100	300	0.15A	0.5	0.15A			60M	T
2N3667	S	N	2N3715	2N3713	SP	117W	C	200	50	50	O	15	60	8.0A	1.5	8.0A			0.5M	T
2N3668 thru 2N3670	Thyristors, see Table on Page 2-66																			
2N3671	S	P			S	0.6W	A	200	60	50	O	75	225	0.15A	0.4	0.15A			200M	T
2N3672	S	P			S	0.4W	A	200	60	50	O	75	225	0.15A	0.4	0.15A			200M	T
2N3673	S	P			S	0.35W	A	200	60	50	O	75	225	0.15A	0.4	0.15A			200M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N3675	S	N	2N4238	2N4237	SP	8.8W	C	200	90	55	O	12	60	1.0A	0.8	1.0A			1.0M	T
2N3676	S	N	2N4239	2N4237	SP	8.8W	C	200	90	90	O	12	60	1.0A	0.8	1.0A			1.0M	T
2N3677	S	P			SC	0.4W	A	200	30	20	O								5.0M	T
2N3678	S	N			SH	0.8W	A	200	75	55	O	40	120	0.15A	0.4	0.15A			250M	T
2N3679	Unijunction Transistors, see Table on Page 2-86																			
2N3680	S	N			AM	0.3W	A	200	60	50	O	150	600	10*	0.7	10M	300	E	60M	T
2N3681	S	N			AH	0.2W	A	200	10	7.0	O	20	220	2.0M	0.37	4.0M	20	E	1.0G	T
2N3682	S	N			AH	0.36W	A	200	40	15	O	40	120	10M			45	E	600M	T
2N3683	S	N			AH	0.2W	A	200	30	12	O	20	150	8.0M			30	E	1.0G	T
2N3684,A thru 2N3687,A	Field-Effect Transistors, see Table on Page 2-76																			
2N3688	S	N			AH	0.2W	A	125	40	40	O	30		4.0M					400M	T
2N3689	S	N			AH	0.2W	A	125	40	40	O	30		4.0M					400M	T
2N3690	S	N			AH	0.2W	A	125	40	40	O	30		4.0M					400M	T
2N3691	S	N	MPS6512	MPS6512	A	0.2W	A	125	35	20	O	40	160	10M	0.7	10M	40	E	200M	T
2N3692	S	N	MPS6513	MPS6512	A	0.2W	A	125	35	20	O	100	400	10M	0.7	10M	100	E	200M	T
2N3693	S	N			AH	0.2W	A	125	45	45	O	40	160	10M					200M	T
2N3694	S	N			AH	0.2W	A	125	45	45	O	100	400	10M					200M	T
2N3695 thru 2N3698	Field-Effect Transistors, see Table on Page 2-76																			
2N3700	S	N			AH	0.5W	A	200	140	80	O	100	300	0.15A	0.2	0.15A	80	E	100M	T
2N3701	S	N			AH	0.5W	A	200	140	80	O	40	120	0.15A	0.2	0.15A	30	E	80M	T
2N3702	S	P			A	0.3W	A	150	40	25	O	60	300	50M	0.25	50M			100M	T
2N3703	S	P			A	0.3W	A	150	50	30	O	30	150	50M	0.25	50M			100M	T
2N3704	S	N			A	0.36W	A	150	50	30	O	100	300	50M	0.6	0.1A			100M	T
2N3705	S	N			A	0.36W	A	150	50	30	O	50	150	50M	0.8	0.1A			100M	T
2N3706	S	N			A	0.36W	A	150	40	20	O	30	600	50M	1.0	0.1A			100M	T
2N3707	S	N			A	0.25W	A	150	30	30	O	100	400	0.1M	1.0	10M	100	E		
2N3708	S	N			A	0.25W	A	150	30	30	O	45	660	1.0M	1.0	10M	45	E		
2N3709	S	N			A	0.25W	A	150	30	30	O	45	165	1.0M	1.0	10M	45	E		
2N3710	S	N			A	0.25W	A	150	30	30	O	90	330	1.0M	1.0	10M	90	E		
2N3711	S	N			A	0.25W	A	150	30	30	O	180	660	1.0M	1.0	10M	180	E		
2N3712	S	N		2N3712	AH	0.8W	A	200	150	150	O	30	150	30M	2.0	50M	25	E	40M	T
2N3713	S	N		2N3713	AHP	150W	C	200	80	60	O	25	75	1.0A	1.0	5.0A	25	E	30K	E
2N3714	S	N		2N3713	AHP	150W	C	200	100	80	O	25	75	1.0A	1.0	5.0A	25	E	30K	E
2N3715	S	N		2N3713	AHP	150W	C	200	80	60	O	50	150	1.0A	0.8	5.0A	25	E	30K	E
2N3716	S	N		2N3713	AHP	150W	C	200	100	80	O	50	150	1.0A	0.8	5.0A	25	E	30K	E
2N3717	S	N			AHP	7.5W	C	200	60	60	S	2.0	100	0.5A	1.0	0.5A			250M	T
2N3718	S	N			AHP	10W	C	200	60	60	S	2.0	100	0.5A	1.0	0.5A			250M	T
2N3719	S	P		2N3719	SHP	6.0W	C	200	40	40	O	25	180	1.0A	1.5	0.3A			60M	T
2N3720	S	P		2N3719	SHP	6.0W	C	200	60	60	O	25	180	1.0A	1.5	3.0A			60M	T
2N3721	S	N	MP3731		A	0.2W	A	125	18	18	O						60	E		
2N3722	S	N		2N3722	S	0.8W	A	200	80	60	O	40	150	0.1A	0.22	0.1A			300M	T
2N3723	S	N		2N3722	SH	0.8W	A	200	100	80	O	40	150	0.1A	0.25	10M			300M	T
2N3724	S	N			SH	0.8W	A	200	50	30	O	60	150	0.1A	0.2	0.1A			300M	T
2N3724A	S	N			SH	1W	A		50	30	O	60	150	100M	0.2	100M				
2N3725	S	N			SH	0.8W	A	200	80	50	O	60	150	0.1A	0.26	0.1A			300M	T
2N3725A	S	N			SH	1W	A		80	50	O	60	150	100M	0.26	100M	3	E		
2N3726	S	P			AM	0.4W	A	200	45	45	O	135	350	1.0M	0.25	50M	135	E	200M	T
2N3727	S	P			AM	0.4W	A	200	45	45	O	135	350	1.0M	0.25	50M	135	E	200M	T
2N3728	S	N			AM	0.45W	A	200	60	30	O	80	280	0.15A	0.22	0.15A	50	E	250M	T
2N3729	S	N			AM	0.45W	A	200	60	30	O	80	280	0.15A	0.22	0.15A	50	E	250M	T
2N3730	G	P			AP	10W	A	100	200	200	S									
2N3731	G	P			AP	5.0W	A	100	320	320	S	15		6.0A						
2N3732	G	P			AP	3.0W	A	100	100	100	S	35	500	0.7A					1.0M	T
2N3733	S	N		2N3733	AHP	23W	C	200	65	40	O	10	150	0.25A	1.0	1.0A			250M	T
2N3734	S	N		2N3734	SH	1.0W	A	200	50	30	O	30	120	1.0A	0.2	10M			300M	T
2N3734A	S	N			SH	1.0W	A		50	30	O	30	120	1.0A	0.9	1.0A	2.5	E		
2N3735	S	N		2N3734	SH	1.0W	A	200	75	50	O	20	80	1.0A	0.2	10M			250M	T
2N3735A	S	N			SH	1.0W	A		75	50	O	20	80	1.0A	0.9	1.0A	2.5	E		
2N3736	S	N		2N3734	SH	0.5W	A	200	50	30	O	30	120	1.0A	0.2	10M			300M	T
2N3736A	S	N			SH	0.5W	A		50	30	O	30	120	1.0A	0.9	1.0A	2.5	E		
2N3737	S	N		2N3734	SH	0.5W	A	200	75	50	O	20	80	1.0A	0.2	10M			250M	T
2N3737A	S	N			SH	0.5W	A		75	50	O	20	80	1.0A	0.9	1.0A	2.5	E		
2N3738	S	N		2N3738	AP	20W	C	175	250	225	O	40	200	0.1A	2.5	0.25A	35	E	15M	T
2N3739	S	N		2N3738	AP	20W	C	175	325	300	O	40	200	0.1A	2.5	0.25A	35	E	15M	T
2N3740,A	S	P		2N3740	AP	25W	C	200	60	60	O	30	100	0.25A	0.6	1.0A	25	E	4.0M	T
2N3741,A	S	P		2N3740	AP	25W	C	200	80	80	O	30	100	0.25A	0.6	1.0A	25	E	4.0M	T
2N3742	S	N		2N3742	AH	1.0W	A	200	300	300	O	20	200	30M	1.0	10M	20	E	30M	T
2N3743	S	P		2N3743	AH	1.0W	A	200	300	300	O	25	250	30M	5.0	10M	30	E	30M	T
2N3744	S	N			AHP	30W	C	200	60	40	O	20	60	1.0A	0.25	1.0A	20	E	30M	T
2N3745	S	N			AHP	30W	C	200	80	60	O	20	60	1.0A	0.25	1.0A	20	E	30M	T
2N3746	S	N			AHP	30W	C	200	100	80	O	20	60	1.0A	0.25	1.0A	20	E	30M	T
2N3747	S	N			AHP	30W	C	200	60	40	O	40	120	1.0A	0.25	1.0A	40	E	40M	T
2N3748	S	N			AHP	30W	C	200	80	60	O	40	120	1.0A	0.25	1.0A	40	E	40M	T
2N3749	S	N			AHP	30W	C	200	100	80	O	40	120	1.0A	0.25	1.0A	40	E	40M	T
2N3750	S	N			AHP	30W	C	200	60	40	O	100	300	1.0A	0.25	1.0A	100	E	50M	T
2N3751	S	N			AHP	30W	C	200	80	60	O	100	300	1.0A	0.25	1.0A	100	E	50M	T
2N3752	S	N			AHP	30W	C	200	100	80	O	100	300	1.0A	0.25	1.0A	100	E	50M	T
2N3753 thru 2N3761	Thyristors, see Table on Page 2-66																			
2N3762	S	P		2N3762	SH	1.0W	A	200	40	40	O	30	120	1.0A	0.1	10M			180M	T
2N3763	S	P		2N3762	SH	1.0W	A	200	60	60	O	20	80	1.0A	0.1	10M			150M	T
2N3764	S	P		2N3762	SH	0.5W	A	200	40	40	O	30	120	1.0A	0.1	10M			180M	T
2N3765	S	P		2N3762	SH	0.5W	A	200	60	60	O	20	80	1.0A	0.1	10M			150M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N3766	S	N		2N3766	AP	20W	C	175	80	60	O	40	160	0.5A	2.5	1.0A	40	E	15M	T
2N3767	S	N		2N3766	AP	20W	C	175	100	80	O	40	160	0.5A	2.5	1.0A	40	E	15M	T
2N3770	G	P			AH	50M	A	100	10	6.0	O	10	200	1.0M			10	E	100M	T
2N3771	S	N			AP	150W	C	200	50	40	O	15	60	15A	2.0	15A	40	E	0.2M	T
2N3772	S	N		2N3713	AP	150W	C	200	100	60	O	15	60	10A	1.4	10A	40	E	0.2M	T
2N3773	S	N			AP	150W	C	200	160	140	O	15	60	8.0A	1.4	8.0A	40	E	0.2M	T
2N3774	S	P	2N4234	2N4234	SP	5.0W	C	200	40	40	O	20	60	0.2A	0.2	0.2A			1.0M	T
2N3775	S	P	2N4235	2N4234	SP	5.0W	C	200	60	60	O	20	60	0.2A	0.2	0.2A			1.0M	T
2N3776	S	P	2N4236	2N4234	SP	5.0W	C	200	80	80	O	20	60	0.2A	0.2	0.2A			1.0M	T
2N3777	S	P	2N4236	2N4234	SP	5.0W	C	200	100	100	O	20	60	0.2A	0.2	0.2A			1.0M	T
2N3778	S	P	2N4234	2N4234	SP	5.0W	C	200	40	40	O	10	40	0.2A	0.2	0.2A			1.0M	T
2N3779	S	P	2N4235	2N4234	SP	5.0W	C	200	60	60	O	10	40	0.2A	0.2	0.2A			1.0M	T
2N3780	S	P	2N4236	2N4234	SP	5.0W	C	200	80	80	O	10	40	0.2A	0.2	0.2A			1.0M	T
2N3781	S	P	2N4236	2N4234	SP	5.0W	C	200	100	100	O	10	40	0.2A	0.2	0.2A			1.0M	T
2N3782	S	P	2N4234	2N4234	SP	5.0W	C	200	40	40	O	10	60	1.0A	0.75	1.0A			1.0M	T
2N3783	G	P		2N3783	AH	0.15W	A	100	30	20	O	20	200	3.0M	0.25	5.0M	20	E	0.8G	T
2N3784	G	P		2N3783	AH	0.15W	A	100	30	20	O	20	200	3.0M	0.25	5.0M	20	E	0.7G	T
2N3785	G	P		2N3783	AH	0.15W	A	100	15	12	O	15	200	3.0M	0.35	5.0M	15	E	0.7G	T
2N3788	S	N			AP	100W	C	200	400	325	O	20	180	0.50A					50K	E
2N3789	S	P		2N3789	AP	150W	C	200	60	60	O	25	90	1.0A	1.0	5.0A	25	E	30K	E
2N3790	S	P		2N3789	AP	150W	C	200	60	80	O	25	90	1.0A	1.0	5.0A	25	E	30K	E
2N3791	S	P		2N3789	AP	150W	C	200	60	60	O	50	180	1.0A	1.0	5.0A	25	E	30K	E
2N3792	S	P		2N3789	AP	150W	C	200	80	80	O	50	180	1.0A	1.0	5.0A	25	E	30K	E
2N3793	S	N	MPS6530	MPS6530	A	0.25W	A	125	40	20	O	20	120	10M	0.4	10M			100M	T
2N3794	S	N	MPS6531	MPS6530	A	0.25W	A	125	40	20	O	100	600	10M	0.4	10M			100M	T
2N3795	S	P			SP	5.0W	C	200	120	120	O	12	36	10M	0.2	10M			0.5M	T
2N3796 2N3797	Field-Effect Transistors, see Table on Page 2-76																			
2N3798	S	P		2N3798	A	0.36W	A	200	60	60	O	150	450	0.5M	0.2	0.1M	150	E	30M	T
2N3799	S	P		2N3798	A	0.36W	A	200	60	60	O	300	900	0.5M	0.2		300	E	30M	T
2N3800	S	P		2N3800	A	0.25W	A	200	60	60	O	150	450	0.1M	0.2	0.1M	150	E	100M	T
2N3801	S	P		2N3800	A	0.25W	A	200	60	60	O	300	900	0.1M	0.2	0.1M	300	E	100M	T
2N3802	S	P		2N3800	AM	0.25W	A	200	60	60	O	150	450	0.1M	0.2	0.1M	150	E	100M	T
2N3803	S	P		2N3800	AM	0.25W	A	200	60	60	O	300	900	0.1M	0.2	0.1M	300	E	100M	T
2N3804	S	P		2N3800	AM	0.25W	A	200	60	60	O	150	450	0.1M	0.2	0.1M	150	E	100M	T
2N3804A	S	P		2N3804A	AM	0.25W	C		60	60	O	150	450	100*	0.2	100*	150	E	30M	T
2N3805	S	P		2N3800	AM	0.25W	A	200	60	60	O	300	900	0.1M	0.2	0.1M	300	E	100M	T
2N3805A	S	P		2N3804A	AM	0.25W	C		60	60	O	300	900	100*	0.2	100*	300	E	30M	T
2N3806	S	P		2N3800	A	0.5W	A	200	60	60	O	150	450	0.1M	0.2	0.1M	150	E	100M	T
2N3807	S	P		2N3800	A	0.5W	A	200	60	60	O	300	900	0.1M	0.2	0.1M	300	E	100M	T
2N3808	S	P		2N3800	AM	0.5W	A	200	60	60	O	150	450	0.1M	0.2	0.1M	150	E	100M	T
2N3809	S	P		2N3800	AM	0.5W	A	200	60	60	O	300	900	0.1M	0.2	0.1M	300	E	100M	T
2N3810	S	P		2N3800	AM	0.5W	A	200	60	60	O	150	450	0.1M	0.2	0.1M	150	E	100M	T
2N3810A	S	P		2N3804A	AM	0.50W	A		60	60	O	150	450	100*	0.2	100*	150	E	30M	T
2N3811	S	P		2N3800	AM	0.5W	A	200	60	60	O	300	900	0.1M	0.2	0.1M	300	E	100M	T
2N3811A	S	P		2N3804A	AM	0.50W	A		60	60	O	300	900	100*	0.2	100*	300	E	30M	T
2N3812	S	P		2N3800	AM	350M	A	200	60	60	O	150	450	0.1M	0.2	0.1M	150	E	100M	T
2N3813	S	P		2N3800	AM	350M	A	200	60	60	O	300	900	0.1M	0.2	0.1M	300	E	100M	T
2N3814	S	P		2N3800	AM	350M	A	200	60	60	O	150	450	0.1M	0.2	0.1M	150	E	100M	T
2N3815	S	P		2N3800	AM	350M	A	200	60	60	O	300	900	0.1M	0.2	0.1M	300	E	100M	T
2N3816	S	P		2N3800	AM	350M	A	200	60	60	O	150	450	0.1M	0.2	0.1M	150	E	100M	T
2N3816A	S	P		2N3804A	AM	0.25W	C		60	60	O	150	450	100*	0.2	100*	150	E	30M	T
2N3817	S	P		2N3800	AM	350M	A	200	60	60	O	300	900	0.1M	0.2	0.1M	300	E	100M	T
2N3817A	S	P		2N3804A	AM	0.25W	C		60	60	O	300	900	100*	0.2	100*	300	E	30M	T
2N3818	S	N		2N3818	AHP	25W	C	175	60	60	S	5.0	50	400M	0.5	1.0A	3.0	E		
2N3819 thru 2N3824	Field-Effect Transistors, see Table on Page 2-76																			
2N3825	S	N	MPS3398		AH	0.25W	A	150	30	15	O	20		2.0M	0.25	2.0M			200M	T
2N3826	S	N	MPS3826		AH	0.2W	A	150	60	45	O	40	160	10M					200M	T
2N3827	S	N	MPS3827		AH	0.2W	A	150	60	45	O	100	400	10M					200M	T
2N3828	S	N	MPS6565	MPS6565	AH	0.3W	A	150	40	40	O	30	200	12M					360M	T
2N3829	S	P			SH	0.36W	A	200	35	20	O	30	120	30M	0.18	10M			350M	T
2N3830	S	N			SH	1.0W	A	200	80	50	O	30		0.15A	0.3	0.15A			200M	T
2N3831	S	N			SH	1.0W	A	200	70	40	O	35		0.15A	0.3	0.15A			200M	T
2N3832	S	N			SH	0.2W	A	200	15	6.0	O	25	125	2.0M	0.4	10M			800M	T
2N3833	S	N			AHP				25	15	O	20		30M			2.5	E		
2N3834	S	N			AHP				25	15	O	20		30M			2.5	E		
2N3835	S	N			AHP				25	15	O	20		30M			2.5	E		
2N3836	S	N			SHP	1.0W	A	200	80	60	O	2K	20K	2.0A	1.8	5.0A			40M	T
2N3837	S	N			SHP	1.0W	A	200	100	80	O	2K	20K	2.0A	1.8	5.0A			40M	T
2N3838	S	N,P		2N3838	SH	0.25W	A	200	60	40	O	100	300	0.15A	0.4	0.15A	60	E	200M	T
2N3839	S	N		2N2857	AH	200M	A	200	30	15	O	30		3.0M					2.0G	T
2N3840	S	P			SC	0.4W	A	200	50	50	O	30		0.2M	0.1	5.0M			6.0M	T
2N3841	S	P			SC	0.3W	A	200	100	100	O	15		0.2M	0.12	5.0M			1.5M	T
2N3842	S	P			SC	0.3W	A	200	120	120	O	10		1.0M		5.0M			1.0M	T
2N3843	S	N	MPS6512	MPS6512	AH	0.2W	A	125	30	30	O	20	40	2.0M					60M	T
2N3843A	S	N	MPS6512	MPS6512	AH	0.2W	A	125	30	30	O	20	40	2.0M					60M	T
2N3844	S	N	MPS6512	MPS6512	AH	0.2W	A	125	30	30	O	35	70	2.0M					90M	T
2N3844A	S	N	MPS6512	MPS6512	AH	0.2W	A	125	30	30	O	35	70	2.0M					90M	T
2N3845	S	N	MPS6512	MPS6512	AH	0.2W	A	125	30	40	O	60	120	2.0M					126M	T
2N3845A	S	N	MPS6513	MPS6512	AH	0.2W	A	125	30	30	O	60	120	2.0M					126M	T
2N3846	S	N			AP	4.0W	A	175	300	200	O	10	60	10A	0.75	10A	50	E	10M	T
2N3847	S	N			AP	4.0W	A	175	400	300	O	10	60	10A	0.75	10A	50	E	10M	T
2N3848	S	N			AP	4.0W	A	175	300	300	O	10	60	15A	1.0	15A	50	E	10M	T
2N3849	S	N			AP	4.0W	A	175	400	300	O	10	60	15A	1.0	15A	50	E	10M	T
2N3850	S	N			SHP	30W	C	200	100	80	O	50	150	1.0A	0.25	1.0A			20M	T
2N3851	S	N			SHP	30W	C	200	100	80	O	30	90	1.0A	0.25	1.0A			20M	T
2N3852	S	N			SHP	30W	C	200	60	40	O	50	150	1.0A	0.25	1.0A			20M	T
2N3853	S	N			SHP	30W	C	200	60	40	O	30	90	1.0A	0.25	1.0A			20M	T
2N3854	S	N	MPS6512	MPS6512	AH	0.2W	A	150	18	18	O	35	70	2.0M					100M	T
2N3854A	S	N	MPS6512	MPS6512	AH	0.2W	A	150	30	30	O	35	70	2.0M					100M	T
2N3855	S	N	MPS6512	MPS6512	AH	0.2W	A	150	18	18	O	60	120	2.0M					130M	T
2N3855A	S	N	MPS6512	MPS6512	AH	0.2W	A	150	30	30	O	60	120	2.0M					130M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N3856	S	N	MPS6513	MPS6512	AH	0.2W	A	150	18	18	O	100	200	2.0M					140M	T
2N3856A	S	N	MPS6513	MPS6512	AH	0.2W	A	150	30	30	O	100	200	2.0M					140M	T
2N3857	S	P			A	0.6W	A	200	45	45	O	50	200	1.0M	0.1	10M	45	E	4.0M	T
2N3858	S	N	MPS6512	MPS6512	AH	0.2W	A	125	30	30	O	60	120	2.0M					90M	T
2N3858A	S	N	MPS6566	MPS6565	AH	200M	A	100	60	60	O	45		1.0M					90M	T
2N3859	S	N	MPS6513	MPS6512	AH	0.2W	A	125	30	30	O	100	200	2.0M					90M	T
2N3859A	S	N	MPS6566	MPS6565	A	200M	A	100	60	60	O	75		1.0M					90M	T
2N3860	S	N	MPS6514	MPS6512	AH	0.2W	A	125	30	30	O	150	300	2.0M					90M	T
2N3861	S	N			AP	2.0W	A	175	530	530	V	30	200	25M	1.5	25M	20	E	50M	T
2N3862	S	N			S	0.36W	A	200	50	20	O	50	150	10M	0.25	10M			600M	T
2N3863	S	N	2N3715	2N3713	SP	117W	C	200	70	50	O	30	90	3.0A	1.0	3.0A			0.5M	T
2N3864	S	N	2N3716	2N3713	SP	117W	C	200	110	90	O	30	90	3.0A	1.0	3.0A			0.5M	T
2N3865	S	N			SP	117W	C	200	160	150	O	30	90	3.0A	1.0	3.0A			0.5M	T
2N3866	S	N		2N3866	AHP	5.0W	C	200	55	30	O	10	200	50M	1.0	0.1A			250M	T
2N3867	S	P			SH	1.0W	A	200	40	40	O	40	200	1.5A	0.75	1.5A			60M	T
2N3868	S	P			SH	1.0W	A	200	60	60	O	30	150	1.5A	0.75	1.5A			60M	T
2N3869	S	N			AHP	2.5W	C	175	40	20	O	20	150	30M	0.7	0.45A			0.4G	T
2N3870 thru 2N3873	Thyristors, see Table on Page 2-66																			
2N3876	S	N			AP	150W	C	175	140	50	O	25	150	10A	1.0	10A	80	E	50M	T
2N3877	S	N	2N4410	2N4409	A	0.2W	A	150	70	70	O	20	250	2.0M						
2N3877A	S	N	2N4410	2N4409	A	0.2W	A	150	85	85	O	20	250	2.0M						
2N3878	S	N			AHP	35W	C	200	120	50	O	40	200	0.5A	2.0	4.0A	40	E	40M	T
2N3879	S	N			SP	35W	C	200	120	75	O	12	100	4.0A	1.2	4.0A			40M	T
2N3880	S	N			AH	0.2W	A	200	30	15	O	30	200	3.0M			50	E	1.2G	T
2N3881	S	N			AH	0.6W	A	200	60	35	O				1.5	0.15A	50	E	70M	T
2N3882	Field-Effect Transistors, see Table on Page 2-76																			
2N3883	G	P		2N3883	SH	0.3W	A	100	25	15	O	30		0.2A	0.5	0.2A			100M	T
2N3884 thru 2N3899	Thyristors, see Table on Page 2-66																			
2N3900	S	N	2N5088	2N5088	A	0.2W	A	125	18	18	O	250	500	2.0M			170	E		
2N3900A	S	N	2N5088	2N5088	A	0.2W	A	125	18	18	O	250	500	2.0M			170	E		
2N3901	S	N	2N5088	2N5088	A	0.2W	A	125	18	18	O	350	700	2.0M			350	E		
2N3902	S	N			SP	100W	C	150	400	400	O	20	100	1.0A	2.5	2.5A			40K	E
2N3903	S	N		2N3903	SH	0.31W	A	135	60	40	O	50	150	10M	0.2	10M	50	E	250M	T
2N3904	S	N		2N3903	SH	0.31W	A	135	60	40	O	100	300	10M	0.2	10M	100	E	300M	T
2N3905	S	P		2N3905	SH	0.31W	A	135	40	40	O	50	150	10M	0.25	10M	50	E	200M	T
2N3906	S	P		2N3905	SH	0.31W	A	135	40	40	O	100	300	10M	0.25	10M	100	E	250M	T
2N3907	S	N	2N2915	2N2913	AM	0.3W	A	200	60	45	O	60	300	10*	0.35	1.0M			60M	T
2N3908	S	N	2N2916	2N2913	AM	0.3W	A	200	60	60	O	100	500	10*	0.35	1.0M			60M	T
2N3909,A	Field-Effect Transistors, see Table on Page 2-76																			
2N3910	S	P			SC	0.5W	A	200	60	50	O	40	160	1.0M	0.3	10M			4.0M	T
2N3911	S	P			SC	0.5W	A	200	60	40	O	60	240	1.0M	0.3	10M			8.0M	T
2N3912	S	P			SC	0.5W	A	200	60	30	O	90		1.0M	0.3	10M			10M	T
2N3913	S	P			SC	0.4W	A	200	60	50	O	40	160	1.0M	0.3	10M			4.0M	T
2N3914	S	P			SC	0.4W	A	200	60	40	O	60	240	1.0M	0.3	10M			8.0M	T
2N3915	S	P			SC	0.4W	A	200	60	30	O	90		1.0M	0.3	10M			10M	T
2N3916	S	N			AP	5.0W	C	150	150	150	O	40	200	0.15A	5.0	0.15A	30	E	50M	T
2N3917	S	N			AP	20W	C	150	80	40	O	30	120	1.0A	1.2	1.0A	15	E	50M	T
2N3918	S	N			AP	20W	C	150	80	40	O	100	300	1.0A	1.2	1.0A	30	E	50M	T
2N3919	S	N			SP	15W	C	150	120	60	O	40	120	2.0A	1.2	10A			80M	T
2N3920	S	N			SP	15W	C	150	120	60	O	100	300	2.0A	1.2	10A			80M	T
2N3921 2N3922	Field-Effect Transistors, see Table on Page 2-76																			
2N3923	S	N			AH	0.8W	A	200	150	150	O	30	120	25M	1.0	25M	20	E	40M	T
2N3924	S	N		2N3924	AHP	7.0W	C	200	36	18	O								250M	T
2N3925	S	N		2N3924	AHP	10W	C	200	36	18	O								250M	T
2N3926	S	N		2N3924	AHP	11.6W	C	200	36	18	O								250M	T
2N3927	S	N		2N3924	AHP	23.2W	C	200	36	18	O								200M	T
2N3928	S	N			SHP	7.5W	C	175	80	40	O	20	300	1.5A	5.0	1.5A			200M	T
2N3929	S	N			SHP	30W	C	175	80	40	O	20	300	1.5A	5.0	1.5A			200M	T
2N3930	S	P			A	0.4W	A	200	180	180	O	80	300	10M	0.25	10M	100	E	40M	T
2N3931	S	P			A	0.7W	A	200	180	180	O	80	300	10M	0.25	10M	100	E	40M	T
2N3932	S	N			AH	0.2W	A	200	30	20	O	40	150	2.0M			50	E	750M	T
2N3933	S	N			AH	0.2W	A	200	40	30	O	60	200	2.0M			60	E	750M	T
2N3934 2N3935	Field-Effect Transistors, see Table on Page 2-76																			
2N3936 thru 2N3940	Thyristors, see Table on Page 2-66																			
2N3941	S	N			AM	0.75W	C	200	60	45	O	400		10*			300	E	200M	T
2N3942	S	N			AM	0.75W	C	200	60	45	O	400		10*			300	E	200M	T
2N3943	S	N			AM	0.5W	C	200	60	45	O	400		10*			300	E	200M	T
2N3944	S	N			AM	0.5W	C	200	60	45	O	400		10*			300	E	200M	T
2N3945	S	N			S	5.0W	C	200	70	50	O	40	250	0.15A	0.5	0.15A			60M	T
2N3946	S	N		2N3946	SH	360M	A	200	60	40	O	50	150	10M	0.3	50M	50	E	250M	T
2N3947	S	N		2N3946	SH	360M	A	200	60	40	O	100	300	10M	0.3	50M	100	E	300M	T
2N3948	S	N		2N3948	AHP	1.0W	A	200	36	20	O	15		50M					700M	T
2N3950	S	N		2N3950	AHP	70W	C	200	65	35	O								150M	T
2N3953	S	N			AH	0.2W	A	200	15	12	O	30	360	2.0M			40	E	1.3G	T
2N3954 2N3954,A 2N3955,A 2N3956 thru 2N3958	Field-Effect Transistors, see Table on Page 2-76																			
2N3959	S	N		2N3959	SH	400M	A	200	20	12	O	40	200	10M	0.3	30M	13	E	1.3G	T
2N3960	S	N		2N3959	SH	400M	A	200	20	12	O	40	200	10M	0.3	30M	16	E	1.6G	T
2N3961	S	N		2N3375	AHP	10W	C	200	65	40	O								400M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N3962	S	P			A	0.36W	A	200	60	60	O	100	300	10*	0.25	10M	100	E	40M	T
2N3963	S	P			A	0.36W	A	200	80	80	O	100	300	10*	0.25	10M	100	E	40M	T
2N3964	S	P			A	0.36W	A	200	45	45	O	250	500	10*	0.25	10M	250	E	50M	T
2N3965	S	P			A	0.36W	A	200	60	60	O	250	500	10*	0.25	10M	250	E	50M	T
2N3966 thru 2N3972	Field-Effect Transistors, see Table on Page 2-76																			
2N3973	S	N	2N4400	2N4400	S	0.36W	A	150	60	30	O	35	100	10M	0.3	0.15A			200M	T
2N3974	S	N	2N4401	2N4400	S	0.36W	A	150	60	30	O	55	200	10M	0.3	0.15A			200M	T
2N3975	S	N	2N4400	2N4400	S	0.36W	A	150	60	30	O	35	100	10M	0.3	0.15A			200M	T
2N3976	S	N	2N4401	2N4400	S	0.36W	A	150	60	30	O	55	200	10M	0.3	0.15A			200M	T
2N3977	S	P			SC	0.4W	A	200	15	10	O	40		5.0M	0.1	5.0M			1.0M	T
2N3978	S	P			SC	0.4W	A	200	25	20	O	30		5.0M	0.15	5.0M			1.0M	T
2N3979	S	P			SC	0.4W	A	200	40	35	O	20		5.0M	0.15	5.0M			1.0M	T
2N3980	Unijunction Transistors, see Table on Page 2-86																			
2N3981	S	N			SH	0.8W	A	200	60	30	O	30	120	0.15A	0.4	0.15A			250M	T
2N3982	S	N			SH	0.8W	A	200	50	20	O	40	140	0.15A	0.4	0.15A			250M	T
2N3983	S	N			AH	0.2W	A	150	30	12	O	30		4.0M					500M	T
2N3984	S	N			AH	0.2W	A	150	30	12	O	20		4.0M					400M	T
2N3985	S	N			AH	0.2W	A	150	30	12	O	20		4.0M					300M	T
2N3986 thru 2N3992	Thyristors, see Table on Page 2-66																			
2N3993	Field-Effect Transistors, see Table on Page 2-76																			
2N3994	Field-Effect Transistors, see Table on Page 2-76																			
2N3995	G	P	2N2929	2N2929	AH	0.3W	A	100	20	12	O	40	200	2.0M			150	E	0.6G	T
2N3996	S	N			SHP	2.0W	A	200	100	80	O	40	120	1.0A	0.25	1.0A			40M	T
2N3997	S	N			SHP	2.0W	A	200	100	80	O	80	240	1.0A	0.25	1.0A			40M	T
2N3998	S	N			SHP	2.0W	A	200	100	80	O	40	120	1.0A	0.25	1.0A			40M	T
2N3999	S	N			SHP	2.0W	A	200	100	80	O	80	240	1.0A	0.25	1.0A			40M	T
2N4000	S	N			SHP	1.0W	A	200	100	80	O	30	120	0.5A	0.3	0.5A			40M	T
2N4001	S	N			SHP	1.0W	A	200	120	100	O	40	120	0.5A	0.3	0.5A			40M	T
2N4002	S	N			AP	4.0W	A		100	80	O	20	80	15A			30	E	30M	B
2N4003	S	N			AP	4.0W	A		120	100	O	20	80	15A			30	E	30M	B
2N4004	S	N			AP	1.2W	A		100	80	O	30	150	10A					30M	B
2N4005	S	N			AP	1.2W	A		120	100	O	30	150	10A					30M	B
2N4006	S	P			A	400M	A	200	10	6.0	O						40	E	20M	T
2N4007	S	P			S	400M	A	200	20	15	O						30	E	15M	T
2N4008	S	P			S	400M	A	200	35	30	O						20	E	15M	T
2N4009	Matched Pair 2N4006																			
2N4010	Matched Pair 2N4007																			
2N4011	Matched Pair 2N4008																			
2N4012	S	N		2N4012	AP	11.6W	C	200	65	40	O	4.0	40	1.0A	1.0	0.25A			400M	T
2N4013	S	N			SH	360M	A	200	60	40	O		150	100M					300M	T
2N4014	S	N			SH	360M	A	200	80	50	O		150	100M					300M	T
2N4015	S	P			AM	0.4W	A	200	60	60	O	135	350	1.0M	0.25	50M	135	E	200M	T
2N4016	S	P			AM	0.4W	A	200	60	60	O	135	350	1.0M	0.25	50M	135	E	200M	T
2N4017	S	P			A	600M	A	200	80	80	O	100	500	1.0M					40M	T
2N4018	S	P			A	400M	A	200	60	60	O						100	E	7.0M	E
2N4019	S	P			A	400M	A	200	45	45	O						250	E	50M	T
2N4020	S	P			AM	0.4W	A	200	45	45	O	250	500	10*	0.25	10M	250	E	50M	T
2N4021	S	P			AM	0.4W	A	200	60	60	O	100	350	10*	0.25	10M	100	E	40M	T
2N4022	S	P			AM	0.4W	A	200	60	60	O	250	500	10*	0.25	10M	250	E	50M	T
2N4023	S	P			AM	0.4W	A	200	45	45	O	250	500	10*	0.25	10M	250	E	50M	T
2N4024	S	P			AM	0.4W	A	200	60	60	O	100	350	10*	0.25	10M	100	E	40M	T
2N4025	S	P			AM	0.4W	A	200	60	60	O	250	500	10*	0.25	10M	250	E	50M	T
2N4026	S	P			A	0.5W	A	200	60	60	O	40	120	0.1A	1.0	1.0A			100M	T
2N4027	S	P			A	0.5W	A	200	80	80	O	40	120	0.1A	0.5	0.5A			100M	T
2N4028	S	P			A	0.5W	A	200	60	60	O	100	300	0.1A	1.0	1.0A			150M	T
2N4029	S	P			A	0.5W	A	200	80	80	O	100	300	0.1A	0.5	0.5A			150M	T
2N4030	S	P			A	0.8W	A	200	60	60	O	40	120	0.1A	1.0	1.0A			100M	T
2N4031	S	P			A	0.8W	A	200	80	80	O	40	120	0.1A	0.5	0.5A			100M	T
2N4032	S	P			A	0.8W	A	200	60	60	O	100	300	0.1A	1.0	1.0A			150M	T
2N4033	S	P			A	0.8W	A	200	80	80	O	100	300	0.1A	0.5	0.5A			150M	T
2N4034	S	P			SH	0.36W	A	200	40	40	O	70	200	10M	0.13	1.0M	50	E	400M	T
2N4035	S	P			SH	0.36W	A	200	40	40	O	150	300	10M	0.13	1.0M	150	E	450M	T
2N4036	S	P			S	5.0W	A	200	90	65	O	40	140	0.15A					60M	T
2N4037	S	P			S	1.0W	A	200	60	40	O	50	250	0.15A					60M	T
2N4038 2N4039	Field-Effect Transistors, see Table on Page 2-76																			
2N4040	S	N			AHP	17.5W	C	200	60	40	O	10	80	0.1A	2.0	1.0A			400M	T
2N4041	S	N			AHP	10W	C	200	60	40	O	10	80	75M	2.0	0.5A			400M	T
2N4042	S	N			AM	0.3W	C	200	60	60	O	200	600	10*	0.35	1.0M			200M	T
2N4043	S	N			AM	0.3W	C	200	45	45	O	80	800	10*	0.35	1.0M			150M	T
2N4044	S	N			AM	0.4W	C	200	60	60	O	200	600	10*	0.35	1.0M			200M	T
2N4045	S	N			AM	0.4W	C	200	45	45	O	80	800	10*	0.35	1.0M			150M	T
2N4046	S	N			SH	800M	A	200	50	30	O		150	100M					250M	T
2N4047	S	N			SH	800M	A	200	80	50	O		150	100M					250M	T
2N4048	G	P		2N4048	AP	170W	C	110	45	30	O	60	120	15A	0.30	60A			2.0K	E
2N4049	G	P		2N4048	AP	170W	C	110	60	45	O	60	120	15A	0.30	60A			2.0K	E
2N4050	G	P		2N4048	AP	170W	C	110	75	60	O	60	120	15A	0.30	60A			2.0K	E
2N4051	G	P		2N4048	AP	170W	C	110	45	30	O	60	180	15A	0.30	60A			2.0K	E
2N4052	G	P		2N4048	AP	170W	C	110	60	45	O	60	180	15A	0.30	60A			2.0K	E
2N4053	G	P		2N4048	AP	170W	C	110	75	60	O	60	180	15A	0.30	60A			2.0K	E
2N4054	S	N			AP	6.25W	C	150	300	300	O	30	90	50M	5.0	75M			15M	T
2N4055	S	N			AP	6.25W	C	150	250	250	O	30	90	50M	5.0	75M			15M	T
2N4056	S	N			AP	6.25W	C	150	200	200	O	30	90	50M	5.0	75M			15M	T
2N4057	S	N			AP	6.25W	C	150	150	150	O	30	90	50M	5.0	75M			15M	T
2N4058	S	P	MPS6522	MPS6516	A	0.25W	A	150	30	30	O	100	400	0.1M	0.7	10M	100	E		
2N4059	S	P	MPS6516	MPS6516	A	0.25W	A	150	30	30	O	45	660	1.0M	0.7	10M	45	E		

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N4060	S	P	MPS6516	MPS6516	A	0.25W	A	150	30	30	O	45	165	1.0M	0.7	10M	45	E		
2N4061	S	P	MPS6517	MPS6516	A	0.25W	A	150	30	30	O	90	330	1.0M	0.7	10M	90	E		
2N4062	S	P	MPS6518	MPS6516	A	0.25W	A	150	30	30	O	180	660	1.0M	0.7	10M	180	E		
2N4063	S	N			AP	10W	C	200	450	350	O	40	160	0.02A					15M	E
2N4064	S	N			AP	10W	C	200	300	250	O	40	160	0.02A					15M	E
2N4065 thru 2N4067	Field-Effect Transistors, see Table on Page 2-76																			
2N4068	S	N			AH	500M	A	175	150	150	O	30		30M					50M	T
2N4069	S	N			AP	1.0W	C	175	150	150	O	30		0.03A	0.68				50M	T
2N4070	S	N	2N3448	2N3445	AP	115W	C	200	100	80	O	40	120	5.0A	1.5	5.0A	40	E	10M	T
2N4072	S	N		2N4072	AHP	1.5W	C	200	40	20	O	10		25A					550M	T
2N4073	S	N		2N4072	AHP	1.5W	C	200	40	20	O	10		25A					550M	T
2N4074	S	N			AH	400M	A	175	40	40	O						400	E		
2N4075	S	N	2N3764	2N3762	AP	30W	C	200		80	O	30	90						30M	T
2N4076	S	N			AP	30W	C	200		80	O	50	150						30M	T
2N4080	S	P			AHP	300M	A	200	20	15	O	20		3.0M					1.0G	T
2N4081	S	N			AH	200M	A		40	40	O	40	180	2.0M			40	E	600M	T
2N4082 thru 2N4085	Field-Effect Transistors, see Table on Page 2-76																			
2N4086	S	N	MPS6514	MPS6512	A	200M	A		12	12	O	150	300	2.0M			150	E		
2N4087	S	N	MPS6515	MPS6512	A	200M	A		12	12	O	250	500	2.0M			250	E		
2N4087A	S	N	MPS6515	MPS6512	A	200M	A		12	12	O	250	500	2.0M			250	E		
2N4088 thru 2N4095	Field-Effect Transistors, see Table on Page 2-76																			
2N4096 thru 2N4098	Thyristors, see Table on Page 2-66																			
2N4099	S	N			AM	300M	A	200	55	55	O	175		1.0M					150M	T
2N4100	S	N			AM	400M	A	200	55	55	O	175		1.0M					150M	T
2N4101 thru 2N4103	Thyristors, see Table on Page 2-66																			
2N4104	S	N			AH	300M	A	175	60	60	O						1400	E	540M	T
2N4106	G	P	MP2060	MPS2060	A	1.6W	A		25			70	350	5.0M						
2N4108 thru 2N4110	Thyristors, see Table on Page 2-66																			
2N4111	S	N			AP	30W	C		100	60	O	40	120	2.0A					70M	T
2N4112	S	N			AP	30W	C		100	60	O	100	300	2.0A					80M	T
2N4113	S	N			AP	30W	C		120	80	O	40	120	2.0A					70M	T
2N4114	S	N			AP	3.0W	A		120	80	O	100	300	2.0A					80M	E
2N4115	S	N			AP	37W	C		120	80	O	40	120	2.0A					70M	E
2N4116	S	N			AP	37W	C		120	80	O	100	300	2.0A					80M	E
2N4117,A thru 2N4120,A	Field-Effect Transistors, see Table on Page 2-76																			
2N4121	S	P	2N3905	2N3905	AH	200M	A	125	40	40	O	70		10M			50	E	400M	T
2N4122	S	P	2N3906	2N3905	AH	200M	A	125	40	40	O	150		10M			150	E	450M	T
2N4123	S	N		2N4123	SH	310M	A	135	40	30	O	50	150	2.0M	0.3	50M	50	E	250M	T
2N4124	S	N		2N4123	SH	310M	A	135	30	25	O	120	360	2.0M	0.3	50M	120	E	300M	T
2N4125	S	P		2N4125	SH	310M	A	135	30	30	O	50	150	2.0M	0.4	50M	50	E	200M	T
2N4126	S	P		2N4125	SH	310M	A	135	25	25	O	120	360	2.0M	0.4	50M	120	E	250M	T
2N4127	S	N			AP	25W	C		60	40	O	10	80	0.2A					300M	T
2N4128	S	N			AP	40W	C		60	40	O	10	80	0.2A					200M	T
2N4130	S	N			AP	120W	C		80	65	O	10	60	2.0A					1.25M	E
2N4131	S	N			AP	60W	C		90	80	O	10	80	1.0A					150M	E
2N4132	S	N			AHP	7.5W	C	175	90	80	O	10	80	0.2A	0.5	0.6A			200M	T
2N4133	S	N			AHP	3.0W	C	175	90	80	O	10	80	0.2A	0.5	0.6A			200M	T
2N4134	S	N			AH	200M	A	200	30	30	O						200	E	350M	T
2N4135	S	N			AH	200M	A	200	30	30	O						200	E	425M	T
2N4136	Pair of 2N2430 and 2N2431																			
2N4137	S	N			SP	360M	A	200	40	40	O	40	120	10M					500M	T
2N4138	S	N			SC	300M	A	200	30	30	O	50		1.0M					20M	T
2N4139	Field-Effect Transistors, see Table on Page 2-76																			
2N4140	S	N	2N4400	2N4400	AH	300M	A	125	60	30	O		120	150M					250M	T
2N4141	S	N	2N4401	2N4400	AH	300M	A	125	60	30	O		300	150M					250M	T
2N4142	S	P	2N4402	2N4402	AH	300M	A	125	60	40	O		120	150M					200M	T
2N4143	S	P	2N4403	2N4402	AH	300M	A	125	60	40	O		300	150M					200M	T
2N4144 thru 2N4149	Thyristors, see Table on Page 2-66																			
2N4150	S	N			AP	5W	C		100	80	O	40	120	5.0A					15M	T
2N4151 thru 2N4204	Thyristors, see Table on Page 2-66																			
2N4207	S	P			SH	300M	A	200	6.0	6.0	O	50	120	10M					650M	T
2N4208	S	P			SH	300M	A	200	12	12	O	30	120	10M					700M	T
2N4209	S	P			SH	300M	A	200	15	15	O	50	120	10M					850M	T
2N4210	S	N			AP	100W	C		80	60	O	20	100	10A					10M	T
2N4211	S	N			AP	100W	C		100	80	O	20	100	10A					10M	T
2N4212 thru 2N4219	Thyristors, see Table on Page 2-66																			
2N4220,A thru 2N4224,A	Field-Effect Transistors, see Table on Page 2-76																			
2N4225	S	N			AP	5.0W	C		100	40	O	40	150	1.0A					150M	T
2N4226	S	N			AP	5.0W	C		200	60	O	40	150	1.0A					150M	T
2N4227	S	N	2N4400	2N4400	S	300M	A	125	60	30	O		150	150M					250M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N4228	S	P	2N4402	2N4402	AH	300M	A	125	60	40	O		150	150M					200M	T
2N4231	S	N		2N4231	AP	35W	C	200		40	O	25	100	1.5A	0.7	1.5A			1.0M	T
2N4232	S	N		2N4231	AP	35W	C	200		60	O	25	100	1.5A	0.7	1.5A			1.0M	T
2N4233	S	N		2N4231	AP	35W	C	200		80	O	25	100	1.5A	0.7	1.5A			1.0M	T
2N4234	S	P		2N4234	SP	1.0W	A	200	40	40	O	30	150	250M	0.6	1.0A			3.0M	T
2N4235	S	P		2N4234	SP	1.0W	A	200	60	60	O	30	150	250M	0.6	1.0A			3.0M	T
2N4236	S	P		2N4234	SP	1.0W	A	200	80	80	O	30	150	250M	0.6	1.0A			3.0M	T
2N4237	S	P		2N4237	AP	5.0W	C	175	50	40	O	40	160	500M	2.5	1.0A	40	E	10M	T
2N4238	S	P		2N4237	AP	5.0W	C	175	80	60	O	40	160	500M	2.5	1.0A	40	E	10M	T
2N4239	S	P		2N4237	AP	5.0W	C	175	100	60	O	40	160	500M	2.5	1.0A	40	E	10M	T
2N4240	S	N			AP	35W	C		440	300	O	30	240	0.75A					15M	T
2N4241	G	P			A	37.5W	C		32	20	O	60	300	300M	0.35	5.0A				
2N4242	G	P			AP	105W	A		80	60	O	40	80	5.0A					500K	T
2N4243	G	P			AP	105W	A		60	45	O	40	80	5.0A					500K	T
2N4244	G	P			AP	105W	A		40	30	O	40	80	5.0A					500K	T
2N4245	G	P			AP	105W	A		80	60	O	60	120	5.0A					500K	T
2N4246	G	P			AP	105W	A		60	45	O	60	120	5.0A					500K	T
2N4247	G	P			AP	105W	A		40	30	O	60	120	5.0A					500K	T
2N4248	S	P	2N5086	2N5086	A	200M	A	125	40	40	O						50	E	40M	T
2N4249	S	P	2N5086	2N5086	A	200M	A	125	60	60	O						100	E	40M	T
2N4250	S	P	2N5087	2N5086	A	200M	A	125	40	40	O						250	E	40M	T
2N4251	S	N			S	250M	A	200	15	10	O	100		10M					1300M	T
2N4252	S	N			AH	200M	A	175	30	18	O	50		2.0M					600M	T
2N4253	S	N			AH	200M	A	175	30	18	O	30		2.0M					600M	T
2N4254	S	N	MPS6547	MPS6546	A	200M	A	175	30	18	O	50		2.0M						
2N4255	S	N	MPS6547	MPS6546	A	200M	A	175	30	18	O	30		2.0M						
2N4256	S	N	2N3904	2N3903	A	200M	A		30	30	S		500	2.0M						
2N4257	S	P			SH	200M	A	125	6.0	6.0	O	30	120	10M					500M	T
2N4258	S	P			SH	200M	A	125	12	12	O	30	120	10M					700M	T
2N4259	S	N			AH	175M	A	175	40	30	O						70	E		
2N4260	S	P		2N4260	SH	200M	A	200	15	15	O	30	150	10M	15	10M	16	E	1500M	T
2N4261	S	P		2N4260	SH	200M	A	200	5.0	15	O	30	150	15A	15	10M	20	E	2000M	T
2N4262	S	N			AP	1.5W	C		25	10	O	75		0.3A					600M	T
2N4263	S	N			AP	1.5W	C		25	10	O	75		0.3A					800M	T
2N4264	S	N		2N4264	S	310M	A	135	30	15	O	40	160	10M					300M	T
2N4265	S	P		2N4264	SH	310M	A	135	30	12	O	100	400	15A	0.22	10M			300M	T
2N4267 2N4268	Field-Effect Transistors, see Table on Page 2-76																			
2N4269	S	N			A	360M	A	200	200	140	O		200	10M						
2N4270	S	N			A	580M	A	200	200	140	O		200	10M						
2N4271	S	N			AP	5.0W	C		175	140	O	20	140	0.2A					20M	T
2N4272	S	N			AP	5.0W	C		175	140	O	20	140	1.0A					10M	T
2N4273	S	N			AP	25W	C		175	140	O	20	140	1.0A					10M	T
2N4274	S	N			SH	280M	A	125	30	12	O	18		100M					400M	T
2N4275	S	N			SH	280M	A	125	40	15	O	18		100M					400M	T
2N4276	G	P		2N4276	AP	170W	C	110	30	20	O	60	120	15A	0.15	15A			2.0K	E
2N4277	G	P		2N4276	AP	170W	C	110	30	20	O	80	180	15A	0.15	15A			2.0K	E
2N4278	G	P		2N4276	AP	170W	C	110	45	30	O	60	120	15A	0.15	15A			2.0K	E
2N4279	G	P		2N4276	AP	170W	C	110	45	30	O	80	180	15A	0.15	15A			2.0K	E
2N4280	G	P		2N4276	AP	170W	C	110	60	45	O	60	120	15A	0.15	15A			2.0K	E
2N4281	G	P		2N4276	AP	170W	C	110	60	45	O	80	180	15A	0.15	15A			2.0K	E
2N4282	G	P		2N4276	AP	170W	C	110	75	60	O	60	120	15A	0.15	15A			2.0K	E
2N4283	G	P		2N4276	AP	170W	C	110	75	60	O	80	180	15A	0.15	15A			2.0K	E
2N4284	S	P			A	250M	A	165	25	25	O		600	1.0M						
2N4285	S	P			A	250M	A	165	35	35	O		600	1.0M						
2N4286	S	N	MPS6515		A	250M	A	150	30	25	O						600	E	40M	T
2N4287	S	N	MPS6566		A	250M	A	150	45	45	O						600	E	40M	T
2N4288	S	P	MPS6518	MPS6516	A	250M	A	150	30	25	O						600	E	40M	T
2N4289	S	P	2N5086		A	250M	A	150	60	45	O						600	E	40M	T
2N4290	S	P	MPS6533	MPS6530	A	250M	A	150	30	20	O						600	E	40M	T
2N4291	S	P	MPS6534	MPS6530	A	250M	A	150	40	30	O						600	E	40M	T
2N4292	S	N	MPS918	MPS918	A	200M	A	150	30	15	O	20		3.0M					600M	T
2N4293	S	N	MPS918	MPS918	A	200M	A	150	30	15	O						60	E	600M	T
2N4294	S	N	2N4264	2N4264	SH	200M	A	150	30	12	O	30	120	10M					400M	T
2N4295	S	N	2N4264	2N4264	SH	200M	A	150	40	15	O	40	120	10M					500M	T
2N4296	S	N			SP	20W	C		350	250	O	50	150	0.05A					20M	T
2N4297	S	N			AP	20W	C		350	250	O	75	300	0.05A					20M	T
2N4298	S	N			AP	20W	C		500	350	O	25	75	0.05A					20M	T
2N4299	S	N			AP	20W	C		500	350	O	50	150	0.05A					20M	T
2N4300	S	N			AP	15W	C		100	80	O	30	120	1.0A					30M	T
2N4301	S	N			AP	50W	C		100	80	O	30	120	5.0A					40M	T
2N4302 thru 2N4304	Field-Effect Transistors, see Table on Page 2-76																			
2N4305	S	N			AP	1.5W	A		120	80	O	50	150	1.0A						
2N4306	S	N			AP	4.0W	A		120	80	O	50	150	1.0A						
2N4307	S	N			AP	1.5W	A		100	60	O	50	150	1.0A						
2N4308	S	N			AP	4.0W	A		100	60	O	50	150	1.0A						
2N4309	S	N			AP	1.5W	A		120	80	O	50	150	1.0A						
2N4310	S	N			AP	4.0W	A		120	80	O	40	120	1.0A						
2N4311	S	N			AP	1.5W	A		100	60	O	40	120	1.0A						
2N4312	S	N			AP	4.0W	A		100	60	O	40	120	1.0A						
2N4313	S	P			SC	200M	A	125	12	12	O	30	120	30M					700M	T
2N4314	S	P			AP	1.0W	A		90	65	O	50	250	0.15A					200M	T
2N4316 thru 2N4319	Thyristors, see Table on Page 2-66																			

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N4338 thru 2N4343	Field-Effect Transistors, see Table on Page 2-76																		
2N4346					AP	5.0W	A			60	0								
2N4347	S	N			AP	100W	C		140	120	0	15	60	2.0A					
2N4348	S	N			AP	120W	C		140	120	0	15	60	5.0A					
2N4350	S	N			AP	7.0W	C		65	40	0	10	200	0.35A				300M	T
2N4351																			
2N4352	Field-Effect Transistors, see Table on Page 2-76																		
2N4353																			
2N4354	S	P			A	350M	A	125	60	60	0	25		0.1M				500M	T
2N4355	S	P			A	350M	A	125	60	60	0	60		0.1M				500M	T
2N4356	S	P			A	350M	A	125	80	80	0	25		0.1M				500M	T
2N4357	S	P			A	400M	A	200	240	240	0	80	300	10M	0.5	10M	100	E 40M	T
2N4358	S	P			A	400M	A	200	240	240	0	80	300	10M	0.5	10M	100	E 40M	T
2N4359	S	P			A	360M	A	200	45	45	0	50	600	1.0M	0.25	10M	50	E	
2N4360	Field-Effect Transistors, see Table on Page 2-76																		
2N4361 thru 2N4380	Thyristors, see Table on Page 2-66																		
2N4381																			
2N4382	Field-Effect Transistors, see Table on Page 2-76																		
2N4383	S	N			AH	800M	A	200	40	30	0						1000	E 120M	T
2N4384	S	N			AH	500M	A	200	40	30	0						1000	E 120M	T
2N4385	S	N			AH	800M	A	200	40	30	0						1000	E 120M	T
2N4386	S	N			AH	500M	A	200	40	30	0						1000	E 120M	T
2N4387	S	P				20W	A	200	40	40	0	25	100	500M					
2N4388	S	P				20W	A	200	60	60	0	25	100	500M					
2N4389	S	P			SH	200M	A	125	12	12	0	30	180	10M	0.15	10M	4.0	E	
2N4390	S	N			S	500M	A	175	120	120	0	20		2.0M				50M	T
2N4391 thru 2N4393	Field-Effect Transistors, see Table on Page 2-76																		
2N4395	S	N	2N3715	2N3713	AP	62.5W	C		60	40	0	50	170	2.0A				4M	T
2N4396	S	N	2N3715	2N3713	AP	62.5W	C		80	60	0	40	170	2.0A				4M	T
2N4397	S	N			AM	200M	A		40	40	0	40	180	2.0M			40	E 600M	T
2N4398	S	P		2N4398	AP	200W	C	200	40	40	0	15	60	15A	1.0	15A	40	E 4M	T
2N4399	S	P		2N4398	AP	200W	C	200	60	60	0	15	60	15A	1.0	15A	40	E 4M	T
2N4400	S	N		2N4400	SH	310M	A	135	60	40	0	50	150	150M	0.4	150M	20	E 200M	T
2N4401	S	N		2N4400	SH	310M	A	135	60	40	0	100	300	150M	0.4	150M	40	E 250M	T
2N4402	S	P		2N4402	SH	310M	A	135	40	40	0	50	150	150M	0.4	150M	30	E 150M	T
2N4403	S	P		2N4402	SH	310M	A	135	40	40	0	100	300	150M	0.4	150M	60	E 200M	T
2N4404	S	P		2N4404	A	5.0W	C		80	80	0	40	120	150M	0.15	10M		200M	T
2N4405	S	P		2N4404	A	5.0W	C		80	80	0	100	300	150M	0.15	10M		200M	T
2N4406	S	P		2N4406	A	5.0W	C		80	80	0	30	120	500M	0.2	150M		150M	T
2N4407	S	P		2N4406	A	5.0W	C		80	80	0	80	240	500M	0.2	150M		150M	T
2N4409	S	N		2N4409	S	310M	A	135	80	50	0	60	400	1.0M	0.2	1.0M			
2N4410	S	N		2N4409	S	310M	A	135	120	80	0	60	400	1.0M	0.2	1.0M			
2N4411	S	P			S	150M	A	200	15	12	0	40		0.5M				400M	T
2N4412	S	N			AH	600M	A	200	40	30	0						1000	E 100M	T
2N4412A	S	P			AH	600M	A	200	60	60	0						120	E 20M	T
2N4413	S	P			AH	400M	A	200	40	30	0						1000	E 100M	T
2N4413A	S	P			AH	400M	A	200	60	60	0						120	E 20M	T
2N4414	S	P			AH	600M	A	200	40	30	0						1000	E 100M	T
2N4414A	S	P			AH	600M	A	200	60	60	0						100	E 20M	T
2N4415	S	P			AH	400M	A	200	40	30	0						1000	E 100M	T
2N4415A	S	P			AH	400M	A	200	60	60	0						100	E 20M	T
2N4416																			
2N4416A	Field-Effect Transistors, see Table on Page 2-76																		
2N4417																			
2N4418	S	N	2N4264	2N4264	S	250M	A	125	40	40	S	40	120	10M				500M	T
2N4419	S	N	2N4264	2N4264	S	250M	A	125	30	30	S	30		10M				400M	T
2N4420	S	N	MPS3646	MPS3646	S	250M	A	125	40	40	S	30	120	30M				350M	T
2N4421	S	N	MPS3646	MPS3646	S	250M	A	125	30	30	S	25		30M				300M	T
2N4422	S	N	MPS3646	MPS3646	S	250M	A	125	40	40	S	30	120	30M				350M	T
2N4423	S	N	MPS3640	MPS3646	S	250M	A	125	12	12	S	40	150	30M				400M	T
2N4424	S	N	MPS3711	MPS3707	S	360M	A	150	40	40	0						180	E	
2N4425	S	N			S	560M	A	150	40	40	0	180		2M					
2N4427	S	N			AP	3.5W	C		40	20	0	10	200	0.1A				500M	T
2N4428	S	N			AP	3.5W	C		55	35	0	20	200	0.05A				700M	T
2N4429	S	N			AP	5.0W	C		55	35	0	20	200	0.05A				700M	T
2N4430	S	N			AP	10W	C		55	40	0	20	200	0.1A				600M	T
2N4431	S	N			AP	18W	C		55	40	0	20	200	0.1A				600M	T
2N4432	S	N			AH	600M	A		50	30	0	40	130	6.0M			45	E	
2N4432A	S	N			AH	600M	A		50	30	0	80	150	6.0M			90	E	
2N4436	S	N			AHP	200M	A	125	60	30	0	40	120	150M	0.22	150M		250M	T
2N4437	S	N			AHP	200M	A	125	60	30	0	100	300	150M	0.22	150M		250M	T
2N4438	S	N			A	1.0W	A	200	300	300	0	40	120	50M	1.0	100M		30M	T
2N4439	S	N			A	1.0W	A	200	300	300	0	100	240	50M	1.0	100M		30M	T
2N4440	S	N			AP	11.6W	C		65	40	0	10	200	0.125A				400M	T
2N4441 thru 2N4444	Thyristors, see Table on Page 2-66																		
2N4445																			
2N4448	Field-Effect Transistors, see Table on Page 2-76																		
2N4449	S	N			SH	0.3W	A			40	0	40		10M	0.18	10M		500M	T
2N4450	S	N			SH	3.0W	C	200	60	30	0	75		10M	0.22	150M		250M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N4451	S	P			S	0.3W	A			12	0	40		30M	0.25	30M			400M	T
2N4452	S	P			S	0.35W	A	200	45	45	0	115	300	50M	0.4	15M	135	E	200M	T
2N4453	S	P			S	0.3W	A			18	0	40		30M	0.25	30M			400M	T
2N4576	S	N	2N3716	2N3713	AHP	150W	C	200	100	80	0	50	150	1.0A	0.8	5.0A	25	E	30K	E
2N4851 thru 2N4853	Unijunction Transistors, see Table on Page 2-86																			
2N4854	Complementary Pair				SH	300M	A	200	60	40	0	50		1.0M					200M	T
2N4855					SH	300M	A	200	60	40	0	25		1.0M					200M	T
2N4856 thru 2N4861	Field-Effect Transistors, see Table on Page 2-76																			
2N4862	S	N			AP			200	140	120	0	50	150	0.5A	0.2	0.5A	50	E	50M	T
2N4863	S	N			AP			200	140	120	0	50	150	0.5A	0.2	0.5A	50	E	50M	T
2N4864	S	N			AP			200	140	120	0	50	150	0.5A	0.2	0.5A	50	E	50M	T
2N4865	S	N			SP	350W	C	200	100	80	0	10	40	70A	1.5	50A			10M	T
2N4866	S	N			SP	350W	C	200	140	120	0	10	40	70A	1.5	50A			10M	T
2N4867,A thru 2N4869,A	Field-Effect Transistors, see Table on Page 2-76																			
2N4870 thru 2N4871	Unijunction Transistors, see Table on Page 2-86																			
2N4872	S	P			SH	700M	C	200	12	12	0	50	120	10M	0.13	1.0M	9.0	E		
2N4873	S	N			SH	360M	A	200	40	15	0	110	150	10M	0.2	10M	7.0	E		
2N4874	S	N			AH	720M	A	175	30	20	0						200	E	900M	T
2N4875	S	N			AH	720M	A	175	40	25	0						200	E	800M	T
2N4876	S	N			AH	720M	A	175	40	30	0						200	E	650M	T
2N4877	S	N			AP	10W	C	200		60	0	20	100	4.0A	1.0	4.0A			4.0M	T
2N4878	S	N			AM	300M	C		60	60	0	200	600	10*	0.35	1.0M			200M	T
2N4879	S	N			AM	300M	C		55	55	0	150	600	10*	0.35	1.0M			150M	T
2N4880	S	N	2N5401		AM	300M	C		45	45	0	80	800	10*	0.35	1.0M			150M	T
2N4881 thru 2N4886	Field-Effect Transistors, see Table on Page 2-76																			
2N4888	S	P			A	300M	A	125	150	150	0	40	400	10M	0.5	10M			30M	T
2N4889	S	P			A	300M	A	125	150	150	0	80	300	10M	0.5	10M			40M	T
2N4890	S	P		2N4890	S	1.0W	A		60	40	0	50	250	150M	1.4	150M	5.0	E		
2N4891 thru 2N4894	Unijunction Transistors, see Table on Page 2-86																			
2N4895	S	N			SP	4.0W	C	200	120	60	0	100	300	2.0A	1.0	5.0A	4.0	E		
2N4896	S	N			SP	4.0W	C	200	120	60	0	40	120	2.0A	1.0	5.0A	2.5	E		
2N4897	S	N			SP	4.0W	C	200	150	80	0	40	120	2.0A	1.0	5.0A	2.5	E		
2N4898	S	P		2N4898	AP	25W	C	200	40	40	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4899	S	P		2N4898	AP	25W	C	200	60	60	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4900	S	P		2N4898	AP	25W	C	200	80	80	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4901	S	P		2N4901	AP	87.5W	C	200	40	40	0	20	80	1.0A	0.4	1.0A	20	E	4.0M	T
2N4902	S	P		2N4901	AP	87.5W	C	200	60	60	0	20	80	1.0A	0.4	1.0A	20	E	4.0M	T
2N4903	S	P		2N4901	AP	87.5W	C	200	80	80	0	20	80	1.0A	0.4	1.0A	20	E	4.0M	T
2N4904	S	P		2N4904	AP	87.5W	C	200	40	40	0	25	100	2.5A	1.0	2.5A	40	E	4.0M	T
2N4905	S	P		2N4904	AP	87.5W	C	200	60	60	0	25	100	2.5A	1.0	2.5A	40	E	4.0M	T
2N4906	S	P		2N4904	AP	87.5W	C	200	80	80	0	25	100	2.5A	1.0	2.5A	40	E	4.0M	T
2N4907	S	P			AP	150W	C	200		40	0	20	80	4.0A	0.75	4.0A			4.0M	T
2N4908	S	P			AP	150W	C	200		60	0	20	80	4.0A	0.75	4.0A			4.0M	T
2N4909	S	P			AP	150W	C	200		80	0	20	80	4.0A	0.75	4.0A			4.0M	T
2N4910	S	N		2N4910	AP	25W	C	200	40	40	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4911	S	N		2N4910	AP	25W	C	200	60	60	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4912	S	N		2N4910	AP	25W	C	200	80	80	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4913	S	N		2N4913	AP	87.5W	C	200	40	40	0	25	100	2.5A	1.0	2.5A	20	E	4.0M	T
2N4914	S	N		2N4913	AP	87.5W	C	200	60	60	0	25	100	2.5A	1.0	2.5A	20	E	4.0M	T
2N4915	S	N		2N4913	AP	87.5W	C	200	80	80	0	25	100	2.5A	1.0	2.5A	20	E	4.0M	T
2N4916	S	P			SH	500M	C	125	30	30	0	70	200	10M	0.14	10M			400M	T
2N4917	S	P			SH	500M	C	125	30	30	0	150	300	10M	0.14	10M			450M	T
2N4918	S	P		2N4918	AP	30W	C	150	40	40	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4919	S	P		2N4918	AP	30W	C	150	60	60	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4920	S	P		2N4918	AP	30W	C	150	80	80	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4921	S	N		2N4921	AP	30W	C	150	40	40	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4922	S	N		2N4921	AP	30W	C	150	60	60	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4923	S	N		2N4921	AP	30W	C	150	80	80	0	20	100	0.5A	0.6	1.0A	25	E	3.0M	T
2N4924	S	N		2N4924	AH	1.0W	A	175	100	100	0	40	200	150M	0.4	50M			100M	T
2N4925	S	N		2N4924	AH	1.0W	A	175	150	150	0	40	200	150M	0.4	50M			100M	T
2N4926	S	N		2N4926	AH	1.0W	A	175	200	200	0	20	200	30M	2.0	30M	25	E	300M	T
2N4927	S	N		2N4926	AH	1.0W	A	175	250	250	0	20	200	30M	2.0	30M	25	E	300M	T
2N4928	S	P		2N4928	A	3.0W	C		100	100	0	25	200	10M	0.5	10M			100M	T
2N4929	S	P		2N4928	A	5.0W	C		150	150	0	25	200	10M	0.5	10M			100M	T
2N4930	S	P		2N4928	A	5.0W	C		200	200	0	20	200	10M	5.0	10M			20M	T
2N4931	S	P		2N4928	A	5.0W	C		250	250	0	20	200	10M	5.0	10M			20M	T
2N4932	S	N			AP	70W	C		50	25	0	10	100	1.0A					100M	T
2N4933	S	N			AP	70W	C		70	35	0	10	100	1.0A					100M	T
2N4934	S	N			AH	200M	A		40	30	0	40	170	2.0M					700M	T
2N4935	S	N			AH	200M	A		50	40	0	60	200	2.0M					700M	T
2N4936	S	N			AH	200M	A		50	40	0	60	250	2.0M			70	E	700M	T
2N4937	S	P		2N4937	AM	600M	A	200	50	40	0	50	250	1.0M			50	E	300M	T
2N4938	S	P		2N4937	AM	600M	A	200	50	40	0	50	250	1.0M			50	E	300M	T
2N4939	S	P		2N4937	AM	600M	A	200	50	40	0	50	250	1.0M			50	E	300M	T
2N4940	S	P		2N4937	AM	600M	A	200	50	40	0	50	250	1.0M			50	E	300M	T
2N4941	S	P		2N4937	AM	600M	A	200	50	40	0	50	250	1.0M			50	E	300M	T
2N4942	S	P		2N4937	AM	600M	A	200	50	40	0	50	250	1.0M			50	E	300M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N4943	S	N			AP	800M	A		120	80	0	100	300	150M	0.25	150M			45M	T
2N4944	S	N			A	600M	C	125	80	40	0	40	100	150M	0.25	150M			60M	T
2N4945	S	N			A	600M	C	125	80	60	0	40	100	150M	0.25	150M			60M	T
2N4946	S	N			A	600M	C	125	80	40	0	100	300	150M	0.25	150M			60M	T
2N4947																				
2N4948	Unijunction Transistors, see Table on Page 2-86																			
2N4949																				
2N4950	S	N			SP	300W	C		80	60	0	10		50A	1.5	50A			100K	T
2N4951	S	N			A	360M	A	150	60	30	0	60	200	150M	0.3	150M			250M	T
2N4952	S	N			A	360M	A	150	60	30	0	100	300	150M	0.3	150M			250M	T
2N4953	S	N			A	360M	A	150	60	30	0	200	600	150M	0.3	150M			250M	T
2N4954	S	N			A	360M	A	150	40	30	0	60	600	150M	0.3	150M			250M	T
2N4955	S	N			AL	750M	C	125	30	25	0	60	600	10*	0.35	1.0M	150	E	60M	T
2N4956	S	N			AM	750M	C	125	30	25	0	60	600	10*	0.35	1.0M	150	E	60M	T
2N4957	S	P		2N4957	A	200M	A	200	30	30	0	20	40	2.0M					1200M	T
2N4958	S	P		2N4957	A	200M	A	200	30	30	0	20	40	2.0M					1000M	T
2N4959	S	P		2N4957	A	200M	A	200	30	30	0	20	40	2.0M					1000M	T
2N4960	S	N			A	800M	A	200	60	60	0	100	300	150M	0.7	10M			250M	T
2N4961	S	N			A	500M	A	200	80	80	0	100	300	150M	0.7	10M			250M	T
2N4962	S	N			A	800M	A	200	60	60	0	100	300	150M	0.7	10M			250M	T
2N4963	S	N			A	500M	A	200	80	80	0	100	300	150M	0.7	10M			250M	T
2N4964	S	P			A	200M	A		50	40	0	30	120	10*	0.4	10M	40	E		
2N4965	S	P			A	200M	A		50	40	0	80	400	10*	0.4	10M	100	E		
2N4966	S	N			A	200M	A		50	40	0	40	200	10*	0.4	10M	40	E		
2N4967	S	N			A	200M	A		50	40	0	100	600	10*	0.4	10M	100	E		
2N4968	S	N			A	200M	A		30	25	0	40	200	10*	0.4	10M	40	E		
2N4969	S	N			SH	200M	A		50	30	0	40	120	150M	0.4	150M				
2N4970	S	N			SH	200M	A		50	30	0	100	350	150M	0.4	150M				
2N4971	S	P			SH	200M	A		50	40	0	40	120	150M	0.4	150M				
2N4972	S	P			SH	200M	A		50	40	0	100	300	150M	0.4	150M				
2N4973	S	P			AH	200M	A		20	15	0	20		3.0M	0.5	10M				
2N4974	S	P		2N4974	AL	800M	A	200	40	30	0	5000	9000	1.0*			25000	E	175M	T
2N4975	S	P		2N4974	AL	800M	A	200	40	30	0	1000	4000	1.0*			15000	E	175M	T
2N4976	S	N			AHP	5.0W	C		55	30	0	20	250	50M					1000M	T
2N4977																				
2N4979	Field-Effect Transistors, see Table on Page 2-76																			
2N4980	S	P			SC	400M	A		30	30	0	60	300	1.0M					10M	T
2N4981	S	P			SC	400M	A		50	50	0	40	200	1.0M					5.0M	T
2N4982	S	P			SC	400M	A		70	70	0	30	150	1.0M					3.0M	T
2N4983																				
2N4993	Thyristors, see Table on Page 2-66																			
2N4994	S	N				200M	A		60	45	0	40	160	10M						
2N4995	S	N			AH	200M	A		60	45	0	100	400	10M						
2N4996	S	N			AH	200M	A		30	18	0	50		2M						
2N4997	S	N			AH	200M	A		30	18	0	30	150	2M						
2N4998	S	N			AP	35W	C	200	100	80	0	30	90	1.0A	5.0	3.0A	20	E	50M	T
2N4999	S	P			AP	35W	C	200	100	80	0	30	90	1.0A	5.0	3.0A	20	E	50M	T
2N5000	S	N			AP	35W	C	200	100	80	0	70	200	1.0A	5.0	3.0A	50	E	60M	T
2N5001	S	P			AP	35W	C	200	100	80	0	70	200	1.0A	5.0	3.0A	50	E	60M	T
2N5002	S	N			AP	58W	C	200	100	80	0	30	90	2.5A	1.5	5.0A	20	E	60M	T
2N5003	S	P			AP	58W	C	200	100	80	0	30	90	2.5A	1.5	5.0A	20	E	60M	T
2N5004	S	N			AP	58W	C	200	100	80	0	70	200	2.5A	1.5	5.0A	50	E	70M	T
2N5005	S	P			AP	58W	C	200	100	80	0	70	200	2.5A	1.5	5.0A	50	E	70M	T
2N5006	S	N			AP	118W	C	200	100	80	0	30	90	5.0A	1.5	10A	20	E	30M	T
2N5007	S	P			AP	118W	C	200	100	80	0	30	90	5.0A	1.5	10A	20	E	30M	T
2N5008	S	N			AP	118W	C	200	100	80	0	70	200	5.0A	1.5	10A	50	E	40M	T
2N5009	S	P			AP	118W	C	200	100	80	0	70	200	5.0A	1.5	10A	50	E	40M	T
2N5010	S	N			A	2.0W	C		500	500	R	30	180	25M	1.4	25M				
2N5011	S	N			A	2.0W	C		600	600	R	30	180	25M	1.5	25M				
2N5012	S	N			A	2.0W	C		700	700	R	30	180	25M	1.6	25M				
2N5013	S	N			A	2.0W	C		800	800	R	30	180	20M	1.6	20M				
2N5014	S	N			A	2.0W	C		900	900	R	30	180	20M	1.6	20M				
2N5015	S	N			A	2.0W	C		1000	1000	R	30	180	20M	1.8	20M				
2N5016	S	N			AHP				65	30	0	10	200	0.5A					500M	T
2N5017	S	N			AHP				65	30	0	10	200	0.5A					500M	T
2N5018																				
2N5021	Field-Effect Transistors, see Table on Page 2-76																			
2N5022	S	P			SH	1.0W	A		50	50	0	25	100	500M	0.2	100M				
2N5023	S	P			SH	1.0W	A		30	30	0	40	100	500M	0.17	100M				
2N5024	S	N			SH	200M	A		20	10	0	25		10M			13	E	1300M	T
2N5025	S	N			AHP	45W	C	300	75	75	0	20		2.0A	1.0	2.0A				
2N5026	S	N			AHP	45W	C	300	90	90	0	20		2.0A	1.0	2.0A				
2N5027	S	N			S	320M	A	120		30	0	50	150	150M	0.45	150M				
2N5028	S	N			S	320M	A	120		30	0	100	300	150M	0.45	150M				
2N5029	S	N				320M	A	120		15	0	40	120	10M	0.25	10M				
2N5030	S	N				320M	A	120		12	0	30		10M	0.25	10M				
2N5031	S	N		2N5031	AH	200M	A		15	10	0	25	300	1.0M						
2N5032	S	N		2N5031	AH	200M	A		15	10	0	25	300	1.0M						
2N5033	Field-Effect Transistors, see Table on Page 2-76																			
2N5034	S	N			AP	83W	C	150	55	45	R	20	70	2.5A	2.5	6.0A	15	E		
2N5035	S	N			AP	83W	C	150	55	45	R	20	70	3.0A	3.0	8.0A	15	E		
2N5036	S	N			AP	83W	C	150	70	60	R	20	70	2.5A	2.5	6.0A	15	E		
2N5037	S	N			AP	83W	C	150	70	60	R	20	70	3.0A	3.0	8.0A	15	E		
2N5038	S	N			SP	140W	C	200	150	150	V	20	100	12A	2.5	20A				
2N5039	S	N			SP	140W	C	200	120	120	V	20	100	10A	2.5	20A				
2N5040	S	P			A	300M	A	125	25	25	0	30	600	150M	1.0	0.5A			100M	T
2N5041	S	P			A	300M	A	125	40	40	0	40	150	150M	0.5	0.5A			80M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N5042	S	P			A	800M	A	200	40	40	0	40	150	150M	1.1	0.5A			100M	T
2N5043	G	P				30M	A	125	15	7.0	0		150	3.0M						
2N5044	G	P				30M	A	125	15	7.0	0		150	3.0M						
2N5045 thru 2N5047	Field-Effect Transistors, see Table on Page 2-76																			
2N5048	S	N			SP	100W	C	175	120	100	0	15	60	10A	2.0	10A			10M	T
2N5049	S	N			SP	100W	C	175	60	50	0	15	60	10A	2.5	10A			10M	T
2N5050	S	N			AP	40W	C	200		120	0	35	105	0.5A	0.9	0.5A			20M	T
2N5051	S	N			AP	40W	C	200		150	0	35	105	0.5A	0.9	0.5A			20M	T
2N5052	S	N			AP	40W	C	200		200	0	35	105	0.5A	0.9	0.5A			20M	T
2N5053	S	N			AH	200M	A	200	30	15	0	25	150	2.0M					1300M	T
2N5054	S	N			AH	200M	A	200	30	15	0	25	150	2.0M					1300M	T
2N5055	S	P			SH	200M	A	125	12	12	0	30	100	30M	0.13	1.0M				
2N5056	S	P			SH	360M	A	200	15	15	0	30	100	30M	0.13	1.0M				
2N5057	S	P			SH	360M	A	200	15	15	0	40	100	30M	0.13	1.0M				
2N5058	S	N				1.0W	C	200	300	300	0	35	150	30M						
2N5059	S	N				1.0W	C	200	250	250	0	30	150	30M						
2N5060 thru 2N5064	Thyristors, see Table on Page 2-66																			
2N5065	S	N			SH	2.5W	C	200	25	15	0	50	120	300M	0.23	100M			550M	T
2N5066	S	N			SC	400M	A		30	20	0								5.0M	T
2N5067	S	N		2N5067	AP	87.5W	C	200	40	40	0	20	80	1.0A	0.4	1.0A	20	E	4.0M	T
2N5068	S	N		2N5067	AP	87.5W	C	200	60	60	0	20	80	1.0A	0.4	1.0A	20	E	4.0M	T
2N5069	S	N		2N5067	AP	87.5W	C	200	80	80	0	20	80	1.0A	0.4	1.0A	20	E	4.0M	T
2N5070	S	N			AHP	70W	C		65	30	0	10	100	3.0A					100M	T
2N5071	S	N			AHP	70W	C		65	30	0	10	100	3.0A					100M	T
2N5072	S	N			AHP	125W	C		100	100	R	15	60	3.0A	1.0	10A			40M	T
2N5073	S	N			AH	600M	A		180	120	0	30	120	200M					40M	T
2N5074	S	N			AP	70W	C	200	200	200	0	30	110	0.5A	2.0	3.0A	30	E	40M	T
2N5075	S	N			AP	70W	C	200	200	200	0	90	250	0.5A	2.0	3.0A	30	E	40M	T
2N5076	S	N			AP	70W	C	200	250	250	0	30	110	0.5A	2.0	3.0A	30	E	40M	T
2N5077	S	N			AP	70W	C	200	250	250	0	90	250	0.5A	2.0	3.0A	30	E	40M	T
2N5078	Field-Effect Transistors, see Table on Page 2-76																			
2N5079	S	N			A	1.8W	C		60	30	0	100	300	150M	0.2	150M			400M	T
2N5080	S	N			A	1.8W	C		60	30	0	200	500	150M	0.2	150M			500M	T
2N5081	S	N			AH	1.2W	C		70	50	0	100	400	1.0M	0.2	10M	100	E	600M	T
2N5082	S	N			AH	1.2W	C		60	30	0	100	400	1.0M	0.2	10M	100	E	600M	T
2N5083	S	N			SP	35W	C	200	120	60	0	40	120	2.0A	1.0	10A			50M	T
2N5084	S	N			SP	35W	C	200	120	60	0	100	300	2.0A	1.0	10A			80M	T
2N5085	S	N			SP	35W	C	200	150	80	0	40	120	2.0A	1.0	10A			50M	T
2N5086	S	P		2N3086	A	310M	A	135	50	50	0	150	500	0.1M	0.3	10M	150	E	40M	T
2N5087	S	P		2N3086	A	310M	A	135	50	50	0	250	800	0.1M	0.3	10M	250	E	40M	T
2N5088	S	N		2N5088	A	310M	A	135	35	30	0	300	900	0.1M	0.5	10M	350	E	50M	T
2N5089	S	N		2N5088	A	310M	A	135	30	25	0	400	1200	0.1M	0.5	10M	450	E	50M	T
2N5090	S	N			AHP			200	55	30	0	10	200	50M	1.0	100M			500M	T
2N5091	S	P			A			175	350	300	0	40	250	25M	3.0	25M			20M	T
2N5092	S	N			A			175	400	350	0	50	300	25M	0.5	25M			50M	T
2N5093	S	P			A			175	400	350	0	40	250	25M	3.0	25M			20M	T
2N5094	S	P			A			175	450	400	0	40	250	25M	3.0	25M			20M	T
2N5095	S	N			A			175	500	400	0	50	300	25M	0.5	25M			50M	T
2N5096	S	P			A			175	500	450	0	40	250	25M	3.0	25M			20M	T
2N5097	S	N			A			175	600	450	0	50	300	25M	0.5	25M			50M	T
2N5098	S	N			A			175	700	500	0	50	300	25M	0.5	25M			50M	T
2N5099	S	N			A			175	800	550	0	50	300	25M	0.5	25M			50M	T
2N5100	S	P			A			175	450	400	0	40	250	25M	3.0	25M			20M	T
2N5101	S	N			A			175	500	400	0	50	300	25M	0.5	25M			50M	T
2N5102	S	N			AHP	70W	C		90	50	R	10	100	500M					150M	T
2N5103 thru 2N5105	Field-Effect Transistors, see Table on Page 2-76																			
2N5106	S	N			A	800M	A	200	60	30	0	100	300	150M	0.22	150M			250M	T
2N5107	S	N			A	360M	A	200	60	30	0	100	300	150M	0.22	150M			250M	T
2N5108	S	N			AHP	3.5W	C		55	55	R								1.2G	T
2N5109	S	N			AHP	3.5W	C		40	20	0	70	210	50M					1.2G	T
2N5110	S	P			AP	5.0W	C	175	40	40	0	15	60	500M	0.9	500M	10	E	1.0M	T
2N5111	S	P			AP	5.0W	C	175	80	80	0	15	60	500M	0.9	500M	10	E	1.0M	T
2N5112	S	P			AP	34W	C	175	40	40	0	15	60	500M	0.9	500M	10	E	1.0M	T
2N5113	S	P			AP	34W	C	175	80	80	0	15	60	500M	0.9	500M	10	E	1.0M	T
2N5114 thru 2N5116	Field-Effect Transistors, see Table on Page 2-76																			
2N5117	S	P			AM	400M	C		45	45	0	100	300	0.010M						
2N5118	S	P			AM	400M	C		45	45	0	100	300	0.010M						
2N5119	S	P			AM	400M	C		45	45	0	50	800	0.010M						
2N5120	S	P			AM	300M	C		45	45	0	100	300	0.010M						
2N5121	S	P			AM	300M	C		45	45	0	100	300	0.010M						
2N5122	S	P			AM	300M	C		45	45	0	50	800	0.010M						
2N5123	S	P			AM	400M	C		45	45	0	100	300	0.010M						
2N5124	S	P			AM	400M	C		45	45	0	100	300	0.010M						
2N5125	S	P			AM	400M	C		45	45	0	50	800	0.010M						
2N5126	S	N	MPS6539		A	200M	A	125	20	20	0	20	350	4M	2.0	10M	15	E		
2N5127	S	N	MPS918		A	200M	A	125	20	12	0	15	300	2M	0.3	10M	12	E		
2N5128	S	N	2N5220		A	200M	A	125	15	12	0	35	350	50M	0.25	150M				
2N5129	S	N	2N5220		A	300M	A	125	15	12	0	35	350	50M	0.25	150M				
2N5130	S	N	MPS3563		A	200M	A	125	30	12	0	15	250	8M	0.6	10M	12	E		
2N5131	S	N	2N5223		A	200M	A	125	20	15	0	30	500	10M	1.0	10M	25	E		
2N5132	S	N	MPS6539		A	200M	A	125	20	20	0	30	400	10M	2.0	10M	20	E		
2N5133	S	N	MPS2714		A	200M	A	125	20	18	0	60	1000	1.0M	0.4	1.0M	50	E		
2N5134	S	N	2N5224		SH	200M	A	125	20	10	0	20	150	10M	0.2	10M				
2N5135	S	N	2N5225		A	300M	A	125	30	25	0	50	600	10M	1.0	100M				
2N5136	S	N	MPS3706		A	220M	A	125	30	20	0	20	400	150M	0.25	150M				
2N5137	S	N	MPS6560		A	300M	A	125	30	20	0	20	400	150M	0.25	150M				
2N5138	S	P	MPS6516		A	200M	A	125	30	30	0	50	800	100*	0.3	10M	40	E		
2N5139	S	P	MPS6516		SH	200M	A	125	20	20	0	40		1.0M	0.15	1.0M				
2N5140	S	P	MPS6518		SH	200M	A	125	5.0	5.0	0	20	140	10M	0.2	10M				

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TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N5141	S	P			SH	200M	A	125	6.0	6.0	0	30		30M	0.2	10M				
2N5142	S	P			SH	300M	A	125	20	20	0	30		50M	0.5	50M				
2N5143	S	P			SH	200M	A	125	20	20	0	30		50M	0.5	50M				
2N5144	S	N			SH	360M	A	200	50	30	0	60	150	100M	0.2	100M			300M	T
2N5145	S	N			SH	800M	A	200	50	30	0	60	150	100M	0.2	100M			300M	T
2N5146	S	P		2N5146	AL	400M	A		40	40	0	20		1.0A	1.0	1.0A			150M	T
2N5147	S	P			AP	1.0W	A	200	100	80	0	30	90	1.0A	5.0	3.0A	20	E	50M	T
2N5148	S	N			AP	1.0W	A	200	100	80	0	30	90	1.0A	5.0	3.0A	20	E	50M	T
2N5149	S	P			AP	1.0W	A	200	100	80	0	70	200	1.0A	5.0	3.0A	50	E	60M	T
2N5150	S	N			AP	1.0W	A	200	100	80	0	70	200	1.0A	5.0	3.0A	50	E	60M	T
2N5151	S	P			AP	1.0W	A	200	100	80	0	30	90	2.5A	1.5	5.0A	20	E	60M	T
2N5152	S	N			AP	1.0W	A	200	100	80	0	30	90	2.5A	1.5	5.0A	20	E	60M	T
2N5153	S	P			AP	1.0W	A	200	100	80	0	70	200	2.5A	1.5	5.0A	50	E	70M	T
2N5154	S	N			AP	1.0W	A	200	100	80	0	70	200	2.5A	1.5	5.0A	50	E	70M	T
2N5155	G	P		2N5155	SP			110	140	120	0	25	100	8.0A	0.9	25A			100G	T
2N5156	G	P			SP	93W	C	100	100	60	0	25	60	5.0A	1.0	10A			150G	T
2N5157	G	P			SP			150	700	500	0	30	90	1.0A	2.5	3.5A			2.8M	T
2N5158	Field-Effect Transistors, see Table on Page 2-76																			
2N5159																				
2N5160	S	P		2N5160	AHP	5.0W	C		60	40	0	10		50M					500M	T
2N5161	S	P		2N5161	AHP	20W	C		60	40	0	10		250M						
2N5162	S	P		2N5161	AHP	50W	C		60	40	0	10		2.0A						
2N5163	Field-Effect Transistors, see Table on Page 2-76																			
2N5164,R thru 2N5171,R	Thyristors, see Table on Page 2-66																			
2N5172	S	N			A	200M	A		25	25	0	100	500	10M	0.25	10M	100	E		
2N5174	S	N			A	200M	A		90	75	0	40	600	10M	0.95	10M	40	E		
2N5175	S	N			A	200M	A		130	100	0	55	160	10M	0.95	10M	55	E		
2N5176	S	N			A	200M	A		130	100	0	140	300	10M	0.95	10M	140	E		
2N5177	S	N			AHP	40W	C	200	60	35	0	10	150	100M					200M	T
2N5178	S	N			AHP	70W	C	200	60	35	0	10	150	200M					200M	T
2N5179	S	N			AH	200M	A		20	12	0	25	250	3.0M	0.4	10M	25	E	900M	T
2N5180	S	N			AH	180M	A		30	15	0	20	200	2.0M					650M	T
2N5181	S	N			AH	180M	A		45			27		1.0M					400M	T
2N5182	S	N			AH	180M	A		35			27		1.0M					400M	T
2N5183	S	N			AH	500M	A		18	18	0	75		10M			70	E	62.5M	T
2N5184	S	N			AH	500M	A			120	0	10		50M						
2N5185	S	N			AH	1.0W	A			120	0	10		50M					50M	T
2N5186	S	N			SH	300M	A		10	5.0	S	25		10M	0.3	10M				
2N5187	S	N			SH	1.0W	A		25	25	S	30		10M	0.25	10M				
2N5188	S	N			SH	800M	A		60	55	S	25		150M	0.5	150M				
2N5189	S	N			SH	1.0W	A		60	55	S	15		1.0M	1.0	1.0A				
2N5190	S	N		2N5190	AP	40W	C	150	40	40	0	25	100	1.5A	1.4	4.0A	20	E		
2N5191	S	N		2N5190	AP	40W	C	150	60	60	0	25	100	1.5A	1.4	4.0A	20	E		
2N5192	S	N		2N5190	AP	40W	C	150	80	80	0	20	80	1.5A	1.4	4.0A	20	E		
2N5193	S	P		2N5193	AP	40W	C	150	40	40	0	25	100	1.5A	1.4	4.0A	20	E		
2N5194	S	P		2N5193	AP	40W	C	150	60	60	0	25	100	1.5A	1.4	4.0A	20	E		
2N5195	S	P		2N5193	AP	40W	C	150	80	80	0	20	80	1.5A	1.4	4.0A	20	E		
2N5196 thru 2N5199	Field-Effect Transistors, see Table on Page 2-76																			
2N5200	S	N			A	1.2W	C	250	20	20	0	50	150	10M	0.5	50M			900M	T
2N5201	S	N			A	1.2W	C	250	20	20	0	75	150	10M	0.5	50M			1100M	T
2N5202	S	N			SP	35W	C	200	100	75	V	10	100	4.0A	1.2	4.0A			60M	T
2N5204 thru 2N5207	Thyristors, see Table on Page 2-66																			
2N5208	S	P		2N5208	AH	310M	A		30	25	0	20	120	2.0M						
2N5209	S	N		2N5209	A	310M	A		50	50	0	100	300	0.1M	0.7	10M	150	E		
2N5210	S	N		2N5209	A	310M	A		50	50	0	200	600	0.1M	0.7	10M	250	E		
2N5211	S	N			AHP	3.0W	C	200	80	80	0	10	60	0.2A	0.5	0.54A			200M	T
2N5212	S	N			AHP	7.5W	C	200	80	80	0	10	60	0.2A	0.5	0.54A			200M	T
2N5213	S	N			AHP	7.5W	C	200	70	40	0	10	80	0.2A	0.5	0.5A			350M	T
2N5214	S	N			AHP	60W	C	200	95	95	S	10	75	1.0A	1.5	4.5A			150M	T
2N5215	S	N			AHP	23W	C	200	70	70	0	10	80	0.5A	0.5	1.0A			400M	T
2N5216	S	N			AHP	25W	C	200	80	80	0	10	60	0.5A	1.2	1.5A			350M	T
2N5217	S	N			AHP	7.5W	C	200	80	80	0	10	80	0.2A	0.5	0.5A			350M	T
2N5218	S	N			AP			200	220	200	0	15	120	5.0A	0.6	5.0A	40	E	40M	T
2N5219	S	N		2N5219	A	310M	A		20	15	0	35	500	2.0M	0.4	10M	35	E		
2N5220	S	N		2N5219	A	310M	A		15	15	0	30	600	50M	0.5	150M	30	E		
2N5221	S	P		2N5219	A	310M	A		15	15	0	30	600	50M	0.5	150M	30	E		
2N5222	S	N		2N5219	A	310M	A		20	15	0	20	1500	4.0M	1.0	4.0M	20	E		
2N5223	S	N		2N5219	A	310M	A		25	20	0	50	800	2.0M	0.7	10M	50	E		
2N5224	S	N		2N5219	SH	310M	A		25	12	0	40	400	10M	0.35	10M				
2N5225	S	N		2N5219	A	310M	A		25	25	0	30	600	50M	0.8	100M	30	E		
2N5226	S	P		2N5219	A	310M	A		25	25	0	30	600	50M	1.0	100M	30	E		
2N5227	S	P		2N5219	A	310M	A		30	30	0	50	700	2.0M	0.4	10M	50	E		
2N5228	S	P		2N5228	SH	310M	A		5.0	5.0	0	30		10M	0.4	10M				
2N5229	S	P			SC	2.0W	C		15	10	0	50		100*						
2N5230	S	P			SC	2.0W	C		30	20	0	50		100*						
2N5231	S	P			SC	2.0W	C		50	30	0	50		100*						
2N5232	S	N			A	330M	A		70	50	0	250	500	2.0M	0.125	10M	250	E		
2N5233	S	N			A	330M	A		80	60	0	100	300	10M	0.125	10M	100	E		
2N5234	S	N			A	330M	A		80	60	0	250	500	10M	0.125	10M	250	E		
2N5235	S	N			A	330M	A		80	60	0	400	800	10M	0.125	10M	400	E		
2N5236	S	N			AH	1.0W	C	200	40	20	0	30	120	50M	0.2	50M			500M	T
2N5237	S	N			SP			200	150	120	0	40	120	5.0A	0.6	5.0A	2.5	E	25M	T
2N5238	S	N			SP			200	200	170	0	40	120	5.0A	0.6	5.0A	2.5	E	25M	T
2N5239	S	N			AP	100W	C	200	300		0	20	80	2.0A	5.0	4.5A	20	E	5.0M	T
2N5240	S	N			AP	100W	C	200	375		0	20	80	2.0A	5.0	4.5A	20	E	5.0M	T
2N5241	S	N			SP			150	400	400	0	15	35	2.5A	2.5	5.0A			2.5M	T
2N5242	S	P			SH	0.5W	A			20	0	25	100	500M	0.38	500M			170M	T
2N5243	S	P			SH	0.5W	A			30	0	25	100	500M	0.38	500M			170M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N5244	S	P			SH	1.0W	C	200		40	0	150	300	10M	0.12	10M			450M	T
2N5245 thru 2N5248	Field-Effect Transistors, see Table on Page 2-76																			
2N5249	S	N			A	330M	A		70	50	0	400	800	2.0M	0.125	10M	400	E		
2N5249A	S	N			A	330M	A		70	50	0	400	800	2.0M	0.125	10M	400	E		
2N5252	S	N			A	7.0W	C		300	300	0	40	120	100M	1.0	200M			30M	T
2N5253	S	N			A	7.0W	C		300	300	0	80	250	100M	1.0	200M			30M	T
2N5254	S	P			AL	0.8W	C	125	40	40	0	50	750	0.1M	0.25	10M	70	E	40M	T
2N5255	S	P			AM	0.8W	C	125	40	40	0	150	750	0.10M	0.25	10M			40M	T
2N5256	S	P			AM	0.8W	C	125	40	40	0	150	750	0.10M	0.25	10M			40M	T
2N5257 thru 2N5261	Thyristors, see Table on Page 2-66																			
2N5262	S	N			SH	1.0W	A		75	50	0	35		100M	0.8	1.0A				
2N5264	S	N			SP	87W	C	200	400	180	0	30	300	1.0A	1.25	7.0A			50M	T
2N5265 thru 2N5270	Field-Effect Transistors, see Table on Page 2-76																			
2N5271	S	N			SH	600M	A													
2N5272	S	N			SH	360M	A		40	40	S	100	400	10M	0.25	10M			500M	T
2N5273 thru 2N5275	Thyristors, see Table on Page 2-66																			
2N5276	S	N			S	360M	A		25	15	0	30	90	1.0M	0.2	20M			600M	T
2N5277 2N5278	Field-Effect Transistors, see Table on Page 2-76																			
2N5279	S	N			AH	5.0W	C		400			40	160	20M	0.5	50M			15M	T
2N5280	S	N			AH	15W	C	175	400			40	160	20M	0.5	50M			15M	T
2N5281	S	P			A			175	175	150	0	20	200	1.0M	2.0	10M			20M	T
2N5282	S	P			A			175	325	300	0	20	200	1.0M	2.0	10M			20M	T
2N5284	S	N			AP			200	120	80	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5285	S	N			AP			200	120	80	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5286	S	P			AP			200	100	100	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5287	S	P			AP			200	100	100	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5288	S	N			AP			200	120	100	0	30	90	5.0A	0.9	5.0A	20	E	30M	T
2N5289	S	N			AP			200	120	100	0	70	200	5.0A	0.9	5.0A	50	E	40M	T
2N5290	S	P			AP			200	100	100	0	30	90	5.0A	0.9	5.0A	20	E	30M	T
2N5291	S	P			AP			200	100	100	0	70	200	5.0A	0.9	5.0A	50	E	40M	T
2N5292	S	P			SH	1.0W	C	200		12	S	40	100	30M	0.12	10M			800M	T
2N5293	S	N			AP	36W	C	150	80	75	R	30	120	0.5A	2.0	3.6A	15	E		
2N5294	S	N			AP	36W	C	150	80	75	R	30	120	0.5A	2.0	3.6A	15	E		
2N5295	S	N			AP	36W	C	150	60	50	R	30	120	1.0A	2.0	3.6A	20	E		
2N5296	S	N			AP	36W	C	150	60	50	R	30	120	1.0A	2.0	3.6A	20	E		
2N5297	S	N			AP	36W	C	150	80	70	R	20	80	1.5A	2.0	3.6A	25	E		
2N5298	S	N			AP	36W	C	150	80	70	R	20	80	1.5A	2.0	3.6A	25	E		
2N5301	S	N		2N5301	AP	200W	C	200	40	40	0	15	60	15A	0.75	10A	40	E		
2N5302	S	N		2N5301	AP	200W	C	200	60	60	0	15	60	15A	0.75	10A	40	E		
2N5303	S	N		2N5301	AP	200W	C	200	80	80	0	15	60	10A	1.0	10A	40	E		
2N5305	S	N			AL	450M	A		25	25	0	2K	20K	2.0M	1.4	200M	2000	E	60M	T
2N5306	S	N			AL	400M	A		25	25	0	7K	70K	2.0M	1.4	200M	7000	E	60M	T
2N5307	S	N			AL	400M	A		40	40	0	2K	20K	2.0M	1.4	200M	2000	E	60M	T
2N5308	S	N			AL	400M	A		40	40	0	7K	70K	2.0M	1.4	200M	7000	E	60M	T
2N5309	S	N			A	330M	A		70	50	0	60	120	10*	0.125	10M	66	E		
2N5310	S	N			A	330M	A		70	50	0	100	300	10*	0.125	10M	110	E		
2N5311	S	N			A	330M	A		70	50	0	250	500	10*	0.125	10M				
2N5312	S	P			AP	50W	C	200	80	80	0	30	90	10A	1.5	10A	30	E	30M	T
2N5313	S	N			AP	50W	C	200	80	80	0	30	90	10A	1.5	10A	30	E	30M	T
2N5314	S	P			AP	50W	C	200	100	100	0	30	90	10A	1.5	10A	30	E	30M	T
2N5315	S	N			AP	50W	C	200	100	100	0	30	90	10A	1.5	10A	30	E	30M	T
2N5316	S	P			AP	50W	C	200	80	80	0	30	90	5.0A	0.6	5.0A	30	E	30M	T
2N5317	S	N			AP	50W	C	200	80	80	0	30	90	5.0A	0.6	5.0A	30	E	30M	T
2N5318	S	P			AP	50W	C	200	100	100	0	30	90	5.0A	0.6	5.0A	30	E	30M	T
2N5319	S	N			AP	50W	C	200	100	100	0	30	90	5.0A	0.6	5.0A	30	E	30M	T
2N5320	S	N			SP	10W	C	200	100	75	0	30	130	500M	0.5	500M			50M	T
2N5321	S	N			SP	10W	C	200	75	50	0	40	250	500M	0.8	500M			50M	T
2N5322	S	P			SP	10W	C	200	100	75	0	30	130	500M	0.7	500M			50M	T
2N5323	S	P			SP	10W	C	200	75	50	0	40	250	500M	1.2	500M			50M	T
2N5324	G	P		2N5324	SP	56W	C	110	250	150	0	20	60	5.0A	0.5	10A			2.0M	T
2N5325	G	P		2N5324	SP	56W	C	110	325	200	0	20	60	5.0A	0.5	10A			2.0M	T
2N5326	S	N			SP	400W*	C	200	100	80	0	50	150	1.0A	1.0	5.0A				
2N5327	S	N			SP	450W*	C	200	100	80	0	100	300	1.0A	0.3	3.0A				
2N5328	S	N			SP	450W*	C	200	100	80	0	100	300	1.0A	0.6	5.0A				
2N5329	S	N			SP	1000W*	C	200	150	90	0	40	120	10A	1.8	20A				
2N5330	S	N			SP	1000W*	C	200	150	90	0	40	120	10A	0.6	10A				
2N5331	S	N			SP	1000W*	C	200	150	90	0	40	120	10A	0.6	10A				
2N5332	S	P			SH	360M	A		20	12	0	20	80	1.0M	0.2	20M			600M	T
2N5333	S	P			AP	1.0W	A	200	100	80	0	30	120	1.0A	1.0	2.0A	30	E	30M	T
2N5334	S	N		2N5334	SP	6.0W	C	200	60	60	0	30	150	1.0A	0.7	2.0A			40M	T
2N5335	S	N		2N5334	SP	6.0W	C	200	80	80	0	30	150	1.0A	0.7	2.0A			40M	T
2N5336	S	N		2N5336	SP	6.0W	C	200	80	80	0	30	120	2.0A	0.7	2.0A			30M	T
2N5337	S	N		2N5336	SP	6.0W	C	200	80	80	0	60	240	2.0A	0.7	2.0A			30M	T
2N5338	S	N		2N5336	SP	6.0W	C	200	100	100	0	30	120	2.0A	0.7	2.0A			30M	T
2N5339	S	N		2N5336	SP	6.0W	C	200	100	100	0	60	240	2.0A	0.7	2.0A			30M	T
2N5344	S	P		2N5344	SP	40W	C	200	250	250	0	25	100	500M	3.0	1.0A			60M	T
2N5345	S	P		2N5344	SP	40W	C	200	300	300	0	25	100	500M	3.0	1.0A			60M	T
2N5346	S	N		2N5346	SP	60W	C	200	80	80	0	30	120	2.0A	0.7	2.0A			30M	T

*Pulsed

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units	Subscript
2N5347	S	N		2N5346	SP	60W	C	200	80	80	0	30	120	2.0A	0.7	2.0A			30M	T
2N5348	S	N		2N5346	SP	60W	C	200	100	100	0	60	240	2.0A	0.7	2.0A			30M	T
2N5349	S	N		2N5346	SP	60W	C	200	100	100	0	60	240	2.0A	0.7	2.0A			30M	T
2N5350	S	N			SP	350W	C	200	125	100	0	10	40	70A	5.0	90A			10M	T
2N5351	S	N			SP	350W	C	200	180	150	0	10	40	70A	5.0	90A			10M	T
2N5354	S	P			A	360M	A		25	25	0	40	120	50M	0.25	50M	32	E		
2N5355	S	P			A	360M	A		25	25	0	100	300	50M	0.25	50M	80	E		
2N5356	S	P			A	360M	A		25	25	0	250	500	50M	0.25	50M	200	E		
2N5357	S	P		2N5357	SP	30W	C	200	300	300	0	25	100	500M	0.3	100M			50M	T
2N5358 thru 2N5364	Field-Effect Transistors, see Table on Page 2-76																			
2N5365	S	P			A	360M	A		40	40	0	40	120	50M	0.25	50M	32	E		
2N5366	S	P			A	360M	A		40	40	0	100	300	50M	0.25	50M	80	E		
2N5367	S	P			A	360M	A		40	40	0	250	500	50M	0.25	50M	200	E		
2N5368	S	N			A	360M	A	150	60	30	0	60	200	150M	0.3	150M			250M	T
2N5369	S	N			A	360M	A	150	60	30	0	100	300	150M	0.3	150M			250M	T
2N5370	S	N			A	360M	A	150	60	30	0	200	600	150M	0.3	150M			250M	T
2N5371	S	N			A	360M	A	150	40	30	0	60	600	150M	0.3	150M			250M	T
2N5372	S	P			A	360M	A	150	60	30	0	40	120	150M	0.3	150M			150M	T
2N5373	S	P			A	360M	A	150	60	30	0	100	300	150M	0.3	150M			150M	T
2N5374	S	P			A	360M	A	150	60	30	0	200	400	150M	0.3	150M			150M	T
2N5375	S	P			A	360M	A	150	40	30	0	40	400	150M	0.3	150M			150M	T
2N5376	S	N			A	360M	A	150	60	30	0	100	500	0.010M	0.2	10M	120	E	300M	T
2N5377	S	N			A	360M	A	150	60	30	0	40	200	0.010M	0.2	10M	100	E	300M	T
2N5378	S	P			A	360M	A	150	40	30	0	100	500	0.010M	0.2	10M	120	E	200M	T
2N5379	S	P			A	360M	A	150	40	30	0	40	200	0.010M	0.2	10M	100	E	200M	T
2N5384	S	P			A	2.0W	A	200	100	80	0	20	80	2.0A	1.4	5.0A	20	E	30M	T
2N5385	S	P			A	2.0W	A	200	100	80	0	20	80	2.0A	1.4	5.0A	20	E	30M	T
2N5386	S	P			A	3.5W	A	200	100	80	0	20	80	6.0A	1.4	12A	20	E	30M	T
2N5387	S	N			A	3.5W	A	200	200	200	0	25	100	2.0A	2.2	7.0A	20	E	15M	T
2N5388	S	N			A	3.5W	A	200	250	250	0	25	100	2.0A	2.2	7.0A	20	E	15M	T
2N5389	S	N			A	3.5W	A	200	300	300	0	25	100	2.0A	2.2	7.0A	20	E	15M	T
2N5390	S	N			AL	1.0W	C	200	120	80	0	2K	20K	2.0A	2.5	5.0A			40M	T
2N5391 thru 2N5398	Field-Effect Transistors, see Table on Page 2-76																			
2N5399	S	N			SH	360M	A		25	15	0	30	90	1.0M	0.2	20M			600M	T
2N5400	S	P		2N5400	A	310M	A		130	120	0	40	180	10M	0.25	50M	30	E	100M	T
2N5401	S	P		2N5400	A	310M	A		160	150	0	60	240	10M	0.25	50M	40	E	100M	T
2N5404	S	P			AP	1.0W	A	200	80	80	0	20	60	2.0A	0.6	2.0A	20	E	40M	T
2N5405	S	P			AP	1.0W	A	200	100	100	0	20	60	2.0A	0.6	2.0A	20	E	40M	T
2N5406	S	P			AP	1.0W	A	200	80	80	0	40	120	2.0A	0.6	2.0A	40	E	40M	T
2N5407	S	P			AP	1.0W	A	200	100	100	0	40	120	2.0A	0.6	2.0A	40	E	40M	T
2N5408	S	P			AP	30W	C	200	80	80	0	20	60	2.0A	0.6	2.0A	20	E	40M	T
2N5409	S	P			AP	30W	C	200	100	100	0	20	60	2.0A	0.6	2.0A	20	E	40M	T
2N5410	S	P			AP	30W	C	200	80	80	0	40	120	2.0A	0.6	2.0A	40	E	40M	T
2N5411	S	P			AP	30W	C	200	100	100	0	40	120	2.0A	0.6	2.0A	40	E	40M	T
2N5412	S	N			AP	100W	C	175	80	60	0	10	160	2.0A	1.0	10A	20	E		
2N5413	S	N			SH	1.0W	A		60	40	0	25	100	2.0A	0.25	150M				
2N5414	S	N			SH	1.0W	A		80	50	0	25	100	2.0A	0.25	150M				
2N5415	S	P			AH	10W	C		200			30	150	50M					15M	T
2N5416	S	P			AH	10W	C		350			30	120	50M					15M	T
2N5417	S	N			SH	500M	A		40	35	0	80	250	150M	0.55	150M			250M	T
2N5418	S	N			A	360M	A		25	25	0	40	120	50M	0.25	50M	25	E		
2N5419	S	N			A	360M	A		25	25	0	100	300	50M	0.25	50M	70	E		
2N5420	S	N			A	360M	A		25	25	0	250	500	50M	0.25	50M	150	E		
2N5421	S	N			AHP	3.0W	C		36	18	0	10	60	0.1A	0.5	0.2A			300M	T
2N5422	S	N			AHP	5.0W	C		36	18	0	10	60	0.5A	0.5	0.5A			300M	T
2N5423	S	N			AHP	12W	C		36	18	0	20	70	1.0A	0.5	1.0A			300M	T
2N5424	S	N			AHP	20W	C		36	18	0	20	100	2.0A	0.5	2.0A			250M	T
2N5425	S	N			AH				60	60	0	500		5.0A	2.5	5.0A	500	E		
2N5426	S	N			AH				60	60	0	1000		5.0A	2.2	5.0A	1000	E		
2N5427	S	N		2N5427	SP	35W	C	200	80	80	0	30	120	2.0A	0.7	2.0A			30M	T
2N5428	S	N		2N5427	SP	35W	C	200	80	80	0	60	240	2.0A	0.7	2.0A			30M	T
2N5429	S	N		2N5427	SP	35W	C	200	100	100	0	30	120	2.0A	0.7	2.0A			30M	T
2N5430	S	N		2N5427	SP	35W	C	200	100	100	0	60	240	2.0A	0.7	2.0A			30M	T
2N5431	Unijunction Transistors, see Table on Page 2-86																			
2N5432																				
2N5433	Field-Effect Transistors, see Table on Page 2-76																			
2N5434																				
2N5435	G	P		2N5435	SP	120W	C	110	80	60	0	20	60	25A	0.75	60A				
2N5436	G	P		2N5435	SP	120W	C	110	110	90	0	20	60	25A	0.75	60A				
2N5437	G	P		2N5435	SP	120W	C	110	140	120	0	20	60	25A	0.75	60A				
2N5438	G	P		2N5435	SP	120W	C	110	80	60	0	40	120	25A	0.50	60A				
2N5439	G	P		2N5435	SP	120W	C	110	110	90	0	40	120	25A	0.50	60A				
2N5440	G	P		2N5435	SP	120W	C	110	140	120	0	40	120	25A	0.50	60A				
2N5447	S	N			A	360M	A		40	25	0	60	300	50M	0.25	50M				
2N5448	S	N			A	360M	A		50	30	0	30	150	50M	0.25	50M				
2N5449	S	N			A	360M	A		50	30	0	100	300	50M	0.6	100M				
2N5450	S	N			A	360M	A		50	30	0	50	150	50M	0.8	100M				
2N5451	S	N			A	360M	A		40	20	0	30	600	50M	1.0	100M				
2N5452 thru 2N5454	Field-Effect Transistors, see Table on Page 2-76																			
2N5455	S	P			SH	340M	A	200	15	15	0	30	120	30M	0.50	300M			450M	T
2N5456	S	P			SH	340M	A	200	25	25	0	30	120	30M	0.55	300M			450M	T
2N5457 thru 2N5465	Field-Effect Transistors, see Table on Page 2-76																			
2N5466	S	N			AP			200	500	400	0	15	60	3.0A	0.5	3.0A	25	E		
2N5467	S	N			AP			200	700	400	0	15	60	3.0A	0.5	3.0A	25	E		
2N5468	S	N			AP			200	500	400	0	15	60	3.0A	0.5	3.0A	25	E		
2N5469	S	N			AP			200	700	400	0	15	60	3.0A	0.5	3.0A	25	E		
2N5471 thru 2N5476	Field-Effect Transistors, see Table on Page 2-76																			
2N5477	S	N		2N5477	SP	60W	C	200	80	80	0	30	120	2.0A	0.7	2.0A			30M	T
2N5478	S	N		2N5477	SP	60W	C	200	80	80	0	60	240	2.0A	0.7	2.0A			30M	T
2N5479	S	N		2N5477	SP	60W	C	200	100	100	0	30	120	2.0A	0.7	2.0A			30M	T
2N5480	S	N		2N5477	SP	60W	C	200	100	100	0	60	240	2.0A	0.7	2.0A			30M	T
2N5481	S	N			AHP	5.0W	C		50	30	0	20		50M						
2N5482	S	N			AHP	10W	C		50	30	0	20		50M						
2N5483	S	N			AHP	20W	C		45	30	0	20		100M						

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N5484 thru 2N5486	Field-Effect Transistors, see Table on Page 2-76																		
2N5487	S	N			SP	15W	C	200	120	80	0	100	300	1.0A	0.25	1.0A				
2N5488	S	N			SP	15W	C	200	150	100	0	40	120	1.0A	0.25	1.0A				
2N5489	S	N			AP			200	100	100	0	15	50	40A	1.5	40A	10	E		
2N5498	S	N			AP	200W	C	200	150	130	0	10	50	15A	1.5	15A	25	E		
2N5515 thru 2N5524	Field-Effect Transistors, see Table on Page 2-76																			
2N5525	S	N			AL	360M	A		40	30	0	5000		10M	1.0	50M	5000	E	200M	T
2N5526	S	N			AL	360M	A		40	30	0	1000		10M	1.0	50M	1000	E	200M	T
2N5527	S	N			AP	5.0W	C	200	60	40	0	40	200	3.0A	1.25	3.0A	20	E	200M	T
2N5528	S	N			AP	35W	C	200	60	40	0	40	200	3.0A	1.25	3.0A	20	E	200M	T
2N5529	S	N			AP	35W	C	200	60	40	0	40	200	3.0A	1.25	3.0A	20	E	200M	T
2N5530	S	N			AP	35W	C	200	60	40	0	40	200	3.0A	1.25	3.0A	20	E	200M	T
2N5531	S	N			AP	5.0W	C	200	90	75	0	30	150	3.0A	1.25	3.0A	20	E	200M	T
2N5532	S	N			AP	35W	C	200	90	75	0	30	150	3.0A	1.25	3.0A	15	E	200M	T
2N5533	S	N			AP	35W	C	200	90	75	0	30	150	3.0A	1.25	3.0A	15	E	200M	T
2N5534	S	N			AP	35W	C	200	90	75	0	30	150	3.0A	1.25	3.0A	15	E	200M	T
2N5535	S	N			AP	50W	C	200	60	50	0	30	150	10A	1.25	5.0A	25	E	150M	T
2N5536	S	N			AP	50W	C	200	60	50	0	30	150	10A	1.25	5.0A	25	E	150M	T
2N5537	S	N			AP	50W	C	200	90	75	0	20	150	10A	1.25	5.0A	20	E	150M	T
2N5538	S	N			AP	50W	C	200	90	75	0	20	150	10A	1.25	5.0A	20	E	150M	T
2N5539	S	N			SP			200	175	130	0	25	75	10A	3.0	20A			20M	T
2N5540	S	N			SP			200	325	300	0	20	60	5.0A	2.5	10A			20M	T
2N5541	S	N			SP			200	175	130	0	30	90	5.0A	2.5	10A			20M	T
2N5542	S	N			SP			200	175	130	0	30	90	5.0A	2.5	10A			20M	T
2N5543 thru 2N5549	Field-Effect Transistors, see Table on Page 2-76																			
2N5550	S	N		2N5550	A	310M	A		160	140	0	60	250	10M	0.25	50M			100M	T
2N5551	S	N		2N5550	A	310M	A		180	160	0	80	250	10M	0.20	50M			100M	T
2N5552	S	N			SP	15W	C	200	120	80	0	50	150	5.0A	0.5	5.0A				
2N5555 thru 2N5558	Field-Effect Transistors, see Table on Page 2-76																			
2N5559	S	N			SP			200	150	120	X	20	60	4.0A	0.75	4.0A				
2N5560	S	N						200	175	120	X	30	90	15A	0.8	15A				
2N5561 thru 2N5566	Field-Effect Transistors, see Table on Page 2-76																			
2N5581	S	N		2N5581	SH	2.0W	C		75	40	0	40	120	150M	0.3	150M			250M	
2N5582	S	N		2N5581	SH	2.0W	C		75	40	0	100	300	150M	0.3	150M			300M	
2N5583	S	N		2N5581	SH	5.0W	C		30	30	0	25	100	100M	0.8	100M			1.3G	
2N5584	S	N			SP			200	225	180	0	40	120	10A	1.8	20A				
2N5589	S	N		2N5589	AP	15W	C		36	18	0	5.0		100M					200M	
2N5590	S	N		2N5589	AP	30W	C		36	18	0	5.0		250M					200M	
2N5591	S	N		2N5589	AP	70W	C		36	18	0	5.0		200M					200M	
2N5592 thru 2N5594	Field-Effect Transistors, see Table on Page 2-76																			

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N5595	S	N			AP	30W	C	200	55	30	0	20		50M					1.5G	T
2N5596	S	N			AP	40W	C	200	55	30	0	20		50M					1.5G	T
2N5597	S	P			AP	20W	C	200	80	60	0	70	200	1.0A	0.46	1.0A	50	E	60M	T
2N5598	S	N			AP	20W	C	200	80	60	0	70	200	1.0A	0.46	1.0A	50	E	60M	T
2N5599	S	P			AP	20W	C	200	100	80	0	30	90	1.0A	0.46	1.0A	20	E	50M	T
2N5600	S	N			AP	20W	C	200	100	80	0	30	90	1.0A	0.46	1.0A	20	E	50M	T
2N5601	S	P			AP	20W	C	200	100	80	0	70	200	1.0A	0.46	1.0A	50	E	60M	T
2N5602	S	N			AP	20W	C	200	100	80	0	70	200	1.0A	0.46	1.0A	50	E	60M	T
2N5603	S	P			AP	20W	C	200	120	100	0	30	90	1.0A	0.46	1.0A	20	E	50M	T
2N5604	S	N			AP	20W	C	200	120	100	0	30	90	1.0A	0.46	1.0A	20	E	50M	T
2N5605	S	P			AP	25W	C	200	80	60	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5606	S	N			AP	25W	C	200	80	60	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5607	S	P			AP	25W	C	200	100	80	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5608	S	N			AP	25W	C	200	100	80	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5609	S	P			AP	25W	C	200	100	80	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5610	S	N			AP	25W	C	200	100	80	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5611	S	P			AP	25W	C	200	120	100	0	30	90	2.5A	1.45	2.5A	20	E	60M	T
2N5612	S	N			AP	25W	C	200	120	100	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5613	S	P			AP	58W	C	200	80	60	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5614	S	N			AP	58W	C	200	80	60	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5615	S	P			AP	58W	C	200	100	80	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5616	S	N			AP	58W	C	200	100	80	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5617	S	P			AP	58W	C	200	100	80	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5618	S	N			AP	58W	C	200	100	80	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5619	S	P			AP	58W	C	200	120	100	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5620	S	N			AP	58W	C	200	120	100	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5621	S	P			AP	116W	C	200	80	60	0	70	200	5.0A	0.9	5.0A	50	E	40M	T
2N5622	S	N			AP	116W	C	200	80	60	0	70	200	5.0A	0.9	5.0A	50	E	40M	T
2N5623	S	P			AP	116W	C	200	100	80	0	30	90	5.0A	0.9	5.0A	20	E	30M	T
2N5624	S	N			AP	116W	C	200	100	80	0	30	90	5.0A	0.9	5.0A	20	E	30M	T
2N5625	S	P			AP	116W	C	200	100	80	0	70	200	5.0A	0.9	5.0A	50	E	40M	T
2N5626	S	N			AP	116W	C	200	100	80	0	70	200	5.0A	0.9	5.0A	50	E	40M	T
2N5627	S	P			AP	116W	C	200	120	100	0	30	90	5.0A	0.9	5.0A	20	E	30M	T
2N5628	S	N			AP	116W	C	200	120	100	0	30	90	5.0A	0.9	5.0A	20	E	30M	T
2N5629	S	N		2N5629	AP	200W	C	200	100	100	0	25	100	8.0A	2.0	16A	15	E	1.0M	T
2N5630	S	N		2N5629	AP	200W	C	200	120	120	0	20	80	8.0A	2.0	16A	15	E	1.0M	T
2N5631	S	N		2N5629	AP	200W	C	200	140	140	0	15	60	8.0A	2.0	16A	15	E	1.0M	T
2N5632	S	N		2N5632	AP	150W	C	200	100	100	0	25	100	5.0A	2.0	10A	15	E	1.0M	T
2N5633	S	N		2N5632	AP	150W	C	200	120	120	0	20	180	5.0A	2.0	10A	15	E	1.0M	T
2N5634	S	N		2N5632	AP	150W	C	200	140	140	0	15	60	5.0A	2.0	10A	15	E	1.0M	T
2N5635	S	N		2N5635	A	7.5W	C		60	35	0	5.0		100M					500M	T
2N5636	S	N		2N5635	A	15W	C		60	35	0	5.0		200M					450M	T
2N5637	S	N		2N5635	A	30W	C		60	35	0	5.0		500M					400M	T
2N5638 thru 2N5640	Field-Effect Transistors, see Table on Page 2-76																			
2N5641	S	N		2N5641	A	15W	C		65	35	0	5.0		100M					300M	T
2N5642	S	N		2N5641	A	30W	C		65	35	0	5.0		200M					250M	T
2N5643	S	N		2N5641	A	60W	C		65	35	0	5.0		200M					200M	T
2N5644	S	N			AP	3.5W	C		36	18	0	15		100M					400M	T
2N5645	S	N			AP	12W	C		36	18	0	15		500M					400M	T
2N5646	S	N			AP	30W	C		36	18	0	15		1.0A					400M	T
2N5647 thru 2N5649	Field-Effect Transistors, see Table on Page 2-76																			
2N5650	S	N			AH	150M	A		20	15	0	30	300	3.0M					2.0G	T
2N5651	S	N			AH	150M	A		20	15	0	30	300	3.0M					2.0G	T
2N5652	S	N			AH	150M	A		20	15	0	30	300	3.0M					2.0G	T
2N5653	Field-Effect Transistors, see Table on Page 2-76																			
2N5654	Field-Effect Transistors, see Table on Page 2-76																			
2N5655	S	N			AP	20W	C	150	275	250	0	30	250	100M	1.0	100M	20	E		
2N5656	S	N			AP	20W	C	150	325	300	0	30	250	100M	1.0	100M	20	E		
2N5657	S	N			AP	20W	C	150	375	350	0	30	250	100M	1.0	100M	20	E		
2N5658	S	N			SP	30W	C	200	120	80	0	50	150	5.0A	1.0	1.0A			30M	T
2N5659	S	N			SP	30W	C	200	120	80	0	50	150	5.0A	1.0	1.0A			30M	T
2N5660	S	N			SP			200	250	200	0	40	150	500M	0.4	1.0A			20M	T
2N5661	S	N			SP			200	400	300	0	40	150	500M	0.4	1.0A			20M	T
2N5662	S	N			SP			200	250	200	0	40	150	500M	0.4	1.0A			20M	T
2N5663	S	N			SP			200	400	300	0	40	150	500M	0.4	1.0A			20M	T
2N5664	S	N			SP			200	250	200	0	40	120	1.0A	0.4	3.0A			20M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N5665	S	N			SP			200	400	300	0	40	120	1.0A	0.4	3.0A			20M	T
2N5666	S	N			SP			200	250	200	0	40	120	1.0A	0.4	3.0A			20M	T
2N5667	S	N			SP			200	400	300	0	40	120	1.0A	0.4	3.0A			20M	T
2N5668 thru 2N5670	Field-Effect Transistors, see Table on Page 2-76																			
2N5679	S	P		2N5679	AP	10W	C	200	100	100	0	40	150	250M	0.6	250M	40	E	30M	T
2N5680	S	P		2N5679	AP	10W	C	200	120	120	0	40	150	250M	0.6	250M	40	E	30M	T
2N5681	S	N		2N5681	AP	10W	C	200	100	100	0	40	150	250M	0.6	250M	40	E	30M	T
2N5682	S	N		2N5681	AP	10W	C	200	120	120	0	40	150	250M	0.6	250M	40	E	30M	T
2N5683	S	P		2N5683	AP	300W	C	200	60	60	0	15	60	25A	5.0	50A	15	E	2.0M	T
2N5684	S	P		2N5683	AP	300W	C	200	80	80	0	15	60	25A	5.0	50A	15	E	2.0M	T
2N5685	S	N		2N5685	AP	300W	C	200	60	60	0	15	60	25A	5.0	50A	15	E	2.0M	T
2N5686	S	N		2N5685	AP	300W	C	200	80	80	0	15	60	25A	5.0	50A	15	E	2.0M	T
2N5687	S	N			AP	5.0W	C		40	20	0	15		50M						
2N5688	S	N			AP	10W	C		40	20	0	15		50M						
2N5689	S	N			AP	25W	C		60	40	0	15		100M						
2N5690	S	N			AP	50W	C		50	30	0	10		100M						
2N5691	S	N			AP	88W	C		50	30	0	10		100M						
2N5692	G	P			AP	125W	C	110	50	30	0	20	65	25A	0.75	60A			200M	T
2N5693	G	P			SP	125W	C	110	80	60	0	20	65	25A	0.75	60A			200M	T
3N5694	G	P			SP	125W	C	110	100	80	0	20	65	25A	0.75	60A			200M	T
2N5695	G	P			SP	125W	C	110	120	100	0	20	65	25A	0.75	60A			200M	T
2N5696	G	P			SP	125W	C	110	140	120	0	20	65	25A	0.75	60A			200M	T
2N5697	S	N			AP	3.5W	C		40	18	0	30		40M						
2N5698	S	N			AP	5.0W	C		40	18	0	30		40M						
2N5699	S	N			AP	10W	C		40	18	0	15		50M						
2N5700	S	N			AP	35W	C		40	18	0	30		50M						
2N5701	S	N			AP	35W	C		40	18	0	30		50M						
2N5702	S	N			AP	880M	C		40	18	0	15		50M						
2N5703	S	N			AP	750M	C		40	18	0	15		50M						
2N5704	S	N			AP	25W	C		40	18	0	15		50M						
2N5705	S	N			AP	44W	C		36	18	0	15		100M						
2N5706	S	N			AP	80W	C		36	18	0	15		100M						
2N5707	S	N			AP	70W	S	200	70	50	0	5.0	50	100M					50M	T
2N5708	S	N			AP	100W	S	200	70	50	0	5.0	50	100M					50M	T
2N5709	S	N			AP	140W	S	200	70	50	0	5.0	50	200M					50M	T
2N5710	S	N			AP	3.5W	C		40	20	0	20		10M						
2N5711	S	N			AP	10W	C		60	36	0	20		50M						
2N5712	S	N			AP	25W	C		60	40	0	10		100M						
2N5713	S	N			A	45W	C		60	40	0	10		10M						
2N5714	S	N			A	45W	C		60	40	0	10		10M						
2N5715	S	N			AP	6.0W	S		50	3.0	0	20	200	50M					3.5W	T
2N5716 thru 2N5718	Field-Effect Transistors, see Table on Page 2-76																			
2N5729	S	N			SP			200	100	80	0	30	300	2.0A	1.5	5.0A	1.5	E	30M	T
2N5730	S	N			SP			200	100	80	0	30	300	2.0A	1.2	5.0A	1.5	E	30M	T
2N5731	S	N			SP			200	100	80	0	30	300	5.0A	1.5	10A	1.5	E	30M	T
2N5732	S	N			SP			200	100	80	0	30	300	5.0A	1.2	10A	1.5	E	30M	T
2N5733	S	N			SP			200	100	80	0	30	300	10A	1.2	20A	1.5	E	30M	T
2N5734	S	N			SP			200	100	80	0	30	300	10A	1.2	20A	1.5	E	30M	T
2N5735	S	N			SH	360M	A		60	30	0	40	120	150M	0.4	150M			200M	T
2N5736	S	N			SH	360M	A		60	30	0	100	300	150M	0.4	150M			200M	T
2N5737	S	P			AP			200	60	60	0	20	80	5.0A	0.5	5.0A	20	E	10M	T
2N5738	S	P			AP			200	100	100	0	20	80	5.0A	0.5	5.0A	20	E	10M	T
2N5739	S	P			AP			200	60	60	0	20	80	5.0A	0.5	5.0A	20	E	10M	T
2N5740	S	P			AP			200	100	100	0	20	80	5.0A	0.5	5.0A	20	E	10M	T
2N5741	S	P			AP			200	60	60	0	20	80	10A	1.5	10A	20	E	10M	T
2N5742	S	P			AP			200	100	100	0	20	80	10A	1.5	10A	20	E	10M	T
2N5743	S	P			AP			200	60	60	0	20	80	10A	1.5	10A	20	E	10M	T
2N5744	S	P			AP			200	100	100	0	20	80	10A	1.5	10A	20	E	10M	T
2N5745	S	P			AP	200W	C	200	80	80	0	15	60	10A	1.0	10A	40	E	2.0M	T
2N5758	S	N			AP	150W	C	200	100	100	0	25	100	3.0A	1.0	3.0A	15	E	1.0M	T
2N5759	S	N			AP	150W	C	200	120	120	0	20	80	3.0A	1.0	3.0A	15	E	1.0M	T
2N5760	S	N			AP	150W	C	200	140	140	0	15	60	3.0A	1.0	3.0A	15	E	1.0M	T
2N5761	S	N			AH	250M	A		20	15	0	30	300	10M			18.5	E		
2N5762	S	N			AH	300M	A		20	15	0	30	300	15M			16.5	E		
2N5763	S	P			SP	400M	A		65	60	0	70		10M	0.4	150M			200M	T
2N5764	S	N			AH	10W	S		55	25	0	20		0.10A						

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units	Subscript
2N5765	S	N			AH	19W	S		55	25	0	20		0.10A						
2N5766	S	N			AH	5.0W	S		55	25	0	20		0.05A						
2N5767	S	N			AH	10W	S		55	25	0	20		0.10A						
2N5768	S	N			AH	20W	S		55	25	0	20		0.10A						
2N5777	S	N			S	200M	A	100	25	25	0									
2N5778	S	N			S	200M	A	100	40	40	0									
2N5779	S	N			S	200M	A	100	25	25	0									
2N5780	S	N			S	200M	A	100	40	40	0									
2N5781	S	P			AP	10W	C	200	80	80	R	4.0		3.2A	2.0	3.2A	25	E	8.0M	T
2N5782	S	P			AP	10W	C	200	65	65	R	4.0		3.2A	2.0	3.2A	25	E	8.0M	T
2N5783	S	P			AP	10W	C	200	45	45	R	4.0		3.2A	2.0	3.2A	25	E	8.0M	T
2N5784	S	N			AP	10W	C	200	80	80	R	4.0		3.2A	2.0	3.2A	25	E	2.5M	T
2N5785	S	N			AP	10W	C	200	65	65	R	4.0		3.2A	2.0	3.2A	25	E	2.5M	T
2N5786	S	N			AP	10W	C	200	45	45	R	4.0		3.2A	2.0	3.2A	25	E	2.5M	T
2N5793	S	N			SH	500M	A		75	40	0	40	120	150M	0.9	300M				
2N5794	S	N			SH	500M	A		75	40	0	100	300	150M	0.9	300M				
2N5795	S	N			SH	500M	A		60	60	0	40	120	150M	1.6	500M				
2N5796	S	N			SH	500M	A		60	60	0	100	300	150M	1.6	500M				
2N5797 thru 2N5803	Field-Effect Transistors, see Table on Page 2-76																			
2N5804	S	N			SP			200	300	300	X	10	100	5.0A	2.0	5.0A			15M	T
2N5805	S	N			SP			200	375	375	X	10	100	5.0A	2.0	5.0A			15M	T
2N5806 thru 2N5809	Thyristors, See Table on Page 2-66																			
2N5810	S	N			A	500M	A	135	35	25	0	60	200	2.0M	0.75	500M				
2N5811	S	N			A	500M	A	135	35	25	0	60	200	2.0M	0.75	500M				
2N5812	S	N			A	500M	A	135	35	25	0	150	500	2.0M	0.75	500M				
2N5813	S	P			A	500M	A	135	35	25	0	150	500	2.0M	0.75	500M				
2N5814	S	N			A	500M	A	135	50	40	0	60	120	2.0M	0.75	500M				
2N5815	S	P			A	500M	A	135	50	40	0	60	120	2.0M	0.75	500M				
2N5816	S	N			A	500M	A	135	50	40	0	100	200	2.0M	0.75	500M				
2N5817	S	P			A	500M	A	135	50	40	0	100	200	2.0M	0.75	500M				
2N5818	S	N			A	500M	A	135	50	40	0	150	300	2.0M	0.75	500M				
2N5819	S	P			A	500M	A	135	50	40	0	150	300	2.0M	0.75	500M				
2N5820	S	N			A	500M	A	135	70	60	0	60	120	2.0M	0.75	500M				
2N5821	S	P			A	500M	A	135	70	60	0	60	120	2.0M	0.75	500M				
2N5822	S	N			A	500M	A	135	70	60	0	100	200	2.0M	0.75	500M				
2N5823	S	P			A	500M	A	135	70	60	0	100	200	2.0M	0.75	500M				
2N5824	S	N			A	360M	A	125	50	40	0	60	120	2.0M	0.125	10M	60	E		
2N5825	S	N			A	360M	A	125	50	40	0	100	200	2.0M	0.125	10M	100	E		
2N5826	S	N			A	360M	A	125	50	40	0	150	300	2.0M						
2N5827	S	N			A	360M	A	125	50	40	0	250	500	2.0M						
2N5828	S	N			A	360M	A	125	50	40	0	400	800	2.0M						
2N5829	S	P			AH	200M	A	125	30	30	0	20	150	2.0M						
2N5834	S	P			SP	5.0W	A													
2N5835	S	N			SH	200M	A	125	15	10	0	25		10M						
2N5836	S	N			SH	2.0W	C		15	10	0	25		50M						
2N5837	S	N			SH	2.0W	C		10	5.0	0	25		100M						
2N5838	S	N			SP			200	275	275	X	8.0	40	3.0A	1.0	3.0A	5.0	E		
2N5839	S	N			SP			200	300	300	X	10	50	2.0A	1.5	2.0A	5.0	E		
2N5840	S	N			SP			200	375	375	X	10	50	2.0A	1.5	2.0A	5.0	E		
2N5841	S	N			SH	350M	C													
2N5842	S	N			SH	350M	C													
2N5847	S	N			AW	20W	C													
2N5902 thru 2N5909	Field-Effect Transistors, see Table on Page 2-76																			
2N5913	S	N			AH				36	14	0									
2N5914	S	N			AH				36	14	0									
2N5915	S	N			AH				36	14	0									
2N5916	S	N			AH				55	24	0									
2N5917	S	N			AH				55	24	0	20		50M						
2N5918	S	N			AH				60	24	0	20		50M						
2N5919	S	N			AH				65	30	0									
2N5920	S	N			AH				50	50	R									
2N5921	S	N			AH	14.5W	C		50	50	R									
2N5938	S	N			AP	2.5W	A	200	60	50	0	30	150	1.0A	0.75	3.0A	20	E		
2N5939	S	N			AP	2.0W	A	200	80	80	0	40	200	5.0A	1.0	10A	30	E		
2N5940	S	N			AP	2.0W	A	200	70	70	0	40	200	5.0A	1.0	10A	30	E		
2N5949 thru 2N5953	Field Effect Transistors, See Table on Page 2-76																			

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units	Subscript
3N22		N			AH			85	15								0.96	B			
3N34	S	N				125M			30												
3N35	S	N				125M			30	30	O						25	E			
3N35A	S	N				125M			30	30	O						10	E			
3N39 thru 3N44	Reference Amplifiers, see Table on Page 2-84																				
3N45	G	P			SP	75W	C	100	60	35		30	120	5.0A	0.4	5.0A	30	E	600K		
3N46	G	P			SP	75W	C	100	80	50		20	80	5.0A	0.4	5.0A			300K		
3N47	G	P			SP	75W	C	100	40	25		30	120	5.0A	0.4	5.0A	30	E	500K		
3N48	G	P			SP	75W	C	100	60	40		20	80	5.0A	0.4	5.0A			300K		
3N49	G	P			SP	94W	C	100	60	35		30	120	5.0A	0.4	5.0A	30	E	600K		
3N50	G	P			SP	94W	C	100	80	50		20	80	5.0A	0.4	5.0A			300K		
3N51	G	P			SP	94W	C	100	40	25		30	120	5.0A	0.4	5.0A	30	E	500K		
3N52	G	P			SP	94W	C	100	60	40		20	80	5.0A	0.4	5.0A			300K		
3N58 thru 3N60	Thyristors, see Table on Page 2-66																				
3N62	S	N			SC				10						V_{off} = 200 μV						
3N63	S	N			SC				10						V_{off}= 100 μV						
3N64	S	N			SC				10						V_{off}= 50 μV						
3N65	S	N			SC										V_{off}= 200 μV						
3N66	S	N			SC										V_{off}= 100 μV						
3N67	S	N			SC										V_{off}= 50 μV						
3N68	S	N			SC				10						V_{off}= 200 μV						
3N68A	S	N				100M	A	200	10												
3N69	S	N			SC				10						V_{off}= 100 μV						
3N70	S	N			SC				10						V_{off}= 50 μV						
3N71	S	N			SC	100M		200	15	8.0	O	40		2.0M	V_{off}= 50 μV				100M	T	
3N72	S	N			SC	100M		200	15	8.0	O	40		2.0M	V_{off}= 100 μV				100M	T	
3N73	S	N			SC	100M		200	15	8.0	O	40		2.0M	V_{off}= 100 μV				100M	T	
3N74	S	N			SC	300M		175	50						V_{off}= 50 μV				30M	T	
3N75	S	N			SC	300M		175	50						V_{off}= 100 μV				30M	T	
3N76	S	N			SC	300M		175	50						V_{off}= 200 μV				30M	T	
3N77	S	N			SC	300M		175	40						V_{off}= 50 μV				30M	T	
3N78	S	N			SC	200M		175	40						V_{off}= 100 μV				30M	T	
3N79	S	N			SC	300M		175	40						V_{off}= 200 μV				30M	T	
3N80 thru 3N86	Thyristors, see Table on Page 2-66																				
3N87	S	N			SC	200M	A		20	10	O	5.0		0.5M	V_{off}= 50 μV				100M	T	
3N88	S	N			SC	200M	A		20	10	O	5.0		0.5M	V_{off}= 100 μV				100M	T	
3N89	Field-Effect Transistors, see Table on Page 2-76																				
3N90	S	P			SC	300M	A	200	50						V_{off}= 50 μV				6.0M	T	
3N91	S	P			SC	300M	A	200	50						V_{off}= 100 μV				6.0M	T	
3N92	S	P			SC	300M	A	200	50						V_{off}= 200 μV				6.0M	T	
3N93	S	P			SC	300M	A	200	50						V_{off}= 50 μV				6.0M	T	
3N94	S	P			SC	300M	A	200	50						V_{off}= 100 μV				6.0M	T	
3N95	S	P			SC	300M	A	200	50						V_{off}= 200 μV				6.0M	T	
3N96 thru 3N99	Field-Effect Transistors, see Table on Page 2-76																				
3N100	S	P			SC	300M	A	200	20						V_{off}= 50 μV						
3N101	S	P			SC	300M	A	200	30						V_{off}= 50 μV						
3N102	S	P			SC	300M	A	200	40						V_{off}= 50 μV						
3N103	S	P			SC	300M	A	200	50						V_{off}= 50 μV						
3N104	S	P			SC	300M	A	200	60						V_{off}= 50 μV						
3N105	S	P			SC	300M	A	200	20						V_{off}= 250 μV						
3N106	S	P			SC	300M	A	200	40						V_{off}= 250 μV						
3N107	S	P			SC	300M	A	200	60						V_{off}= 250 μV						
3N108	S	P			SC	300M	A	200	50										12M	T	
3N109	S	P			SC	300M	A	200	50										12M	T	
3N110	S	P			SC	300M	A	200	50										12M	T	
3N111	S	P			SC	300M	A	200	50										12M	T	
3N112	S	P			SC	200M	A	200	50												
3N113	S	P			SC	200M	A	200	50												
3N114	S	P			SC	300M	A	200	30										12M	T	
3N115	S	P			SC	300M	A	200	30										12M	T	
3N116	S	P			SC	300M	A	200	30										12M	T	
3N117	S	P			SC	300M	A	200	50										12M	T	
3N118	S	P			SC	300M	A	200	50										12M	T	
3N119	S	P			SC	300M	A	200	50										12M	T	
3N120	S	N			SC	200M	A	200	30												

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
3N121	S	N			SC	200M	A	125	30										40M	T
3N123	S	P			SC	100M	A	200	30										6.0M	E
3N124 thru 3N126	Field-Effect Transistors, see Table on Page 2-76																			
3N127	S	N			SC	200M	A	200	30	20	0									
3N128	Field-Effect Transistors, see Table on Page 2-76																			
3N129	S	P			SC	300M	A		20										2.0M	E
3N130	S	P			SC	300M	A		30										2.0M	E
3N131	S	P			SC	300M	A		40										2.0M	E
3N132	S	P			SC	300M	A		50										2.0M	E
3N133	S	P			SC	300M	A		60										2.0M	E
3N134	S	P			SC	300M	A		20										2.0M	E
3N135	S	P			SC	300M	A		40										2.0M	E
3N136	S	P			SC	300M	A		60										2.0M	E
3N138 thru 3N143	Field-Effect Transistors, see Table on Page 2-76																			
3N145 thru 3N186	Field-Effect Transistors, see Table on Page 2-76																			
3N188 thru 3N191	Field-Effect Transistors, see Table on Page 2-76																			



THYRISTORS

INDEX AND SHORT FORM SPECIFICATIONS

This table contains a numerical listing and short-form specifications for thyristors with EIA-registered 2N and 3N numbers. Specific types of thyristors listed include silicon controlled rectifiers, gate-controlled switches, and silicon controlled switches.

KEY

TYPE	REPLACEMENT	REFERENCE	$I_{T(RMS)}$ Amp	V_{DRM}/V_{RRM} Volts	T_J T_C(1) °C	I_{GT} mA	V_{GT} Volts
Numerical Listing of Registered Type Numbers. *Device with gate turn-off characteristics							
	Type number of recommended replacement or of nearest electrical equivalent fully characterized in this book						
		Reference device number indicates specific Data Sheet on which device is characterized					
			On-State (RMS) Current				
				Peak Forward Blocking Voltage Peak Reverse Blocking Voltage			
					Maximum Junction Temperature, Maximum Case Temperature(1)		
						Gate Trigger Current	
							Gate Trigger Voltage

TYPE	REPLACEMENT	REF.	$I_{T(RMS)}$ Amp	V_{DRM}/V_{RRM} volts	T_J T_C(1) °C	I_{GT} mA	V_{GT} volts
2N681		2N681	25	25	125	40	2.0
2N681A			28	25	125	40	2.0
2N682		2N681	25	50	125	40	2.0
2N682A			28	50	125	40	2.0
2N683		2N681	25	100	125	40	2.0
2N683A			28	100	125	40	2.0
2N684		2N681	25	150	125	40	2.0
2N684A			28	150	125	40	2.0
2N685		2N681	25	200	125	40	2.0
2N685A			28	200	125	40	2.0
2N686		2N681	25	250	125	40	2.0
2N686A			28	250	125	40	2.0
2N687		2N681	25	300	125	40	2.0
2N687A			28	300	125	40	2.0
2N688		2N681	25	400	125	40	2.0
2N688A			28	400	125	40	2.0
2N689		2N681	25	500	125	40	2.0
2N689A			28	500	125	40	2.0
2N690			25	600	125	40	2.0
2N690A			25	600	125	40	2.0
2N691			25	700	125	40	2.0
2N692			25	800	125	40	2.0
2N764*			0.39	30	125	1.0	1.0
2N765*			0.20	60	125	1.0	1.0
2N766*			0.20	100	125	1.0	1.0
2N767*			0.20	200	125	1.0	1.0
2N876	2N4212	2N4212	0.35	15	150	0.2	0.8
2N877	2N4212	2N4212	0.35	30	150	0.2	0.8
2N878	2N4213	2N4212	0.35	60	150	0.2	0.8
2N879	2N4214	2N4212	0.35	100	150	0.2	0.8
2N880	2N4215	2N4212	0.35	150	150	0.2	0.8
2N881	2N4216	2N4212	0.35	200	150	0.2	0.8
2N882			0.35	300	150	0.2	0.8
2N883			0.35	400	150	0.2	0.8
2N884	2N4212	2N4212	0.35	15	150	0.02	0.6
2N885	2N4213	2N4212	0.35	30	150	0.02	0.6
2N886	2N4214	2N4212	0.35	60	150	0.02	0.6
2N887	2N4214	2N4212	0.35	100	150	0.02	0.6
2N888	2N4215	2N4212	0.35	150	150	0.02	0.6
2N889	2N4216	2N4212	0.35	200	150	0.02	0.6
2N890			0.35	300	150	0.02	0.6
2N891			0.35	400	150	0.02	0.6
2N892*			0.250	15	125	0.05	0.70
2N893*			0.250	15	125	0.05	0.70
2N894*			0.250	30/15	125	0.05	0.70
2N895*			0.250	30/15	125	0.05	0.70
2N896*			0.250	60/15	125	0.05	0.70
2N897*			0.250	60/15	125	0.05	0.70
2N898*			0.250	100/15	125	0.05	0.70
2N899*			0.250	100/15	125	0.05	0.70
2N900*			0.250	200/15	125	0.05	0.70
2N901*			0.250	200/15	125	0.05	0.70
2N948	2N4212	2N4212	0.26	30	150	0.02	1.0
2N949	2N4213	2N4212	0.26	60	150	0.02	1.0
2N950	2N4214	2N4212	0.26	100	150	0.02	1.0
2N951	2N4215	2N4212	0.26	200	150	0.02	1.0
2N1595		2N1595	1.6	50	125	10	3.0
2N1595A	2N1595	2N1595	1.6	50	150	2.0	2.0
2N1596		2N1595	1.6	100	125	10	3.0
2N1596A	2N1596	2N1595	1.6	100	150	2.0	2.0
2N1597		2N1595	1.6	200	125	10	3.0
2N1597A	2N1597	2N1595	1.6	200	150	2.0	2.0
2N1598		2N1595	1.6	300	125	10	3.0
2N1598A	2N1598	2N1595	1.6	300	150	2.0	2.0
2N1599		2N1595	1.6	400	125	10	3.0
2N1599A	2N1599	2N1595	1.6	400	150	2.0	2.0
2N1600	2N4168	2N4151	4.0	50	125	10	3.0
2N1600A	2N4168	2N4151	4.0	50	125	4.5	3.0
2N1601	2N4169	2N4151	4.0	100	125	10	3.0

THYRISTOR INDEX (continued)

TYPE	REPLACEMENT	REF.	$I_{T(RMS)}$ Amp	V_{DRM}/V_{RRM} volts	T_J T_C(1) °C	I_{GT} mA	V_{GT} volts
2N1602	2N4170	2N4151	4.0	200	125	10	3.0
2N1603	2N4171	2N4151	4.0	300	125	10	3.0
2N1604	2N4172	2N4151	4.0	400	125	10	3.0
2N1686*			0.5	30	125	1.0	1.0
2N1687*			0.5	60	125	1.0	1.0
2N1688*			0.5	100	125	1.0	1.0
2N1689*			0.5	200	125	1.0	1.0
2N1765	2N1765		0.5	400	85	10	1.5
2N1770	2N4167	2N4151	4.7	25	125	15	2.0
2N1770A			4.7	25	150	15	2.0
2N1771	2N4168	2N4151	4.7	50	125	15	2.0
2N1771A			4.7	50	150	15	2.0
2N1772	2N4169	2N4151	4.7	100	125	15	2.0
2N1772A			4.7	100	150	15	2.0
2N1773	2N4170	2N4151	4.7	150	125	15	2.0
2N1773A			4.7	150	150	15	2.0
2N1774	2N4170	2N4151	4.7	200	125	15	2.0
2N1774A			4.7	200	150	15	2.0
2N1775	2N4171	2N4151	4.7	250	125	15	2.0
2N1775A			4.7	250	150	15	2.0
2N1776	2N4171	2N4151	4.7	300	125	15	2.0
2N1776A			4.7	300	150	15	2.0
2N1776B			4.7	300	150	15	2.0
2N1777	2N4172	2N4151	4.7	400	125	15	2.0
2N1777A			7.0	400	150	15	2.0
2N1778	2N4173	2N4151	7.4	500	125	15	2.0
2N1778A			7.0	500	150	15	2.0
2N1792			110	60	125	75	3.0
2N1793			110	120	125	75	3.0
2N1794			110	180	125	75	3.0
2N1795			110	240	125	75	3.0
2N1796			110	300	125	75	3.0
2N1797			110	360	125	75	3.0
2N1798			110	480	125	75	3.0
2N1799			110	600	125	75	3.0
2N1800			110	720	125	75	3.0
2N1801			110	840	125	75	3.0
2N1802			110	960	125	75	3.0
2N1803			110	1080	125	90	3.0
2N1804			110	1200	125	90	3.0
2N1805			110	500	125	75	3.0
2N1806			110	600	125	75	3.0
2N1807			110	700	125	75	3.0
2N1842		2N1842	16	25	100	80	2.0
2N1842A		2N1842A	16	25	125	80	2.0
2N1842B	2N1842A	2N1842A	20	25	125	75	3.0
2N1843		2N1842	16	50	100	80	2.0
2N1843A		2N1842A	16	50	125	80	2.0
2N1843B	2N1843A	2N1842A	20	50	125	75	3.0
2N1844		2N1842	16	100	100	80	2.0
2N1844A		2N1842A	16	100	125	80	2.0
2N1844B	2N1844A	2N1842A	20	100	125	75	3.0
2N1845		2N1842	16	150	100	80	2.0
2N1845A		2N1842A	16	150	125	80	2.0
2N1845B	2N1845A	2N1842A	20	150	125	75	3.0
2N1846		2N1842	16	200	100	80	2.0
2N1846A		2N1842A	16	200	125	80	2.0
2N1846B	2N1846A	2N1842A	20	200	125	75	3.0
2N1847		2N1842	16	250	100	80	2.0
2N1847A		2N1842A	16	250	125	80	2.0
2N1847B	2N1847A	2N1842A	20	250	125	75	3.0
2N1848		2N1842	16	300	100	80	2.0
2N1848A		2N1842A	16	300	125	80	2.0
2N1848B	2N1848A	2N1842A	20	300	125	75	3.0
2N1849		2N1842	16	400	100	80	2.0
2N1849A		2N1842A	16	400	125	80	2.0
2N1849B	2N1849A	2N1842A	20	400	125	75	3.0
2N1850		2N1842	16	500	100	80	2.0
2N1850A		2N1842A	16	500	125	80	2.0

TYPE	REPLACEMENT	REF.	$I_{T(RMS)}$ Amp	V_{DRM}/V_{RRM} volts	T_J T_C[1] °C	I_{GT} mA	V_{GT} volts
2N1850B	2N1850A	2N1842A	20	500	125	75	3.0
2N1869	2N4212	2N4212	1.25	15	150	0.2	0.8
2N1869A			1.25	15	150	0.2	0.8
2N1870	2N4213	2N4212	1.25	30	150	0.2	0.8
2N1870A			1.25	30	150	0.2	0.8
2N1871	2N4214	2N4212	1.25	60	150	0.2	0.8
2N1871A			1.25	60	150	0.2	0.8
2N1872	2N4214	2N4212	1.25	100	150	0.2	0.8
2N1872A			1.25	100	150	0.2	0.8
2N1873	2N4215	2N4212	1.25	150	150	0.2	0.8
2N1873A			1.25	150		0.2	0.8
2N1874	2N4216	2N4212	1.25	200	150	0.2	0.8
2N1874A			1.25	200	150	0.2	0.8
2N1875	2N4212	2N4212	1.25	15	150	0.020	0.6
2N1875A			1.25	15	150	0.020	0.6
2N1876	2N4213	2N4212	1.25	30	150	0.020	0.6
2N1876A			1.25	30	150	0.020	0.6
2N1877	2N4214	2N4212	1.25	60	150	0.020	0.6
2N1877A			1.25	60	150	0.020	0.6
2N1878	2N4214	2N4212	1.25	100	150	0.020	0.6
2N1878A			1.25	100	150	0.020	0.6
2N1879	2N4215	2N4212	1.25	150	150	0.020	0.6
2N1879A			1.25	150	150	0.020	0.6
2N1880	2N4216	2N4212	1.25	200	150	0.020	0.6
2N1880A			1.25	200	150	0.020	0.6
2N1881	2N4212	2N4212	1.0	30	150	2.0	2.0
2N1882	2N4213	2N4212	1.0	60	150	2.0	2.0
2N1883	2N4214	2N4212	1.0	100	150	2.0	2.0
2N1884	2N4215	2N4212	1.0	150	150	2.0	2.0
2N1885	2N4216	2N4212	1.0	200	150	2.0	2.0
2N1909			70	25	125	75	3.0
2N1910			70	50	125	75	3.0
2N1911			70	100	125	75	3.0
2N1912			70	150	125	75	3.0
2N1913			70	200	125	75	3.0
2N1914			70	250	125	75	3.0
2N1914A			70	250	125	75	3.0
2N1914B			70	250	125	75	3.0
2N1915			70	300	125	75	3.0
2N1916			70	400	125	75	3.0
2N1929	2N4191	2N4151	0.75	25	125	15	2.0
2N1930	2N4192	2N4151	0.75	50	125	15	2.0
2N1931	2N4193	2N4151	0.75	100	125	15	2.0
2N1932	2N4194	2N4151	0.75	150	125	15	2.0
2N1933	2N4194	2N4151	0.75	200	125	15	2.0
2N1934	2N4195	2N4151	0.75	250	125	15	2.0
2N1935	2N4195	2N4151	0.75	300	125	15	2.0
2N2009	2N4212	2N4212	1.3	25	150	0.2	1.0
2N2010	2N4213	2N4212	1.3	50	150	0.2	1.0
2N2011	2N4214	2N4212	1.3	100	150	0.2	1.0
2N2012	2N4216	2N4212	1.3	200	150	0.2	1.0
2N2013			1.3	300	150	0.2	1.0
2N2014			1.3	400	150	0.2	1.0
2N2023			70	25	150	75	3.0
2N2024			70	50	150	75	3.0
2N2025			70	100	150	75	3.0
2N2026			70	150	150	75	3.0
2N2027			70	200	150	75	3.0
2N2028			70	250	150	75	3.0
2N2029			70	300	150	75	3.0
2N2030			70	400	150	75	3.0
2N2031			110	50	125	75	3.0
2N2044			150	200	125	80	3.0
2N2045			150	300	125	80	3.0
2N2046			150	400	125	80	3.0
2N2047			150	500	125	80	3.0
2N2074	2N4213	2N4212	1.0	50	150	0.2	0.65
2N2260*			200	30	100	0.25	
2N2261*			200	30	100	0.5	

TYPE	REPLACEMENT	REF.	$I_{T(RMS)}$ Amp	V_{DRM}/V_{RRM} volts	T_J T_C(1) °C	I_{GT} mA	V_{GT} volts
2N2262*			200	30	100	5.0	
2N2322		2N2322	1.6	25	125	0.2	0.8
2N2322A			1.6	25	125	0.02	0.6
2N2323		2N2322	1.6	50	125	0.2	0.8
2N2323A			1.6	50	125	0.02	0.6
2N2324		2N2322	1.6	100	125	0.2	0.8
2N2324A			1.6	100	125	0.02	0.6
2N2325		2N2322	1.6	150	125	0.2	0.8
2N2325A			1.6	150	125	0.02	0.6
2N2326		2N2322	1.6	200	125	0.2	0.8
2N2326A			1.6	200	125	0.02	0.6
2N2327			1.6	250	125	0.2	0.8
2N2327A			1.6	250	125	0.02	0.6
2N2328			1.6	300	125	0.2	0.8
2N2328A			1.6	300	125	0.02	0.6
2N2329			1.6	400	125	0.2	0.8
2N2329A			1.6	400	125	0.02	0.6
2N2344			1.6	25	100	0.02	0.8
2N2345			1.6	50	100	0.02	0.8
2N2346			1.6	100	100	0.02	0.8
2N2347			1.6	150	100	0.02	0.8
2N2348			1.6	200	100	0.02	0.8
2N2454			3.0	400	105	15	3.0
2N2502	2N1850A	2N1842A	7.0	500	125	75	3.0
2N2503			225	50	125	100	2.5
2N2504			225	100	125	100	2.5
2N2505			225	200	125	100	2.5
2N2506			225	300	125	100	2.5
2N2507			225	400	125	100	2.5
2N2508			225	500	125	100	2.5
2N2542			230	50	125	125	3.0
2N2543			230	100	125	125	3.0
2N2544			230	200	125	125	3.0
2N2545			230	300	125	125	3.0
2N2546			230	400	125	125	3.0
2N2547			230	500	125	125	3.0
2N2548			230	600	125	125	3.0
2N2549			150	800	125	125	3.0
2N2550			150	1000	125	125	3.0
2N2573		2N2573	25	25	125	40	3.5
2N2574		2N2573	25	50	125	40	3.5
2N2575		2N2573	25	100	125	40	3.5
2N2576		2N2573	25	200	125	40	3.5
2N2577		2N2573	25	300	125	40	3.5
2N2578		2N2573	25	400	125	40	3.5
2N2579		2N2573	25	500	125	40	3.5
2N2619	2N4174	2N4151	7.4	600	125	45	2.0
2N2653	2N4172	2N4151	3.0	400	105	35	3.0
2N2679			0.35	30	150	0.02	0.7
2N2679A			0.35	30	150	0.02	0.7
2N2680			0.35	60	150	0.02	0.7
2N2680A			0.35	60	150	0.02	0.7
2N2681			0.35	100	150	0.02	0.7
2N2681A			0.35	100	150	0.02	0.70
2N2682			0.35	200	150	0.02	0.7
2N2682A			0.35	200	150	0.02	0.70
2N2683			0.28	30	125	0.02	0.8
2N2683A			0.28	30	125	0.02	0.80
2N2684			0.28	60	125	0.02	0.8
2N2684A			0.28	60	125	0.02	0.80
2N2685			0.28	100	125	0.02	0.8
2N2685A			0.28	100	125	0.02	0.80
2N2686			0.28	200	125	0.02	0.8
2N2686A			0.28	200	125	0.02	0.80
2N2687	2N4213	2N4212	0.28	30	125	0.2	1.0
2N2688	2N4214	2N4212	0.28	60	125	0.2	1.0
2N2689	2N4214	2N4212	0.28	100	125	0.2	1.0
2N2690	2N4216	2N4212	0.28	200	125	0.2	1.0
2N2888			25	200	125	40	1.5

TYPE	REPLACEMENT	REF.	$I_{T(RMS)}$ Amp	V_{DRM}/V_{RRM} volts	T_J T_C[1] °C	I_{GT} mA	V_{GT} volts
2N2889			25	250	125	40	1.5
2N3001			0.35	30	150	0.02	0.7
2N3002			0.35	60	150	0.02	0.7
2N3003			0.35	100	150	0.02	0.7
2N3004			0.35	200	150	0.02	0.7
2N3005			0.35	30	150	0.2	0.8
2N3006			0.35	60	150	0.2	0.8
2N3007			0.35	100	150	0.2	0.8
2N3008			0.35	200	150	0.2	0.8
2N3027			0.5	30	150	0.2	0.8
2N3028			0.5	60	150	0.2	0.8
2N3029			0.5	100	150	0.2	0.8
2N3030			0.5	30	150	0.02	0.6
2N3031			0.5	60	150	0.02	0.6
2N3032			0.5	100	150	0.02	0.6
2N3091			110	600	125	70	2.0
2N3092			110	700	125	70	2.0
2N3093			110	800	125	70	2.0
2N3094			110	900	125	70	2.0
2N3095			110	1000	125	70	2.0
2N3096			110	1100	125	70	2.0
2N3097			110	1200	125	70	2.0
2N3098			110	1300	125	70	2.0
2N3099			110	600	125	70	2.0
2N3100			110	700	125	70	2.0
2N3101			110	800	125	70	2.0
2N3102			110	900	125	70	2.0
2N3103			110	1000	125	70	2.0
2N3104			110	1100	125	70	2.0
2N3105			110	1200	125	70	2.0
2N3106			110	1300	125	70	2.0
2N3228	2N4154	2N4151	3.2	200	100	15	2.0
2N3254			0.25	15	150	0.02	0.75
2N3255			0.25	30	150	0.02	0.75
2N3256			0.25	60	150	0.02	0.75
2N3257			0.25	15	150	0.2	0.75
2N3258			0.25	30	150	0.2	0.75
2N3259			0.25	60	150	0.2	0.75
2N3269			8.0	100	150	0.2	0.8
2N3270			8.0	200	150	0.2	0.8
2N3271			8.0	300	150	0.2	0.8
2N3272			8.0	400	150	0.2	0.8
2N3273			2.2	100	150	0.2	0.8
2N3274			2.2	200	150	0.2	0.8
2N3275			2.2	300	150	0.2	0.8
2N3276			2.2	400	150	0.2	0.8
2N3353			400	50	125	200	4.0
2N3354			400	100	125	200	4.0
2N3355			400	200	125	200	4.0
2N3356			400	300	125	200	4.0
2N3357			400	400	125	200	4.0
2N3358			400	500	125	200	4.0
2N3359			400	600	125	200	4.0
2N3360			400	700	125	200	4.0
2N3361			400	800	125	200	4.0
2N3362			400	900	125	200	4.0
2N3363			400	1000	125	200	4.0
2N3364			400	1200	125	200	4.0
2N3422			196	600	125	150	3.0
2N3525	2N4156	2N4151	3.2	400	100	15	2.0
2N3528	2N4186	2N4151	1.3	200	100	15	2.0
2N3529	2N4188	2N4151	1.3	400	100	15	2.0
2N3530			400	50	125	300	4.0
2N3531			400	100	125	300	4.0
2N3532			400	200	125	300	4.0
2N3533			400	300	125	300	4.0
2N3534			400	400	125	300	4.0
2N3535			400	500	125	300	4.0
2N3536			400	600	125	300	4.0

TYPE	REPLACEMENT	REF.	$I_{T(RMS)}$ Amp	V_{DRM}/V_{RRM} volts	T_J T_C(1) °C	I_{GT} mA	V_{GT} volts
2N3537			400	700	125	300	4.0
2N3538			400	800	125	300	4.0
2N3539			400	900	125	300	4.0
2N3540			400	1000	125	300	4.0
2N3541			400	1200	125	300	4.0
2N3555			1.6	30	150	0.020	0.7
2N3556			1.6	60	150	0.020	0.7
2N3557			1.6	100	150	0.020	0.7
2N3558			1.6	200	150	0.020	0.7
2N3559			1.6	30	150	0.20	0.8
2N3560			1.6	60	150	0.20	0.8
2N3561			1.6	100	150	0.20	0.8
2N3562			1.6	200	150	0.20	0.8
2N3649			16	50	120	180	3.0
2N3650			16	100	120	180	3.0
2N3651			16	200	120	180	3.0
2N3652			16	300	120	180	3.0
2N3653			16	400	120	180	3.0
2N3654			16	50	120	180	3.0
2N3655			16	100	120	180	3.0
2N3656			16	200	120	180	3.0
2N3657			16	300	120	180	3.0
2N3658			16	400	120	180	3.0
2N3668	MCR649P-3	MCR649-1	13	100	100	40	2.0
2N3669	MCR649P-4	MCR649-1	13	200	100	40	2.0
2N3670	MCR649P-6	MCR649-1	13	400	100	40	2.0
2N3753			7.5	50	120	100	3.0
2N3754			7.5	100	120	100	3.0
2N3755			7.5	200	120	100	3.0
2N3756			7.5	300	120	100	3.0
2N3757			7.5	400	120	100	3.0
2N3758			7.5	500	120	100	3.0
2N3759			7.5	600	120	100	3.0
2N3760			7.5	700	120	100	3.0
2N3761			7.5	800	120	100	3.0
2N3870	MCR3835-3	MCR3835	22	100	100	40	2.0
2N3871	MCR3835-4	MCR3835	22	200	100	40	2.0
2N3872	MCR3835-6	MCR3835	22	400	100	40	2.0
2N3873	MCR3835-8	MCR3835	22	600	100	40	2.0
2N3884			175	50	125	300	4.0
2N3885			175	100	125	300	4.0
2N3886			175	200	125	300	4.0
2N3887			175	300	125	300	4.0
2N3888			175	400	125	300	4.0
2N3889			175	500	125	300	4.0
2N3890			175	600	125	300	4.0
2N3891			175	700	125	300	4.0
2N3892			175	800	125	300	4.0
2N3893			175	900	125	300	4.0
2N3894			175	1000	125	300	4.0
2N3895			175	1200	125	300	4.0
2N3896	MCR3935-3	MCR3835	22	100	100	40	2.0
2N3897	MCR3935-4	MCR3835	22	200	100	40	2.0
2N3898	MCR3935-6	MCR3835	22	400	100	40	2.0
2N3899	MCR3935-8	MCR3835	22	600	100	40	2.0
2N3936			7.0	100	125	60	3.2
2N3937			7.0	200	125	60	3.2
2N3938			7.0	300	125	60	3.2
2N3939			7.0	400	125	60	3.2
2N3940			7.0	500	125	60	3.2
2N3986			70	500	125	150	3.0
2N3987			70	600	125	150	3.0
2N3988			70	700	125	150	3.0
2N3989			70	800	125	150	3.0
2N3990			70	900	125	150	3.0
2N3991			70	1000	125	150	3.0
2N3992			70	1100	125	150	3.0
2N4096	2N4213	2N4212	0.2	50	125	0.2	0.8
2N4097	2N4214	2N4212	0.2	100	125	0.2	0.8

TYPE	REPLACEMENT	REF.	$I_{T(RMS)}$ Amp	V_{DRM}/V_{RRM} volts	T_J T_C (1) °C	I_{GT} mA	V_{GT} volts
2N4098	2N4216	2N4212	0.2	50	125	0.2	0.8
2N4101	2N4166	2N4151	3.2	600	100	15	2.0
2N4102	2N4166	2N4151	1.3	600	100	15	2.0
2N4103	MCR649P-8	MCR649-1	8.0	600	100	40	2.0
2N4108	2N4213	2N4212		50	125		
2N4109	2N4214	2N4212		100	125		
2N4110	2N4216	2N4212		200	125		
2N4144	MCR1906-1	MCR1906-1	0.250	15	150	1.0	0.8
2N4145	MCR1906-1	MCR1906-1	0.250	30	150	1.0	0.8
2N4146	MCR1906-2	MCR1906-1	0.250	60	150	1.0	0.8
2N4147	MCR1906-3	MCR1906-1	0.250	100	150	1.0	0.8
2N4148	MCR1906-4	MCR1906-1	0.250	150	150	1.0	0.8
2N4149	MCR1906-4	MCR1906-1	0.250	200	150	1.0	0.8
2N4151		2N4151	8.0	25	100	20	1.5
2N4152		2N4151	8.0	50	100	20	1.5
2N4153		2N4151	8.0	100	100	20	1.5
2N4154		2N4151	8.0	200	100	20	1.5
2N4155		2N4151	8.0	300	100	20	1.5
2N4156		2N4151	8.0	400	100	20	1.5
2N4157		2N4151	8.0	500	100	20	1.5
2N4158		2N4151	8.0	600	100	20	1.5
2N4159		2N4151	8.0	25	100	20	1.5
2N4160		2N4151	8.0	50	100	20	1.5
2N4161		2N4151	8.0	100	100	20	1.5
2N4162		2N4151	8.0	200	100	20	1.5
2N4163		2N4151	8.0	300	100	20	1.5
2N4164		2N4151	8.0	400	100	20	1.5
2N4165		2N4151	8.0	500	100	20	1.5
2N4166		2N4151	8.0	600	100	20	1.5
2N4167		2N4151	8.0	25	100	20	1.5
2N4168		2N4151	8.0	50	100	20	1.5
2N4169		2N4151	8.0	100	100	20	1.5
2N4170		2N4151	8.0	200	100	20	1.5
2N4171		2N4151	8.0	300	100	20	1.5
2N4172		2N4151	8.0	400	100	20	1.5
2N4173		2N4151	8.0	500	100	20	1.5
2N4174		2N4151	8.0	600	100	20	1.5
2N4175		2N4151	8.0	25	100	20	1.5
2N4176		2N4151	8.0	50	100	20	1.5
2N4177		2N4151	8.0	100	100	20	1.5
2N4178		2N4151	8.0	200	100	20	1.5
2N4179		2N4151	8.0	300	100	20	1.5
2N4180		2N4151	8.0	400	100	20	1.5
2N4181		2N4151	8.0	500	100	20	1.5
2N4182		2N4151	8.0	600	100	20	1.5
2N4183		2N4151	8.0	25	100	20	1.5
2N4184		2N4151	8.0	50	100	20	1.5
2N4185		2N4151	8.0	100	100	20	1.5
2N4186		2N4151	8.0	200	100	20	1.5
2N4187		2N4151	8.0	300	100	20	1.5
2N4188		2N4151	8.0	400	100	20	1.5
2N4189		2N4151	8.0	500	100	20	1.5
2N4190		2N4151	8.0	600	100	20	1.5
2N4191		2N4151	8.0	25	100	20	1.5
2N4192		2N4151	8.0	50	100	20	1.5
2N4193		2N4151	8.0	100	100	20	1.5
2N4194		2N4151	8.0	200	100	20	1.5
2N4195		2N4151	8.0	300	100	20	1.5
2N4196		2N4151	8.0	400	100	20	1.5
2N4197		2N4151	8.0	500	100	20	1.5
2N4198		2N4151	8.0	600	100	20	1.5
2N4199		2N4199	100*	300	105	50	1.5
2N4200		2N4199	100*	400	105	50	1.5
2N4201		2N4199	100*	500	105	50	1.5
2N4202		2N4199	100*	600	105	50	1.5
2N4203		2N4199	100*	700	105	50	1.5
2N4204		2N4199	100*	800	105	50	1.5
2N4212		2N4212	1.6	25	125	0.1	1.5
2N4213		2N4212	1.6	50	125	0.1	1.5

TYPE	REPLACEMENT	REF.	$I_{T(RMS)}$ Amp	V_{DRM}/V_{RRM} volts	T_J T_C(1) °C	I_{GT} mA	V_{GT} volts
2N4214		2N4212	1.6	100	125	0.1	1.5
2N4215		2N4212	1.6	150	125	0.1	1.5
2N4216		2N4212	1.6	200	125	0.1	1.5
2N4217			1.0	250	125		
2N4218			1.0	300	125		
2N4219			1.0	400	125		
2N4316			9.2	100	150	15	1.2
2N4317			9.2	200	150	15	1.2
2N4318			9.2	300	150	15	1.2
2N4319			9.2	400	150	15	1.2
2N4361			70	100		250	5.0
2N4362			70	200		250	5.0
2N4363			70	400		250	5.0
2N4364			70	600		250	5.0
2N4365			70	800		250	5.0
2N4366			70	1000		250	5.0
2N4367			70	1200		250	5.0
2N4368			70	1400		250	5.0
2N4369			70	1600		250	5.0
2N4370			70	1800		250	5.0
2N4371			70	100		250	5.0
2N4372			70	200		250	5.0
2N4373			70	400		250	5.0
2N4374			70	600		250	5.0
2N4375			70	800		250	5.0
2N4376			70	1000		250	5.0
2N4377			70	1200		250	5.0
2N4378			70	1400		250	5.0
2N4379			70	1600		250	5.0
2N4380			70	1800		250	5.0
2N4441		2N4441	8.0	50	100	30	1.5
2N4442		2N4441	8.0	200	100	30	1.5
2N4443		2N4441	8.0	400	100	30	1.5
2N4444		2N4441	8.0	600	100	30	1.5
2N4983			0.175	30	125	0.50	6.0
2N4984			0.200	30	150	0.15	7.5
2N4985			0.200	30	150	0.30	7.5
2N4986			0.175	30	125	0.20	7.0
2N4987			0.175	30	125	0.50	6.0
2N4988			0.200	30	150	0.15	7.5
2N4989			0.200	30	150	0.30	7.5
2N4990			0.175	30	125	0.20	7.0
2N4991	MBS4991	MBS4991	0.175		125	0.50	6.0
2N4992	MBS4992	MBS4991	0.200		150	0.12	7.5
2N4993			0.200		150	0.50	6.0
2N5060		2N5060	0.8	30	125	0.2	0.8
2N5061		2N5060	0.8	60	125	0.2	0.8
2N5062		2N5060	0.8	100	125	0.2	0.8
2N5063		2N5060	0.8	150	125	0.2	0.8
2N5064		2N5060	0.510	200	125	350	1.2
2N5164		2N5164	13	50	100	75	0.2
2N5165		2N5164	13	200	100	75	0.2
2N5166		2N5164	13	400	100	75	0.2
2N5167		2N5164	13	600	100	75	0.2
2N5168		2N5164	13	50	100	75	0.2
2N5169		2N5164	13	200	100	75	0.2
2N5170		2N5164	13	400	100	75	0.2
2N5171		2N5164	13	600	100	75	0.2
2N5204			200	600		80	3.0
2N5205			200	600		80	3.0
2N5206			200	600		80	3.0
2N5207			200	600		80	3.0
2N5257			200	400	105	800	3.0
2N5258			200	600	105	800	3.0
2N5259			200	800	105	800	3.0
2N5260			200	1000	105	800	3.0
2N5261			200	1200	105	800	3.0
2N5273			25	200	125	150	3.5
2N5274			25	400	125	150	3.5
2N5275			25	600	125	150	3.5
2N5806			25	200	115(1)	±120	±4.0
2N5807			25	400	115(1)	±120	±4.0
2N5808			25	500	115(1)	±120	±4.0
2N5809			25	600	115(1)	±120	±4.0

TYPE	REPLACEMENT	REF.	$I_{T(RMS)}$ Amp	V_{DRM}/V_{RRM} volts	T_J T_C(1) °C	I_{GT} mA	V_{GT} volts
3N58			0.064	40	150	0.001	0.65
3N59			0.064	40	150	0.001	0.65
3N60			0.064	40	150	0.001	0.65
3N80			0.127	40	150	0.001	0.65
3N81			0.127	65	150	0.001	0.65
3N82			0.127	100	150	0.001	0.65
3N83			0.032	70	125	0.15	0.80
3N84			0.111	40	125	0.01	0.65
3N85			0.111	100	125	0.01	0.65
3N86			0.127	65	150	0.001	0.65

FIELD-EFFECT TRANSISTORS

INDEX AND SHORT-FORM SPECIFICATIONS

This table contains a numerical listing and short-form specifications for field-effect transistors with EIA-registered 2N and 3N numbers, introduced since the publication of the Motorola Semiconductor Data Book (4th Edition).

KEY

TYPE	POLARITY	CONST.	NEAREST EQUIV.	REF.	I_{DSS} Min mA	I_{DSS} Max mA (*nA)	I_{GSS} I_{DGO}* nA	Breakdown Voltage $V_{(BR)}$ Volts	Breakdown Voltage Sub-script	y_{fs} Min μmhos	y_{fs} Max μmhos	C_{iss} pF	NF @ f dB $\mu V^*/\sqrt{Hz}$ Units	NOTE D = Dual MP = Matched Pair
Numerical Listing of Registered Type Numbers	N = n-channel P = p-channel	J = Junction FET M = MOS FET	Type number of nearest electrical equivalent fully characterized in this book	Reference device number indicates specific Data Sheet on which device is characterized	Minimum and Maximum Drain Current with gate connected to source		Maximum Gate Current (leakage) with drain connected to source *Maximum leakage from drain to gate with source open			Minimum and Maximum Forward Transadmittance		Maximum Input Capacitance	Noise Figure in dB or *, $\mu V / \sqrt{Hz}$ at a specified frequency; frequency units: H = Hz, K = kHz, M = MHz	

Minimum Breakdown Voltage (Subscript defines conditions)
- GS = Gate to source, drain connection not specified
- GSS = Gate to source, drain connected to source
- GD = Gate to drain, source connection not specified
- GDS = Gate to drain, source connected to drain
- DGO = Drain to gate, source open
- DGS = Drain to gate, source connected to drain
- DS = Drain to source, gate connection not specified
- DSX = Drain to source, gate biased to cutoff or beyond

TYPE	POLARITY	CONST.	NEAREST EQUIVALENT	REF.	I_{DSS} Min mA	I_{DSS} Max mA	I_{GSS} I_{DGO}* nA	Breakdown Voltage $V_{(BR)}$ Volts	Breakdown Voltage Sub-script	y_{fs} Min μmhos	y_{fs} Max μmhos	C_{iss} pF	NF @ f dB	NF @ f μV* / √Hz	NF @ f Units	NOTE
					*nA					*mmhos						
2N2386	P	J	2N5266-9	2N5265			10	20	GS	1000		50				
2N2386A	P	J	2N5267-70	2N5265	1.0	15	10	20	DGO	2200	5000	10				
2N2497	P	J	2N5267	2N5265	1.0	5.0	10	20	GD	1000	2000	32	3.0		1.0 K	
2N2498	P	J	2N5268	2N5265	2.0	6.0	10	20	GD	1500	3000	32	3.0		1.0 K	
2N2499	P	J	2N5269-70	2N5265	5.0	15	10	20	GD	2000	4000	32	4.0		1.0 K	
2N2500	P	J	2N5267-8	2N5265	1.0	6.0	10	20	GS	1000	2000	32	1.0		1.0 K	
2N2606	P	J	2N5473-4	2N5471	0.1	0.5	1.0	30	GDS	110		6.0	3.0		1.0 K	
2N2607	P	J	2N5475-6	2N5471	0.3	1.5	3.0	30	GDS	330		10	3.0		1.0 K	
2N2608	P	J	2N5266-8	2N5265	0.9	4.5	10	30	GDS	1000		17	3.0		1.0 K	
2N2609	P	J	2N5268-70	2N5265	2.0	10	30	30	GDS	2500		30	3.0		1.0 K	
2N2620	N	J					100	50	DGO							
2N2794	P	J			1.5	5.0	10	20	DGO							
2N2841	P	J	2N5471-2	2N5471	0.025	0.125	1.0			60		6.0	3.0		1.0 K	
2N2842	P	J	2N5472-3	2N5471	0.065	0.325	3.0			180		10	3.0		1.0 K	
2N2843	P	J	2N5265	2N5265	0.2	1.0	10			540		17	3.0		1.0 K	
2N2844	P	J	2N5265-7	2N5265	1.0	2.2	30			1400		30	3.0		1.0 K	
2N3066	N	J	MFE2095	MFE2093	0.8	4.0	1.0	50	DGO	400	1000	10	3.0		1.0 K	
2N3066A	N	J			0.8	4.0	1.0	50	DGO	400	1000	10	0.25		1.0 K	
2N3067	N	J	MFE2093-4	MFE2093	0.2	1.0	1.0	50	DGO	400		18	3.0		1.0 K	
2N3067A	N	J			0.2	1.0	1.0	50	DGO	300	1000	10	0.25		1.0 K	
2N3068	N	J	MFE2093	MFE2093	0.05	0.25	1.0	50	DGO	200		18	3.0		1.0 K	
2N3068A	N	J	MFE2093	MFE2093	0.05	0.25	1.0	50	DGO	200	1000	10	0.25		1.0 K	
2N3069	N	J	2N4220A-2A	2N4220	2.0	10	1.0	50	DGO	1000		15	3.0		1.0 K	
2N3069A	N	J			2.0	10	1.0	50	DGO	1000	2500	15	0.25		1.0 K	
2N3070	N	J	2N4220A	2N4220	0.5	2.5	1.0	50	DGO	750		15	3.0		1.0 K	
2N3070A	N	J			0.5	2.5	1.0	50	DGO	750	2500	15	0.25		1.0 K	
2N3071	N	J	2N4220A	2N4220	0.1	0.6	1.0	50	DGO	500	2500	15	3.0		1.0 K	
2N3084	N	J	MFE2095	MFE2093	0.8	3.0	0.1	15	DGO	400	2000	14				
2N3085	N	J	MFE2095	MFE2093	0.8	3.0	0.1	15	DGO	400	2000	14				
2N3086	N	J	MFE2095	MFE2093	0.8	3.0	1.0	30	DGS	400	2000	14				
2N3087	N	J	MFE2095	MFE2093	0.8	3.0	1.0	30	DGS	400	2000	14				
2N3088	N	J	MFE2094-5	MFE2093	0.5	2.0	1.0	10	DGS	300	2000	14	3.0			
2N3088A	N	J	MFE2094-5	MFE2093	0.5	2.0	1.0	10	DGS	300	2000	14	0.5		10 H	
2N3089	N	J	MFE2094-5	MFE2093	0.5	2.0	1.0	10	DGS	300	2000	14	3.0			
2N3089A	N	J	MFE2094-5	MFE2093	0.5	2.0	1.0	10	DGS	300	2000	14	0.5		10 H	
2N3112	P	J	2N5471-3	2N5471	0.035	0.175	0.05	20	GDS	50	115	3.5				
2N3113	P	J	2N5471-3	2N5471	0.035	0.175	0.05	20	GDS	50	115	2.0				
2N3277	P	J	2N5473-4	2N5471	0.15	0.5	0.4	25	DGO	100		3.0				
2N3278	P	J	2N5475	2N5471	0.4	0.9	0.4	25	DGO	150		3.0				
2N3328	P	J	2N5473-5	2N5471	1.0		1.0	20	GSS	100		3.0	3.0			
2N3329	P	J	2N5266-7	2N5265	1.0	3.0	10	20	GSS	1000	2000	20	3.0			
2N3330	P	J	2N5267-8	2N5265	2.0	6.0	10	20	GSS	1500	3000	20	3.0			
2N3331	P	J	2N5269-70	2N5265	5.0	15	10	20	GSS	2000	4000	20	4.0			
2N3332	P	J	2N5267-8	2N5265	1.0	6.0	10	20	GSS	1000	2200	20	1.0			
2N3333	P	J			0.3	1.0	10	20	GSS	600	1800	30				Dual
2N3334	P	J			0.3	1.0	10	20	GSS	600	1800	30				Dual
2N3335	P	J			0.3	1.0	10	20	GSS	600	1800	30				Dual
2N3336	P	J			0.3	1.0	10	20	GSS	600	1800	30				Dual
2N3365	N	J	2N4220A 1A	2N4220	0.8	4.0	5.0	40	DGO	250	1000	15				
2N3366	N	J	MFE2093-4	MFE2093	0.2	1.0	5.0	40	DGO	250	1000	15				
2N3367	N	J	MFE2093	MFE2093	0.005	0.25	5.0	40	DGO	100	1000	15				
2N3368	N	J	2N4221A-2A	2N4220	2.0	12	5.0	40	DGO	1000	4000	20				
2N3369	N	J	2N4220A	2N4220	0.5	2.5	5.0	40	DGO	600	2500	20				
2N3370	N	J	MFE2093	MFE2093	0.1	0.6	5.0	40	DGO	300	2500	20				
2N3376	P	J	2N5265-8	2N5265	0.6	6.0	3.0	30	DGS	800		5.0				
2N3377	P	J	2N5265-8	2N5265	0.6	6.0	3.0	30	DGS	800	2300	4.0				
2N3378	P	J	2N5268	2N5265	3.0	6.0	3.0	30	DGS	1500	2300	5.0				
2N3379	P	J	2N5268	2N5265	3.0	6.0	3.0	30	DGS	1500	2300	4.0				
2N3380	P	J	2N5268-70	2N5265	3.0	20	3.0	30	DGS	1500	3000	4.0				
2N3381	P	J	2N5268-70	2N5265	3.0	20	3.0	30	DGS	1500	3000	4.0				
2N3382	P	J			3.0	30	15	30	DGS	4500	12500					
2N3383	P	J			3.0	30	15	30	DGS	4500	12500					
2N3384	P	J			15	30	15	30	DGS	7500	12500					
2N3385	P	J			15	30	15	30	DGS	7500	12500					
2N3386	P	J			13	50	15	30	DGS	7500	12500					
2N3387	P	J			13	50	15	30	DGS	5000	10000					
2N3436	N	J			3.0	15	0.5	50	DGO	2500	10000	18	2.0			
2N3437	N	J			0.8	4.0	0.5	50	DGO	1500	6000	18	2.0			
2N3438	N	J			0.2	1.0	0.5	50	DGO	800	4500	18	2.0			
2N3452	N	J	MFE2095	MFE2093	0.8	4.0	0.1	50	DGO	200	1200	6.0	2.0			
2N3453	N	J	MFE2094	MFE2093	0.2	1.0	0.1	50	DGO	150	900	6.0	2.0			
2N3454	N	J	MFE2093	MFE2093	0.05	0.25	0.1	50	DGO	100	600	6.0	2.0			
2N3455	N	J	MFE2095	MFE2093	0.8	4.0	0.04	50	DGO	400	1200	5.0	4.0			
2N3456	N	J	MFE2094	MFE2093	0.2	1.0	0.04	50	DGO	300	900	5.0	4.0			
2N3457	N	J	MFE2093	MFE2093	0.05	0.25	0.04	50	DGO	150	600	5.0	4.0			
2N3458	N	J			3.0	15	0.25	50	DGO	2500	10000	18	6.0			
2N3459	N	J			0.8	4.0	0.25	50	DGO	1500	6000	18	4.0			
2N3460	N	J			0.2	1.0	0.25	50	DGO	800	4500	18	4.0			
2N3465	N	J	MFE2095	MFE2093	1.0	5.0	1.0	40	DGO	400	1200	15	5.0			
2N3466	N	J	MFE2095	MFE2093	1.0	5.0	1.0	40	DGO	400	1200	15	5.0			
2N3573	P	J	2N5471-2	2N5471	0.02	0.1	0.6	25	GSS	100	300	6.0	3.0			
2N3574	P	J	2N5472-4	2N5471	0.075	0.375	0.6	25	GSS	200	600	6.0	3.0			
2N3575	P	J	2N5474-5	2N5471	0.2	1.0	0.6	25	GSS	300	900	6.0	3.0			
2N3578	P	J	2N5266-8	2N5265	0.9	4.5	15	20	GSS	1200	3500	65				
2N3608	P	M	2N4352	2N4352	30	0.025										
2N3609	P	M			35	0.02										
2N3610	P	M	2N4352	2N4352	10	0.02										
2N3631	N	M	2N3797	2N3796	2.0	10		20	DSX	1400	2800	7.5				
2N3684	N	J	2N4221A	2N4221	2.5	7.5	0.1	50	GS	2000	3000	4.0	0.5			

2N3684A-2N4342

TYPE	POLARITY	CONST.	NEAREST EQUIVALENT	REF.	I_{DSS} Min mA	I_{DSS} Max mA	I_{GSS} / I_{DGO}* nA	Breakdown Voltage $V_{(BR)}$ Volts	Breakdown Voltage Sub-script	y_{fs} Min μmhos	y_{fs} Max μmhos	C_{iss} pF	NF @ f dB	NF @ f μV*/√Hz	NF @ f Units	NOTE
					* nA					*mmhos						
2N3684A	N	J	2N4221A		2.5	7.5	0.1	50	GSS			4.0	0.5		100H	
2N3685	N	J	2N4220A	2N4221	1.0	3.0	0.1	50	GS	1500	2500	4.0	0.5			
2N3685A	N	J	2N4220A		1.0	3.0	0.1	50	GSS			4.0	0.5		100H	
2N3686	N	J	2N4220A	2N4221	0.4	1.2	0.1	50	GS	1000	2000	4.0	0.5			
2N3686A	N	J	2N4220A		0.4	1.2	0.1	50	GSS			4.0	0.5		100H	
2N3687	N	J	2N5358	2N5358	0.1	0.5	0.1	50	GS	500	1500	4.0	0.15*			
2N3687A	N	J	2N4220A		0.1	0.5	0.1	50	GSS			4.0	0.5		100H	
2N3695	P	J	2N5267	2N5265	1.25	3.75	0.1	30	GS	1000	1750	5.0	0.2*			
2N3696	P	J	2N5266	2N5265	0.5	1.5	0.1	30	GS	750	1250	5.0	0.2*			
2N3697	P	J	2N5265	2N5265	0.2	0.6	0.1	30	GS	500	1000	5.0	0.2*			
2N3698	P	J	2N5265	2N5265	0.05	0.25	0.1	30	GS	250	750	5.0	0.2*			
2N3796	N	M		2N3796	0.5	3.0	0.001	25	DSX	900	1800	6.0	4.0			
2N3797	N	M		2N3796	2.0	6.0	0.001	20	DSX	1500	3000	8.0	4.0			
2N3819	N	J	MPF102	MPF102	2.0	20	2.0	25	GSS	2000	6500	8.0				
2N3820	P	J	2N5460-2	2N5460	0.3	15	20	20	GSS	800	5000	32				
2N3821	N	J		2N3821	0.5	2.5	0.1	50	GSS	1500	4500	6.0	5.0		10 H	
2N3822	N	J		2N3821	2.0	10	0.1	50	GSS	3000	6500	6.0	5.0		10 H	
2N3823	N	J		2N3823	4.0	20	0.5	30	DGS	3500	6500	6.0	2.5		100 M	
2N3824	N	J		2N3821			0.1	50	GSS			6.0				
2N3882	P	M	MFE3003	MFE3003	0.25		0.1	30	DS	1000	2400	4.0	3.0			
2N3909	P	J	2N5460-2	2N5460	0.3	15	10	20	DGS	1000	5000	32				
2N3909A	P	J	2N5460-2		1.0	15	10	20	GSS	2000		9.0				
2N3921	N	J	MMF1,2	MMF1	1.0	10	0.25	50	GSS	1500	7500	18	2.0		1.0 K	Dual
2N3922	N	J	MMF3,4	MMF1	1.0	10	0.25	50	GSS	1500	7500	18	2.0		1.0 K	Dual
2N3934	N	J	MMF1,2	MMF1	0.25	1.3	0.1	50	GSS	300	900	7.0	2.0		100 H	Dual
2N3935	N	J	MMF5,6	MMF1	0.25	1.3	0.1	50	GSS	300	900	7.0	2.0		100 H	Dual
2N3954	N	J	MMF1,2	MMF1	0.5	5.0	0.1	50	GSS	1000		4.0	0.5		100 H	Dual
2N3954A	N	J	MMF1,2	MMF1	0.5	5.0	0.1	50	GSS	1000		4.0	0.5		100 H	
2N3955	N	J	MMF1,2	MMF1	0.5	5.0	0.1	50	GSS	1000		4.0	0.5		100 H	Dual
2N3955A	N	J	MMF1,2	MMF1	0.5	5.0	0.1	50	GSS	1000		4.0	0.5		100 H	
2N3956	N	J	MMF5,6	MMF1	0.5	5.0	0.1	50	GSS	1000		4.0	0.5		100 H	Dual
2N3957	N	J	MMF5,6	MMF1	0.5	5.0	0.1	50	GSS	1000		4.0	0.5		100 H	Dual
2N3958	N	J	MMF5,6	MMF1	0.5	5.0	0.1	50	GSS	1000		4.0	0.5		100 H	Dual
2N3966	N	J	2N4221	2N4220	2.0		0.1	30	DGS			6.0				
2N3967	N	J	2N4221A-2A	2N4220	2.5	10	0.1	30	DGS	1600	2400	5.0				
2N3967A	N	J	2N4221A-2A	2N4220	2.5	10	0.1	30	GSS	1600	2400	5.0	1.5		100 H	
2N3968	N	J	2N4221A	2N4220	1.0	5.0	0.1	30	DGS	1400	2000	5.0				
2N3968A	N	J	2N4221A	2N4220	1.0	5.0	0.1	30	GSS	1400	2000	5.0	1.5		100 H	
2N3969	N	J	2N4220A	2N4220	0.4	2.0	0.1	30	DGS	950	1450	5.0				
2N3969A	N	J	2N4220A	2N4220	0.4	2.0	0.1	30	GSS	950	1450	5.0	1.5		100 H	
2N3970	N	J	2N4091	2N4091	50	150	0.25*	40	DGS			25				
2N3971	N	J	2N4091-2	2N4091	25	75	0.25*	40	DGS			25				
2N3972	N	J	2N4093	2N4091	5.0	30	0.25*	40	DGS			25				
2N3993	P	J			10		1.2*	25	GSS	6000	12000	16				
2N3994	P	J			2.0		1.2*	25	GSS	4000	10000	16				
2N4038	N	M				0.1		15	DSX							
2N4039	N	M			0.1	1.5		15	DSX							
2N4065	P	M	2N4352	2N4352		0.005	0.0025	25	GSS			4.5				
2N4066	P	M					0.0025	25	GSS			7.0				
2N4067	P	M				1.0*		30	DSS	2500		7.0				
2N4082	N	J	MMF1,2	MMF1	0.25	1.3	0.1	50		300		7.0				Dual
2N4083	N	J	MMF3,4	MMF1	0.25	1.3	0.1	50		300		7.0				Dual
2N4084	N	J	MMF1,2	MMF1	1.0	10	0.25	50		1500		18				Dual
2N4085	N	J	MMF3,4	MMF1	1.0	10	0.25	50		1500		18				Dual
2N4088	P	J			5.0	15	0.1	30	GSS	1000	1600	10	1.5		1.0 K	
2N4089	P	J			2.0	8.0	0.1	30	GSS	800	1300	10	1.5		1.0 K	
2N4090	P	J			0.4	2.5	0.1	30	GSS	500	900	10	1.5		1.0 K	
2N4091	N	J		2N4091	30		0.2*	40	DGO			16				
2N4091A	N	J	2N4091		30		0.04	50	GSS			16				
2N4092	N	J		2N4091	15		0.2*	40	DGO			16				
2N4092A	N	J	2N4092		15		0.04	50	GSS			16				
2N4093	N	J		2N4091	8.0		0.2*	40	DGO			16				
2N4093A	N	J	2N4093		8.0		0.04	50	GSS			16				
2N4094	N	J	2N4091	2N4091	75			40	GSS			32				
2N4095	N	J	2N4092	2N4091	20			40	GSS			32				
2N4117	N	J	MFE2093	MFE2093	0.03	0.09	0.01	40	GSS	70	210	3.0				
2N4117A	N	J	MFE2093	MFE2093	0.03	0.09	0.001	40	DGO			3.0				
2N4118	N	J	MFE2093	MFE2093	0.08	0.24	0.01	40	GSS	80	250	3.0				
2N4118A	N	J	MFE2093	MFE2093	0.08	0.24	0.001	40	DGO			3.0				
2N4119	N	J	MFE2093	MFE2093	0.2	0.6	0.01	40	GSS	100	330	3.0				
2N4119A	N	J	MFE2093	MFE2093	0.2	0.6	0.001	40	DGO			3.0				
2N4120	P	M	2N4352	2N4352		500*	0.0025	30	DSS	700		0.7				
2N4139	N	J	2N4222A	2N4221	8.0	11	1.0	50	DGO			18				
2N4220	N	J		2N4220	0.5	3.0	0.1	30	GSS	1000	4000	6.0				
2N4220A	N	J		2N4220	0.5	3.0	0.1	30	GSS	1000	4000	6.0	2.5		1.0 H	
2N4221	N	J		2N4220	2.0	6.0	0.1	30	GSS	2000	5000	6.0				
2N4221A	N	J		2N4220	2.0	6.0	0.1	30	GSS	2000	5000	6.0	2.5		1.0 H	
2N4222	N	J		2N4220	5.0	15	0.1	30	GSS	2500	6000	6.0				
2N4222A	N	J		2N4220	5.0	15	0.1	30	GSS	2500	6000	6.0	2.5		1.0 H	
2N4223	N	J			3.0	18	0.25	30	GSS	3000	7000	6.0	5.0		200 M	
2N4224	N	J		2N4223	2.0	20	0.5	30	GSS	2000	7500	6.0				
2N4267	P	M	2N4352	2N4223		0.001	0.005	30	GSS			15				
2N4268	P	M	2N4352	2N4352		0.001	0.005	30	GSS			15				
2N4302	N	J	2N5457	2N4352		5.0	1.0	30	DGO			6.0				
2N4303	N	J	2N5458	2N5457		10	1.0	30	DGO			6.0				
2N4304	N	J	2N5457-9	2N5457		15	1.0	30	DGO			6.0				
2N4338	N	J	2N4220A	2N4220	0.2	0.6	0.1	50	DGO			6.0				
2N4339	N	J	2N4220A	2N4220	0.5	1.5	0.1	50	DGO			6.0				
2N4340	N	J	2N4220A-1A	2N4220	1.2	3.6	0.1	50	DGO			6.0				
2N4341	N	J	2N4221A-2A	2N4220	3.0	9.0	0.1	50	DGO			6.0				
2N4342	P	J			4.0	12	10	25	DGO			5.0				

TYPE	POLARITY	CONST.	NEAREST EQUIVALENT	REF.	I_{DSS} Min mA	I_{DSS} Max mA	I_{GSS} / I_{DGO}* nA	Breakdown Voltage $V_{(BR)}$ Volts	Breakdown Voltage Sub-script	y_{fs} Min μmhos	y_{fs} Max μmhos	C_{iss} pF	NF @ f dB	NF @ f μV*/√Hz	Units	NOTE
					* nA					* mmhos						
2N4343	P	J			10	30	10	25	DGO			5.0				
2N4351	N	M		2N4351		0.01	0.01	25	DSS	1000		5.5				
2N4352	P	M		2N4352		0.005	0.01	25	DSS	1000		6.5				
2N4353	P	M	2N4352	2N4352				3.0	GSS	1000	4000	12				
2N4360	P	J			3.0	30	10	20	GSS	2000	8000	20	5.0	100	H	
2N4382	P	J			10	30	1.0	25	GSS			5.0				
2N4391	N	J			50	100	0.1	40	GSS							
2N4392	N	J			25	75	0.1	40	GSS							
2N4393	N	J			5.0	30	0.1	40	GSS							
2N4416	N	J		2N4416	5.0	15		30	GSS			4.0				
2N4416A	N	J	2N4416	2N4416	5.0	15	0.1	35	GSS	4500	7500	4.0	4.0	400	M	
2N4417	N	J	2N4416	2N4416	5.0	15		30	GSS			3.5				
2N4445	N	J	MFE2012	MFE2010			3.0	25	GSS			50				
2N4446	N	J	MFE2012	MFE2010			3.0	25	GSS			50				
2N4447	N	J	MFE2012	MFE2010			3.0	20	GSS			50				
2N4448	N	J	MFE2012	MFE2010			3.0	20	GSS			50				
2N4856	N	J	2N4091	2N4091	50		0.25	40	GSS			18				
2N4856A	N	J	2N4091	2N4091	50		0.25	40	GSS			10				
2N4857	N	J	2N4092	2N4091	20	100	0.25	40	GSS			18				
2N4857A	N	J	2N4092	2N4091	20	100	0.25	40	GSS			10				
2N4858	N	J	2N4093	2N4091	8.0	80	0.25	40	GSS			18				
2N4858A	N	J	2N4093	2N4091	8.0	80	0.25	40	GSS			10				
2N4859	N	J	2N4091	2N4091	50		0.25	30	GSS			18				
2N4859A	N	J	2N4091	2N4091	50		0.25	30	GSS			10				
2N4860	N	J	2N4092	2N4091	20	100	0.25	30	GSS			18				
2N4860A	N	J	2N4092	2N4091	20	100	0.25	30	GSS			10				
2N4861	N	J	2N4093	2N4091	8.0	80	0.25	30	GSS			15				
2N4861A	N	J	2N4093	2N4091	8.0	80	0.25	30	GSS			10				
2N4867	N	J	2N4220A	2N4220	0.4	1.2	0.25	40	GSS	700	2000	25	1.0	1.0	K	
2N4867A	N	J	2N4220A	2N4220	0.4	1.2	0.25	40	GSS	700	2000	25	1.0	1.0	K	
2N4868	N	J	2N4220A	2N4220	1.0	3.0	0.25	40	GSS	1000	3000	25	1.0	1.0	K	
2N4868A	N	J	2N4220A	2N4220	1.0	3.0	0.25	40	GSS	1000	3000	25	1.0	1.0	K	
2N4869	N	J	2N4221A2A	2N4220	2.5	7.5	0.25	40	GSS	1300	4000	25	1.0	1.0	K	
2N4869A	N	J	2N4221A2A	2N4220	2.5	7.5	0.25	40	GSS	1300	4000	25	1.0	1.0	K	
2N4881	N	J			0.4	2.0	2.0	100	GSS			15				
2N4882	N	J			1.5	7.5	2.0	100	GSS			15				
2N4883	N	J			0.4	2.0	1.0	100	GSS			15				
2N4884	N	J			1.5	7.5	1.0	100	GSS			15				
2N4885	N	J			0.4	2.0	1.0	75	GSS			15				
2N4886	N	J			1.5	7.5	1.0	75	GSS			15				
2N4977	N	J	MFE2009	MFE2007	50		0.5	30	GSS			35				
2N4978	N	J	MFE2008	MFE2007	15		0.5	30	GSS			35				
2N4979	N	J	MFE2007	MFE2007	7.5		0.5	30	GSS			35				
2N5018	P	J			10		2.0	30	GSS			45				
2N5019	P	J			5.0		2.0	30	GSS			45				
2N5020	P	J	2N5265-6	2N5265	0.3	1.2	1.0	25	GSS			25				
2N5021	P	J	2N5266-7	2N5265	1.0	3.5	1.0	25	GSS			25				
2N5033	P	J	2N5265-7	2N5265	0.3	3.5	10	20	GSS	1000	5000	25	2.0	1.0	K	
2N5045	N	J	MMF5,6	MMF1	0.5	8.0	0.25					8.0				
2N5046	N	J	MMF5,6	MMF1	0.5	8.0	0.25					8.0				
2N5047	N	J	MMF5,6	MMF1	0.5	8.0	0.25					8.0				
2N5078	N	J	2N4416	2N4416	4.0	25	0.25	30	GSS	4500	10000	6.0	3.0	200	M	
2N5103	N	J	2N3823	2N3823	1.0	8.0	0.1	25	GSS	2000	8000	5.0	1.5	100	H	
2N5104	N	J	2N3823	2N3823	2.0	6.0	0.1	25	GSS	3500	7500	5.0	1.5	100	H	
2N5105	N	J	2N3823	2N3823	5.0	15	0.1	25	GSS	5000	10000	5.0	1.5	100	H	
2N5114	P	J			30	90	0.5	30	GSS			25				
2N5115	P	J			15	60	0.5	30	GSS			25				
2N5116	P	J			5.0	25	0.5	30	GSS			25				
2N5158	N	J	MFE2012	MFE2010			1.0	40	GSS			50				
2N5159	N	J	MFE2012	MFE2010			1.0	40	GSS			50				
2N5163	N	J	MPF102	MPF102	1.0	40	10	25	GSS	2000	9000	12				
2N5196	N	J	MMF1,2	MMF1	0.7	7.0	0.025	50	GSS	1000	4000	6.0	1.0	100	H	
2N5197	N	J	MMF1,2	MMF1	0.7	7.0	0.025	50	GSS	1000	4000	6.0	1.0	100	H	
2N5198	N	J	MMF3,4	MMF1	0.7	7.0	0.025	50	GSS	1000	4000	6.0	1.0	100	H	
2N5199	N	J	MMF5,6	MMF1	0.7	7.0	0.025	50	GSS	1000	4000	6.0	1.0	100	H	
2N5245	N	J	2N5486	2N5484	5.0	15	1.0	30	GSS	4500	7500	4.5	2.0	100	M	
2N5246	N	J	2N5485	2N5484	1.5	7.0	1.0	30	GSS	3000	6000	4.5				
2N5247	N	J	2N5486	2N5484	8.0	24	1.0	30	GSS	4500	8000	4.5				
2N5248	N	J	MPF102	MPF102	4.0	20	5.0	30	GSS	3500	6500	6.0				
2N5265	P	J		2N5265	0.5	1.0	2.0	60	GSS	900	2700	7.0	2.5	100	H	
2N5266	P	J		2N5265	0.8	1.6	2.0	60	GSS	1000	3000	7.0	2.5	100	H	
2N5267	P	J		2N5265	1.5	3.0	2.0	60	GSS	1500	3500	7.0	2.5	100	H	
2N5268	P	J		2N5265	2.5	5.0	2.0	60	GSS	2000	4000	7.0	2.5	100	H	
2N5269	P	J		2N5265	4.0	8.0	2.0	60	GSS	2200	4500	7.0	2.5	100	H	
2N5270	P	J		2N5265	7.0	14.0	2.0	60	GSS	2500	5000	7.0	2.5	100	H	
2N5277	N	J	2N3822	2N3821	2.5	12.5	5.0	150	GSS	2000	5000	25	3.0	1.0	K	
2N5278	N	J			10	25	5.0	150	GSS	3000	6000	25	3.0	1.0	K	
2N5358	N	J		2N5358	0.5	1.0	0.1	40	GSS	1000	3000	6.0	2.5	100	H	
2N5359	N	J		2N5358	0.8	1.6	0.1	40	GSS	1200	3600	6.0	2.5	100	H	
2N5360	N	J		2N5358	1.5	3.0	0.1	40	GSS	1400	4200	6.0	2.5	100	H	
2N5361	N	J		2N5358	2.5	5.0	0.1	40	GSS	1500	4500	6.0	2.5	100	H	
2N5362	N	J		2N5358	4.0	8.0	0.1	40	GSS	2000	5500	6.0	2.5	100	H	
2N5363	N	J		2N5358	7.0	14	0.1	40	GSS	2500	6000	6.0	2.5	100	H	
2N5364	N	J		2N5358	9.0	18	0.1	40	GSS	2700	6500	6.0	2.5	100	H	
2N5391	N	J	2N5358	2N5358	0.5	1.5	0.2	70	GSS	1500	4500	18	1.0	100	H	
2N5392	N	J	2N5360	2N5358	1.0	3.0	0.2	70	GSS	2000	6000	18	1.0	100	H	
2N5393	N	J	2N5360	2N5358	2.5	4.5	0.2	70	GSS	3000	6500	18	1.0	100	H	
2N5394	N	J	2N5361	2N5358	4.0	6.0	0.2	70	GSS	4000	7000	18	1.0	100	H	
2N5395	N	J	2N5362	2N5358	5.5	8.0	0.2	70	GSS	4500	7000	18	1.0	100	H	
2N5396	N	J	2N5362	2N5358	7.5	10	0.2	70	GSS	4500	7500	18	1.0	100	H	
2N5397	N	J	MFE2001	MFE2000	10	30	0.1	25	GSS	6000	10000	5.0	3.5	450	M	
2N5398	N	J	MFE2001	MFE2000	5.0	40	0.1	25	GSS	5500	10000	5.5				
2N5432	N	J			150		0.2	25	GSS			30				
2N5433	N	J			100		0.2	25	GSS			30				
2N5434	N	J			30		0.2	25	GSS			30				

TYPE	POLARITY	CONST.	NEAREST EQUIVALENT	REF.	I_{DSS}		I_{GSS} I_{DGO}*	Breakdown Voltage		y_{fs}		C_{iss}	NF @ f		NOTE
					Min mA	Max mA	nA	$V_{(BR)}$ Volts	Sub-script	Min μmhos	Max μmhos	pF	dB $\frac{\mu V^*}{\sqrt{Hz}}$	Units	
					*nA					*mmhos					
2N5452	N	J	MMF1,2	MMF1	0.5	5.0	0.1	50	GSS	1000	3000	4.0	0.02*	1.0K	
2N5453	N	J	MMF1,2	MMF1	0.5	5.0	0.1	50	GSS	1000	3000	4.0	0.02*	1.0K	
2N5454	N	J	MMF3,4	MMF1	0.5	5.0	0.1	50	GSS	1000	3000	4.0	0.02*	1.0K	
2N5457	N	J		2N5457	1.0	5.0	1.0	25	GSS	1000	5000	7.0			
2N5458	N	J		2N5457	2.0	9.0	1.0	25	GSS	1500	5500	7.0			
2N5459	N	J		2N5457	4.0	16	1.0	25	GSS	2000	6000	7.0			
2N5460	P	J		2N5460	1.0	5.0	5.0	40	GSS	1000	4000	7.0	2.5	100 H	
2N5461	P	J		2N5460	2.0	9.0	5.0	40	GSS	1500	5000	7.0	2.5	100 H	
2N5462	P	J		2N5460	4.0	16	5.0	40	GSS	2000	6000	7.0	2.5	100 H	
2N5463	P	J		2N5460	1.0	5.0	5.0	60	GSS	1000	4000	7.0	2.5	100 H	
2N5464	P	J		2N5460	2.0	9.0	5.0	60	GSS	1500	5000	7.0	2.5	100 H	
2N5465	P	J		2N5460	4.0	16	5.0	60	GSS	2000	6000	7.0	2.5	100 H	
2N5471	P	J		2N5471	0.02	0.06	0.5	40	GSS	60	180	5.0	2.5	1.0 K	
2N5472	P	J		2N5471	0.05	0.12	0.5	40	GSS	90	225	5.0	2.5	1.0 K	
2N5473	P	J		2N5471	0.10	0.25	0.5	40	GSS	120	300	5.0	2.5	1.0 K	
2N5474	P	J		2N5471	0.20	0.50	0.5	40	GSS	160	400	5.0	2.5	1.0 K	
2N5475	P	J		2N5471	0.40	1.0	0.5	40	GSS	200	500	5.0	2.5	1.0 K	
2N5476	P	J		2N5471	0.80	2.0	0.5	40	GSS	260	650	5.0	2.5	1.0 K	
2N5484	N	J		2N5484	1.0	5.0	1.0	25	GSS	3000	6000	5.0	3.0	100 M	
2N5485	N	J		2N5484	4.0	10	1.0	25	GSS	3500	7000	5.0	2.0	100 M	
2N5486	N	J		2N5484	8.0	20	1.0	25	GSS	4000	8000	5.0	2.0	100 M	
2N5505	P	J					0.25	30	GSS	1000	3500	16	2.0	1.0 K	Dual
2N5506	P	J					0.25	30	GSS	1000	3500	16	2.0	1.0 K	Dual
2N5507	P	J					0.25	30	GSS	1000	3500	16	2.0	1.0 K	Dual
2N5508	P	J					0.25	30	GSS	1000	3500	16	2.0	1.0 K	Dual
2N5509	P	J					0.25	30	GSS	1000	3500	16	2.0	1.0 K	Dual
2N5510	P	J					0.25	30	GSS	500	3000	16	2.0	1.0 K	Dual
2N5511	P	J					0.25	30	GSS	500	3000	16	2.0	1.0 K	Dual
2N5512	P	J					0.25	30	GSS	500	3000	16	2.0	1.0 K	Dual
2N5513	P	J					0.25	30	GSS	500	3000	16	2.0	1.0 K	Dual
2N5514	P	J					0.25	30	GSS	500	3000	16	2.0	1.0 K	Dual
2N5515	N	J			0.5	7.5	0.25	40	GSS	1000	4000	25	2.0	1.0 H	Dual
2N5516	N	J			0.5	7.5	0.25	40	GSS	1000	4000	25	2.0	1.0 H	Dual
2N5517	N	J			0.5	7.5	0.25	40	GSS	1000	4000	25	2.0	1.0 H	Dual
2N5518	N	J			0.5	7.5	0.25	40	GSS	1000	4000	25	2.0	1.0 H	Dual
2N5519	N	J			0.5	7.5	0.25	40	GSS	1000	4000	25	2.0	1.0 H	Dual
2N5520	N	J			0.5	7.5	0.25	40	GSS	1000	4000	25	1.0	1.0 H	Dual
2N5521	N	J			0.5	7.5	0.25	40	GSS	1000	4000	25	1.0	1.0 H	Dual
2N5522	N	J			0.5	7.5	0.25	40	GSS	1000	4000	25	1.0	1.0 H	Dual
2N5523	N	J			0.5	7.5	0.25	40	GSS	1000	4000	25	1.0	1.0 H	Dual
2N5524	N	J			0.5	7.5	0.25	40	GSS	1000	4000	25	1.0	1.0 H	Dual
2N5543	N	J			2.0	10	1000			750	3000	10			
2N5544	N	J			2.0	10	1000			750	3000	10			
2N5545	N	J			0.5	8.0	0.1			1500	6000	6.0	3.5	10 H	Dual
2N5546	N	J			0.5	8.0	0.1			1500	6000	6.0	5.0	10 H	Dual
2N5547	N	J			0.5	8.0	0.1			1500	6000	6.0			Dual
2N5548	P	M				10*	0.05			3500	6500	10			
2N5549	N	J			10	60	0.25	40	GSS	6000	15000	8.0			
2N5555	N	J		2N5555	15		1.0	25	GSS			5.0			
2N5556	N	J		2N5556	0.5	2.5	0.1	30	GSS	1500	6500	6.0	1.0	10 H	
2N5557	N	J		2N5556	2.0	5.0	0.1	30	GSS	1500	6500	6.0	1.0	10 H	
2N5558	N	J		2N5556	4.0	10	0.1	30	GSS	1500	6500	6.0	1.0	10 H	
2N5561	N	J			1.0	10	0.1	50	GSS			7.0	1.0	10 H	MP
2N5562	N	J			1.0	10	0.1	50	GSS			7.0	1.0	10 H	MP
2N5563	N	J			1.0	10	0.1	50	GSS			7.0	1.0	10 H	MP
2N5564	N	J			5.0	30	0.1	40	GSS			12	1.0	10 H	MP
2N5565	N	J			5.0	30	0.1	40	GSS			12	1.0	10 H	MP
2N5566	N	J			5.0	30	0.1	40	GSS			12	1.0	10 H	MP
2N5592	N	J		2N5592	1.0	10	0.25	50	GSS			20	2.6	10 H	
2N5593	N	J		2N5592	1.0	10	0.25	50	GSS			20	6.0	10 H	
2N5594	N	J		2N5592	1.0	10	0.25	50	GSS			20	10	10 H	
2N5638	N	J				50	1.0	30	GSS				10		
2N5639	N	J				25	1.0	30	GSS				10		
2N5640	N	J				5.0	1.0	30	GSS				10		
2N5647	N	J			0.3	0.6	0.01	50	GSS			3.0	1.0	1.0 K	
2N5648	N	J			0.5	1.0	0.01	50	GSS			3.0	1.0	1.0 K	
2N5649	N	J			0.8	1.6	0.01	50	GSS			3.0	1.0	1.0 K	
2N5653	N	J			40		1.0	30	GSS			10	2.5		
2N5654	N	J			15		1.0	30	GSS			10	2.5		
2N5668	N	J		2N5668	1.0	5.0	2.0	25	GSS			7.0	2.5	100 M	
2N5669	N	J		2N5668	4.0	10	2.0	25	GSS			7.0	2.5	100 M	
2N5670	N	J		2N5669	8.0	20	2.0	25	GSS			7.0	2.5	100 M	
2N5797	P	J			0.02	0.10	3.0	40	GSS	60*	225*	5.0			MP
2N5798	P	J			0.08	0.40	3.0	40	GSS	100*	440*	5.0			MP
2N5799	P	J			0.25	1.00	3.0	40	GSS	160*	500*	5.0			MP
2N5800	P	J			0.70	2.00	3.0	40	GSS	250*	700*	5.0			MP
2N5801	N	J			2.0	15	0.1	-40	GSS			15	1.0	100 H	MP
2N5802	N	J			10	40	0.1	-40	GSS			15	1.0	100 H	MP
2N5803	N	J			30	80	0.1	-40	GSS			15	1.0	100 H	MP
2N5902	N	J			0.03	0.5	0.005	-40	GSS	70	250	3.0	3.0	100 H	MP
2N5903	N	J			0.03	0.5	0.005	-40	GSS	70	250	3.0	3.0	100 H	MP
2N5904	N	J			0.03	0.5	0.005	-40	GSS	70	250	3.0	3.0	100 H	MP
2N5905	N	J			0.03	0.5	0.005	-40	GSS	70	250	3.0	3.0	100 H	MP
2N5906	N	J			0.03	0.5	0.002	-40	GSS	70	250	3.0	1.0	100 H	MP
2N5907	N	J			0.03	0.5	0.002	-40	GSS	70	250	3.0	1.0	100 H	MP
2N5908	N	J			0.03	0.5	0.002	-40	GSS	70	250	3.0	1.0	100 H	MP
2N5909	N	J			0.03	0.5	0.002	-40	GSS	70	250	3.0	1.0	100 H	
2N5949	N	M			12	18	-1.0	30	GSS	3.0	7.5	6.0	2.0	1.0 K	
2N5950	N	M			10	15	-1.0	30	GSS	3.0	7.5	6.0	2.0	1.0 K	
2N5951	N	M			7.0	13	-1.0	30	GSS	3.0	6.5	6.0	2.0	1.0 K	
2N5952	N	M			4.0	8.0	-1.0	30	GSS	1.0	6.5	6.0	2.0	1.0 K	
2N5953	N	M			2.5	5.0	-1.0	30	GSS	1.0	6.5	6.0	2.0	1.0 K	

TYPE	POLARITY	CONST.	NEAREST EQUIVALENT	REF.	I_{DSS}		I_{GSS} I_{DGO}*	Breakdown Voltage		y_{fs}		C_{ISS}	NF @ f		NOTE
					Min mA	Max mA	nA	$V_{(BR)}$ Volts	Sub-script	Min μmhos	Max μmhos	pF	dB / $\frac{\mu V^*}{\sqrt{Hz}}$	Units	
					*nA					*mmhos					
3N89	P	J			0.5	2.5	5.0	30		450	1300	3.0			
3N96	P	J			0.5	2.5	5.0	30		450	1300	4.0			Dual
3N97	P	J			0.5	2.5	5.0	30		450	1300	4.0			Dual
3N98	N	M	MFE3004-5	MFE3004	3.5	7.7	0.05	32		1000	3000	7.0			
3N99	N	M	MFE3004-5	MFE3004	5.0	10.5	0.05	32		1000	4500	7.0			
3N124	N	J		3N124	0.2	2.0	0.25	50	GSS	500	2000	14	4.0	1.0 K	
3N125	N	J		3N124	1.5	4.5	0.25	50	GSS	800	2400	14	4.0	1.0 K	
3N126	N	J		3N124	3.0	9.0	0.25	50	GSS	1200	3600	14	4.0	1.0 K	
3N128	N	M	MFE3004-5	MFE3004	5.0	25	0.05			5000	12000	7.0	5.0	200 M	
3N138	N	M	MFE3004-5	MFE3004			0.010	45	GD			5.0			
3N139	N	M	MFE3004-5	MFE3004	5.0	25	1.0	45	GD	3000	7500	7.0			
3N140	N	M		3N140	5.0	30	1.0	20	DS			7.0	4.5	200 M	
3N141	N	M	MFE3006-7	MFE3006	5.0	30	1.0	20	DS			7.0			
3N142	N	M	MFE3004-5	MFE3004	5.0	50	5.0	20	DS			10			
3N143	N	M	MFE3004-5	MFE3004	10	50	1.0					7.0			
3N145	P	M	2N4352	2N4352				30	DB						
3N146	P	M	3N157A	3N157				30	DB						
3N147	P	M						30	DB						
3N148	P	M						30	DB						
3N149	P	M	3N157A-8A	3N157				30	DB						
3N150	P	M	3N157A-8A	3N157				30	DB						
3N151	P	M			-5.0*							12	10	100 H	
3N152	N	M	MFE3004-5	MFE3004	5.0	30	1.0						3.5	200 M	
3N153	N	M	MFE3004-5	MFE3004			0.05					8.0			
3N154	N	M	MFE3004-5	MFE3004	10	25	0.05						5.0	200 M	
3N155	P	M		3N155		1.0	1.0	35	DSS	1000	4000	5.0			
3N155A	P	M		3N155		0.25	1.0	35	DSS	1000	4000	5.0			
3N156	P	M		3N155		1.0	1.0	35	DSS	1000	4000	5.0			
3N156A	P	M		3N155		0.25	1.0	35	DSS	1000	4000	5.0			
3N157	P	M		3N157		1.0	0.010	35	DSS	1000	4000	5.0			
3N157A	P	M		3N157		0.25	0.010	50	DSS	1000	4000	5.0			
3N158	P	M		3N157		1.0	0.010	35	DSS	1000	4000	5.0			
3N158A	P	M		3N157		0.25	0.010	50	DSS	1000	4000	5.0			
3N159	N	M			5.0	30	1.0			7000	18000	7.0	3.5	200 M	
3N160	P					10*	0.01			3500	6500	10			
3N161	P					10*				3500	6500	10			
3N162	P	M	MFE3003			150*						20			
3N163	P	M				0.2*	0.01					2.5			
3N164	P	M				0.4*	0.01					2.5			
3N165	P	M				0.2*	0.01					3.0			
3N166	P	M				0.2*	0.01					3.0			
3N167	P	M				-0.5*						35			
3N168	P	M				-1.0*						35			
3N169	N	M	3N169			10*						5.0			
3N170	N	M	3N169			10*						5.0			
3N171	N	M	3N169			10*						5.0			
3N172	P	M				0.4*						3.5			
3N173	P	M				10*						3.5			
3N174	P	M				5.0*	0.0025					4.0			
3N175	N	M				5.0*	0.2					5.0			
3N176	N	M				10*	0.2					5.0			
3N177	N	M				25*	0.2					7.0			
3N178	P	M				0.5*	0.2					3.5			
3N179	P	M				1.0*						4.5			
3N180	P	M				1.0*						5.0			
3N181	P	M				0.5*						25			
3N182	P	M				2.5*						25			
3N183	P	M				10*						30			
3N184	P	M				2.0*						9.0			
3N185	P	M				5.0*						10			
3N186	P	M				10*						11			
3N188	P	M				0.2*						4.5			
3N189	P	M				0.2*						4.5			
3N190	P	M				0.2*	0.01					4.5			
3N191	P	M				0.2*	0.01					4.5			

REFERENCE AMPLIFIERS

INDEX AND SHORT-FORM SPECIFICATIONS

This table contains a numerical listing and short-form specifications for reference amplifiers with EIA-registered 3N numbers. In addition, short-form specifications are also provided for special house numbered reference amplifiers.

KEY

TYPE	REF.	V_{REF} (volts)	Tol ±%	$\triangle V_{REF}$ (volts) / *TC (%/°C)	I_{ZT} (mA)	Z_{ZT} (ohms)	T_1 °C	T_2 °C
Numerical Listing of Registered Type Numbers		Nominal Reference Voltage	Tolerance of Nominal Reference Voltage				Temperature Range over which $\triangle V_{REF}$ is specified	
Reference device number indicates specific Data Sheet on which device is characterized.							*Maximum Operating Temperature	
Maximum Voltage Variation over the Temperature Range from T_1 to T_2						Maximum Zener Impedance		
*Temperature Coefficient $\frac{\triangle V_1 \ 100}{V \ (T_2 - T_1)}$					Zener Test Current			

TYPE	REF.	V_{REF} (volts)	Tol ±%	$\triangle V_{REF}$ (volts) / *TC (%/°C)	I_{ZT} (mA)	Z_{ZT} (ohms)	T_1 °C	T_2 °C
3N39		9.0	9.0	0.005*	5.0			71*
3N40		9.0	9.0	0.003*	5.0			71*
3N41		9.0	9.0	0.002*	5.0			71*
3N42		9.0	9.0	0.005*	5.0			100*
3N43		9.0	9.0	0.003*	5.0			100*
3N44		9.0	9.0	0.002*	5.0			100*
3N44A		9.0	10	0.001*	5.0			150*
MCA1911	MCA1911	6.8	10	0.051	5.0	40	0	75
MCA1912	MCA1911	6.8	10	0.025	5.0	40	0	75
MCA1913	MCA1911	6.8	10	0.010	5.0	40	0	75
MCA1914	MCA1911	6.8	10	0.005	5.0	40	0	75
MCA1921	MCA1911	6.8	5.0	0.105	5.0	40	-55	100
MCA1922	MCA1911	6.8	5.0	0.052	5.0	40	-55	100
MCA1923	MCA1911	6.8	5.0	0.020	5.0	40	-55	100
MCA1924	MCA1911	6.8	5.0	0.010	5.0	40	-55	100
MCA1931	MCA1911	6.8	5.0	0.139	5.0	40	-55	150
MCA1932	MCA1911	6.8	5.0	0.069	5.0	40	-55	150
MCA1933	MCA1911	6.8	5.0	0.026	5.0	40	-55	150
MCA1934	MCA1911	6.8	5.0	0.013	5.0	40	-55	150
MCA2011	MCA1911	8.6	10	0.060	5.0	40	0	75
MCA2012	MCA1911	8.6	10	0.030	5.0	40	0	75
MCA2013	MCA1911	8.6	10	0.012	5.0	40	0	75
MCA2014	MCA1911	8.6	10	0.006	5.0	40	0	75
MCA2021	MCA1911	8.6	5.0	0.124	5.0	40	-55	100
MCA2022	MCA1911	8.6	5.0	0.062	5.0	40	-55	100
MCA2023	MCA1911	8.6	5.0	0.024	5.0	40	-55	100
MCA2024	MCA1911	8.6	5.0	0.012	5.0	40	-55	100
MCA2031	MCA1911	8.6	5.0	0.164	5.0	40	-55	150
MCA2032	MCA1911	8.6	5.0	0.082	5.0	40	-55	150
MCA2033	MCA1911	8.6	5.0	0.032	5.0	40	-55	150
MCA2034	MCA1911	8.6	5.0	0.016	5.0	40	-55	150
MCA2111	MCA1911	9.5	10	0.071	5.0	40	0	75
MCA2112	MCA1911	9.5	10	0.035	5.0	40	0	75
MCA2113	MCA1911	9.5	10	0.014	5.0	40	0	75
MCA2114	MCA1911	9.5	10	0.007	5.0	40	0	75
MCA2121	MCA1911	9.5	5.0	0.147	5.0	40	-55	100
MCA2122	MCA1911	9.5	5.0	0.073	5.0	40	-55	100
MCA2123	MCA1911	9.5	5.0	0.028	5.0	40	-55	100
MCA2124	MCA1911	9.5	5.0	0.014	5.0	40	-55	100
MCA2131	MCA1911	9.5	5.0	0.194	5.0	40	-55	150
MCA2132	MCA1911	9.5	5.0	0.097	5.0	40	-55	150
MCA2133	MCA1911	9.5	5.0	0.038	5.0	40	-55	150
MCA2134	MCA1911	9.5	5.0	0.019	5.0	40	-55	150
MCA2211	MCA1911	11.0	10	0.082	5.0	40	0	75
MCA2212	MCA1911	11.0	10	0.041	5.0	40	0	75
MCA2213	MCA1911	11.0	10	0.016	5.0	40	0	75
MCA2214	MCA1911	11.0	10	0.008	5.0	40	0	75
MCA2221	MCA1911	11.0	5.0	0.170	5.0	40	-55	100
MCA2222	MCA1911	11.0	5.0	0.085	5.0	40	-55	100
MCA2223	MCA1911	11.0	5.0	0.034	5.0	40	-55	100
MCA2224	MCA1911	11.0	5.0	0.017	5.0	40	-55	100
MCA2231	MCA1911	11.0	5.0	0.225	5.0	40	-55	150
MCA2232	MCA1911	11.0	5.0	0.112	5.0	40	-55	150
MCA2233	MCA1911	11.0	5.0	0.044	5.0	40	-55	150
MCA2234	MCA1911	11.0	5.0	0.022	5.0	40	-55	150

UNIJUNCTION TRANSISTORS

This table contains a numerical listing and short-form specifications for unijunction transistors with EIA-registered 2N numbers.

KEY

P_D = Power Dissipation @ 25°C
R_{BB} = Interbase Resistance
η = Intrinsic Standoff Ratio
$I_{V(min)}$ = Minimum Valley Current
$I_{P(max)}$ = Maximum Peak Point Current
I_{EO} = Maximum Emitter Reverse Current at Indicated V_{B2E}
$V_{EB1(sat)}$ = Emitter Saturation Voltage @ I_E = 50 mA, V_{BB} = 10 V

TYPE	REPLACEMENT	REF.	P_D (mW)	R_{BB} (kΩ)	η	I_V(min) (mA)	I_P(max) (μA)	I_{EO} @ V_{B2E} (μA @ V max)	$V_{EB1(SAT)}$ I_E @ 50 mA)
2N489			450	6.8	0.62	8.0	20	12 @ 60	5.0
2N489A			450	6.8	0.62	8.0	15	12 @ 60	4.0
2N489B			450	6.8	0.62	8.0	6.0	0.2 @ 60	4.0
2N490			450	9.1	0.62	8.0	20	12 @ 60	5.0
2N490A			450	9.1	0.62	8.0	15	12 @ 60	4.0
2N490B			450	9.1	0.62	8.0	6.0	0.2 @ 60	4.0
2N490C			450	9.1	0.51				
2N491			450	6.8	0.68	8.0	20	12 @ 60	5.0
2N491A			450	6.8	0.68	8.0	15	12 @ 60	4.3
2N491B			450	6.8	0.68	8.0	6.0	0.2 @ 60	4.3
2N492			450	9.1	0.68	8.0	20	12 @ 60	5.0
2N492A			450	9.1	0.68	8.0	15	12 @ 60	4.3
2N492B			450	9.1	0.68	8.0	6.0	0.2 @ 60	4.3
2N492C			450	9.1	0.56				
2N493			450	6.8	0.75	8.0	20	12 @ 60	5.0
2N493A			450	6.8	0.75	8.0	15		
2N493B			450	6.8	0.75	8.0	6.0	0.2 @ 60	5.0
2N494			450	9.1	0.75	8.0	20	12 @ 60	5.0
2N494A			450	9.1	0.75	8.0	15	12 @ 60	4.6
2N494B			450	9.1	0.75	8.0	6.0	0.2 @ 60	4.6
2N494C			450	9.1	0.62	8.0	2.0	0.02 @ 60	4.6
2N1671			450	9.1	0.62	8.0	25	12 @ 30	5.0
2N1671A			450	9.1	0.62	8.0	25	12 @ 30	5.0
2N1671B			450	9.1	0.62	8.0	6.0	0.2 @ 30	5.0
2N1671C			450	4.1 -9.1					
2N2160			450	4.0 -12	0.47 -0.80	8.0	25	12 @ 30	
2N2417			390	0.68	0.62	8.0	20	12 @ 60	5.0
2N2417A			390	0.68	0.62	8.0	20	12 @ 60	4.0
2N2417B			300	6.8	0.51 -0.62	8.0	6.0	0.2 @ 30	4.0
2N2418			390	0.68	0.62	8.0	20	12 @ 60	5.0
2N2418A			390	9.1	0.62	8.0	20	12 @ 60	4.0
2N2418B			300	9.1	0.51 - 0.62	8.0	6.0	0.2 @ 60	4.0
2N2419			390	4.7 -6.8	0.68	8.0	20	12 @ 60	5.0
2N2419A			390	6.8	0.68	8.0	20	12 @ 60	4.3
2N2419B			300	6.8	0.56 -0.68	8.0	6.0	0.2 @ 30	4.3
2N2420			390	9.1	0.68	8.0	20	12 @ 60	5.0
2N2420A			390	9.1	0.68	8.0	20	12 @ 60	4.3
2N2420B			300	9.1	0.56 -0.68	8.0	6.0	0.2 @ 30	4.3
2N2421			390	6.8	0.75	8.0	20	12 @ 60	5.0
2N2421A			390	6.8	0.75	8.0	20	12 @ 60	4.6
2N2421B			300	6.8	0.62 -0.75	0.2	6.0	0.2 @ 30	4.6
2N2422			390	9.1	0.75	8.0	20	12 @ 60	5.0
2N2422A			390	9.1	0.75	8.0	20	12 @ 60	4.6
2N2422B			300	9.1	0.62 -0.75	8.0	6.0	0.2 @ 30	
2N2646		2N2646	300	4.7 (min)	0.56	4.0	25	12 @ 30	2.0
2N2647		2N2646	300	4.7 (min)	0.68	8.0	2.0	0.2 @ 30	2.0
2N2840			300	4.7 -9.1	0.4 -0.85	0.70	10	1.0 @ 30	
2N3406			450			8.0			
2N3479			400	4.7 -9.1	0.47 -0.62	6.0	20	12 @ 30	5.0
2N3480			400	9.1	0.75	4.0	15	12 @ 30	5.0
2N3481			400	9.1	0.85	6.0	15	12 @ 30	5.0
2N3482			400	4.7 -6.8	0.51 -0.62	8.0	2.0	0.02 @ 30	5.0
2N3483			400	9.1	0.72	8.0	2.0	1.0 @ 30	5.0
2N3484			400	9.1	0.85	8.0	2.0	0.2 @ 30	5.0
2N3679			250	9.1	0.80	4.2			
2N3980		2N3980	360	8.0					
2N4851		2N4851	300	4.7 (min)	0.56 (min)	2.0	2.0	0.1 @ 30	2.5
2N4852		2N4851	300	4.7 (min)	0.70 (min)	4.0	2.0	0.1 @ 30	2.5
2N4853		2N4851	300	4.7 (min)	0.70 (min)	6.0	0.4	0.05 @ 30	2.5
2N4870		2N4870	300	4.0 (min)	0.56 (min)	2.0	5.0	0.05 @ 30	2.5
2N4871		2N4870	300	4.0 (min)	0.70 (min)	4.0	5.0	0.05 @ 30	2.5
2N4891	MU4891	MU4891	300	4.0 (min)	0.55 (min)	2.0	5.0	0.01 @ 30	4.0
2N4892	MU4892	MU4891	300	4.0 (min)	0.51 (min)	4.0	2.0	0.01 @ 30	4.0
2N4893	MU4893	MU4891	300	4.0 (min)	0.55 (min)	2.0	2.0	0.01 @ 30	4.0
2N4894	MU4894	MU4891	300	4.0 (min)	0.74 (min)	2.0	1.0	0.01 @ 30	4.0
2N4947			360	4.0 -9.1	0.51 -0.69	4.0	2.0	0.01 @ 30	2.5
2N4948		2N4948	360	4.0 (min)	0.55 (min)	2.0	2.0	0.01 @ 30	2.5
2N4949		2N4948	360	4.0 (min)	0.74 (min)	2.0	1.0	0.01 @ 30	2.5
2N5431		2N5431	360	6.0 -8.5	0.72 -0.80	2.0	4.0		3.0

ALPHABETICAL INDEX of NON-REGISTERED TYPE NUMBERS

The following index lists all of the non-registered device types characterized in this book in alphabetical sequence. The data sheets in this book are arranged in alphanumerical sequence (registered device types) and in alphabetical sequence (non-registered device types). The key to proper identification of these non-registered devices is listed below.

KEY

Type	Device Identification	Reference
Non-registered device types		
C-REG	Diode, Current Regulator	
D-3L	Diode, 3 Layer	
D-4L	Diode, 4 Layer	
DIAC	Silicon Bilateral Trigger	
MD	Multiple Device	
PH	Photo Device	
PIN	Microwave Pin Switching Diodes	
PR. REF	Diode, Precision Reference	
PUT	Programmable Unijunction Transistors	
RECT	Rectifier	
RECT-A	Rectifier Assemblies	
REF	Diode, Reference	
RHC	Rectifier Hot Carrier	
SBS	Silicon Bidirectional Switch	
SCR	Silicon Controlled Rectifier	
SUP	Diode, Transient Suppressor	
T(BP)	Transistor, Bi-Polar	
T(FE)	Transistor, Field Effect	
T(QD)	Transistor, Quad	
TRIAC	Silicon Bidirectional Thyristors	
T(UJ)	Transistor, Unijunction	
VAR-M	Varactor, Multiplier	
VAR-T	Varactor, Tuning	
ZD	Zener Diode	

Reference device number indicates specific Data Sheet on which device is characterized.

ALPHABETICAL INDEX OF NON-REGISTERED TYPE NUMBERS

This table lists non-registered device types characterized in this book in alphabetical sequence.

TYPE	DEVICE IDENT.	REFERENCE
¼M2.4AZ thru ¼M200Z	ZD	¼M2.4AZ
.4M.64FR10	REF	1N816
.4M1.36FR5	REF	1N816
.4M1.36FR2	REF	1N816
.4M2.04FR5	REF	1N816
.4M2.04FR2	REF	1N816
1N110ZS thru 1M200ZS	ZD	1N4728
AF139	T(BP)	AF139
AF239	T(BP)	AF239
MA100	T(BP)	MA100
MA112 thru MA117	T(BP)	MA112
MA200 thru MA206	T(BP)	MA200
MA286 thru MA288	T(BP)	MA286
MA881 thru MA889	T(BP)	MA881
MA909	T(BP)	MA909
MA910	T(BP)	MA909
MA1702 thru MA1708	T(BP)	MA1702
MAC1 thru MAC3	TRIAC	MAC1
MAC35-1 thru MAC35-7	TRIAC	MAC35-1
MAC36-1 thru MAC36-7	TRAIC	MAC35-1
MAC37-1 thru MAC37-7	TRIAC	MAC37-1
MAC38-1 thru MAC38-7	TRIAC	MAC37-1
MBD101	HCD	MBD101
MBD501	HCD	MBD501
MBD701	HCD	MBD501
MBD5500A	RHC	MBD5500A
MBS4991	SBS	MBS4991
MBS4992	SBS	MBS4991
MCxxxx See Integrated Circuits Section		
MCA1911N,P thru MCA1914N,P	REF	MCA11911N,P
MCA1921N,P thru MCA1924N,P	REF	MCA1911N,P
MCA1931N,P thru MCA1934N,P	REF	MCA1911N,P
MCA2011N,P thru MCA2014N,P	REF	MCA1911N,P
MCA2021N,P thru MCA2024N,P	REF	MCA1911N,P
MCA2031N,P thru MCA2034N,P	REF	MCA1911N,P
MCA2111N,P thru MCA2114N,P	REF	MCA1911N,P
MCA2121N,P thru MCA2124N,P	REF	MCA1911N,P
MCA2131N,P thru MCA2134N,P	REF	MCA1911N,P
MCA2211N,P thru MCA2214N,P	REF	MCA1911N,P
MCA2221N,P thru MCA2224N,P	REF	MCA1911N,P
MCA2231N,P thru MCA2234N,P	REF	MCA1911N,P
MCHxxxx See Microcircuit Components and Integrated Circuits Section, see pages 8-1 and 9-1.		
MCL1300 thru MCL1304	C-REG	MCL1300
MCR101 thru MCR104	SCR	MCR101

ALPHABETICAL INDEX OF NON-REGISTERED TYPE NUMBERS (continued)

TYPE	DEVICE IDENT.	REFERENCE
MCR115	SCR	MCR115
MCR120	SCR	MCR115
MCR406-1 thru MCR406-4	SCR	MCR406-1
MCR407-1 thru MCR407-4	SCR	MCR407-1
MCR649-1 thru MCR649-7	SCR	MCR649-1
MCR729-5 thru MCR729-10	SCR	MCR729-5
MCR846-1 thru MCR846-4	SCR	MCR846
MCR1336-5 thru MCR1336-10	SCR	MCR1336-5
MCR1718-5 thru MCR1718-8	SCR	MCR1718-5
MCR1906-1 thru MCR1906-4	SCR	MCR1906-1
MCR1907-1 thru MCR1907-6	SCR	MCR1907-1
MCR2315-1 thru MCR2315-6	SCR	MCR2315
MCR2604-1 thru MCR2604-8	SCR	2N4151
MCR2605-1 thru MCR2605-8	SCR	2N4151
MCR2614L-1 thru MCR2614L-6	SCR	MCR2315
MCR3818-1 thru MCR3818-8	SCR	MCR3818-1
MCR3835-1 thru MCR3835-8	SCR	MCR3818-1
MCR3918-1 thru MCR3918-8	SCR	MCR3918-1
MCR3935-1 thru MCR3935-8	SCR	MCR3918-1
MD708,A,AF,B,BF,F	MD	MD708
MD918,A,AF,B,BF,F	MD	MD918
MD984	MD	MD984
MD986,F	MD	MD986
MD1120,F	MD	MD1120
MD1121,F	MD	MD1120
MD1122,F	MD	MD1120
MD1126	MD	MD1126
MD1127	MD	MD1126
MD1128	MD	MD1128
MD1129,F	MD	MD1129
MD1130,F	MD	MD1130
MD1131,F	MD	MD1131
MD1132,F	MD	MD1132
MD1134	MD	MD1134
MD2218,A,AF,F	MD	MD2218
MD2219,A,AF,F	MD	MD2218
MD2369,A,AF,B,BF,F	MD	MD2369
MD2904,A,AF,F	MD	MD2904
MD2905,A,AF,F	MD	MD2904
MD3133,F	MD	MD3133
MD3134,F	MD	MD3133
MD3250,A,AF,F	MD	MD3250
MD3251,A,AF,F	MD	MD3250
MD3467,F	MD	MD3468
MD3725,F	MD	MD3725
MD3762,F	MD	MD3762
MD4957	MD	MD4957
MD5000,A,B	MD	MD5000
MD6001	MD	MD6001
MD6002	MD	MD6001
MD6003	MD	MD6003
MD6003F	MD	MD6003
MD6100	MD	MD6100
MDA920-1 thru MDA920-7	RECT-A	MD920
MDA922-1 thru MDA922-9	RECT-A	MDA920
MDA930-1 thru MDA930-7	RECT-A	MDA920
MDA940-1 thru MDA940-7	RECT-A	MDA920
MDA942-1 thru MDA942-6	RECT-A	MDA942

ALPHABETICAL INDEX OF NON-REGISTERED TYPE NUMBERS (continued)

MDA950-1 – MJ3772

TYPE	DEVICE IDENT.	REFERENCE
MDA950-1 thru MDA950-7	RECT-A	MDA920
MDA952-1 thru MDA952-6	RECT-A	MDA942
MDA960-1 thru MDA960-3	RECT-A	MDA960
MDA962-1 thru MDA962-5	RECT-A	MDA942
MDA970-1 thru MDA970-3	RECT-A	MDA960
MDA972-1 thru MDA972-5	RECT-A	MDA942
MDA980-1 thru MDA980-6	RECT-A	MDA980-1
MDA990-1 thru MDA990-6	RECT-A	MDA980-1
MDA1330H thru MDA1333H	RECT-A	MDA1330H
MDA1491-1 thru MDA1491-6	RECT-A	MDA942
MDA1505-1 thru MDA1505-6	RECT-A	MDA942
MDA1591-1 thru MDA1591-6	RECT-A	MDA942
MF3304	T(BP)	MF3304
MFCxxxx	See Integrated Circuits Section	
MFE2000	T(FE)	MFE2000
MFE2001	T(FE)	MFE2000
MFE2004 thru MFE2006	T(FE)	MFE2004
MFE2007 thru MFE2009	T(FE)	MFE2007
MFE2010 thru MFE2012	T(FE)	MFE2010
MFE2093 thru MFE2095	T(FE)	MFE2093
MFE2133	T(FE)	MFE2133
MFE3001	T(FE)	MFE3001
MFE3002	T(FE)	MFE3002
MFE3003	T(FE)	MFE3003
MFE3004	T(FE)	MFE3004
MFE3005	T(FE)	MFE3004
MFE3006	T(FE)	MFE3006
MFE3007	T(FE)	MFE3006
MFE3008	T(FE)	MFE3006
MFE3020	T(FE)	MFE3020
MFE3021	T(FE)	MFE3020
MFE4007 thru MFE4012	T(FE)	MFE4007
MH745 MH746	See Hardware Section	
MJ400	T(BP)	MJ400
MJ413	T(BP)	MJ413
MJ420	T(BP)	MJ420
MJ421	T(BP)	MJ420
MJ423	T(BP)	MJ413
MJ431	T(BP)	MJ413
MJ450	T(BP)	MJ450
MJ480	T(BP)	MJ480
MJ481	T(BP)	MJ480
MJ490	T(BP)	MJ490
MJ491	T(BP)	MJ490
MJ500	T(BP)	MJ500
MJ501	T(BP)	MJ500
MJ802	T(BP)	MJ802
MJ900	T(BP)	MJ900
MJ901	T(BP)	MJ900
MJ1000	T(BP)	MJ900
MJ1001	T(BP)	MJ900
MJ1800	T(BP)	MJ1800
MJ2249	T(BP)	MJ2249
MJ2250	T(BP)	MJ2249
MJ2251	T(BP)	MJ2251
MJ2252	T(BP)	MJ2251
MJ2267	T(BP)	MJ2267
MJ2268	T(BP)	MJ2267
MJ2500	T(BP)	MJ2500
MJ2501	T(BP)	MJ2500
MJ2840	T(BP)	MJ2840
MJ2841	T(BP)	MJ2840
MJ2940	T(BP)	MJ2940
MJ2941	T(BP)	MJ2941
MJ3000	T(BP)	MJ2500
MJ3001	T(BP)	MJ2500
MJ3029	T(BP)	MJ3029
MJ3030	T(BP)	MJ3029
MJ3101	T(BP)	MJ2249
MJ3201	T(BP)	MJ3201
MJ3202	T(BP)	MJ3201
MJ3771	T(BP)	2N3771
MJ3772	T(BP)	2N3771

ALPHABETICAL INDEX OF NON-REGISTERED TYPE NUMBERS (continued)

TYPE	DEVICE IDENT.	REFERENCE
MJ3801	T(BP)	MJ3801
MJ3802	T(BP)	MJ3801
MJ4502	T(BP)	MJ4502
MJ6700	T(BP)	MJ6700
MJ6701	T(BP)	MJ6700
MJ7000	T(BP)	MJ7000
MJ7200	T(BP)	MJ7200
MJ7201	T(BP)	MJ7200
MJ8100	T(BP)	MJ8100
MJ8101	T(BP)	MJ8100
MJ8400	T(BP)	MJ8400
MJ9000	T(BP)	MJ9000
MJCxxxx	See Microcircuit Components Section	
MJE105	T(BP)	MJE105
MJE205	T(BP)	MJE205
MJE340	T(BP)	MJE340
MJE341	T(BP)	MJE341
MJE344	T(BP)	MJE341
MJE370	T(BP)	MJE370
MJE371	T(BP)	MJE371
MJE520	T(BP)	MJE520
MJE521	T(BP)	MJE521
MJE1090 thru MJE1093	T(BP)	MJE1090
MJE1100 thru MJE1103	T(BP)	MJE1090
MJE2801	T(BP)	MJE2801
MJE2901	T(BP)	MJE2901
MJE2955	T(BP)	MJE2955
MJE3055	T(BP)	MJE3055
MJE3439	T(BP)	MJE3439
MJE3440	T(BP)	MJE3439
MK10 MK15 MK20 MK25 MK30 MK35	See Hardware Section	
MLED600	PH	MLED600
MLED610	PH	MLED610
MM380	T(BP)	MM380
MM404	T(BP)	MM404
MM404A	T(BP)	MM404A
MM709	T(BP)	MM709
MM1139	T(BP)	MM1139
MM1500	T(BP)	MM1500
MM1501	T(BP)	MM1501
MM1552	T(BP)	MM1552
MM1553	T(BP)	MM1553
MM1619	T(BP)	MM1619
MM1620	T(BP)	MM1619
MM1748	T(BP)	MM1748
MM1803	T(BP)	2N3137
MM1812	T(BP)	MM1812

TYPE	DEVICE IDENT.	REFERENCE
MM1941	T(BP)	MM1941
MM2258 thru MM2260	T(BP)	MM2258
MM2483	T(BP)	MM2483
MM2484	T(BP)	MM2483
MM2894	T(BP)	MM2894
MM3000 thru MM3003	T(BP)	MM3000
MM3008	T(BP)	MM3008
MM3009	T(BP)	MM3008
MM3724	T(BP)	MM3724
MM3725	T(BP)	MM3724
MM3726	T(BP)	MM3726
MM3903	T(BP)	MM3903
MM3904	T(BP)	MM3903
MM3905	T(BP)	MM3905
MM3906	T(BP)	MM3905
MM4000 thru MM4003	T(BP)	MM4000
MM4018	T(BP)	MM4018
MM4019	T(BP)	MM4019
MM4020 thru MM4023	T(BP)	MM4020
MM4048	T(BP)	MM4048
MM4049	T(BP)	MM4049
MM4052	T(BP)	MM4052
MM4261H	T(BP)	MM4261H
MM4429	T(BP)	MM4429
MM4430	T(BP)	MM4430
MM4545 thru MM4547	T(BP)	MM4545
MM4645 thru MM4647	T(BP)	MM4545
MM5000 thru MM5002	T(BP)	MM5000
MM5005 thru MM5007	T(BP)	MM5005
MM8000	T(BP)	MM8000
MM8001	T(BP)	MM8000
MM8002	T(BP)	MM8002
MM8003	T(BP)	MM8003
MM8006	T(BP)	MM8006
MM8007	T(BP)	MM8006
MM8008	T(BP)	MM8008

ALPHABETICAL INDEX OF NON-REGISTERED TYPE NUMBERS (continued)

MM8009 – MPS3640

TYPE	DEVICE IDENT.	REFERENCE
MM8009	T(BP)	MM8009
MM8010	T(BP)	MM8008
MM8011	T(BP)	MM8008
MM8012	T(BP)	MM8012
MMCDxxxx	See Microcircuit Components Section	
MMCSxxxx	See Microcircuit Components Section	
MMD70	T(BP)	MMD70
MMD6050	T(BP)	MMD6050
MMD6100	T(BP)	MMD6050
MMD6150	T(BP)	MMD6050
MMD7000	T(BP)	MMD6050
MMD7001	T(BP)	MMD7001
MMF1 thru MMF6	T(FE)	MMF1
MMT70	T(BP)	MMT70
MMT71	T(BP)	MMT71
MMT72	T(BP)	MMT72
MMT73	T(BP)	MMT73
MMT74	T(BP)	MMT74
MMT75	T(BP)	MMT75
MMT76	T(BP)	MMT76
MMT918	T(BP)	MMT918
MMT930	T(BP)	MMT930
MMT2222	T(BP)	MMT2222
MMT2369	T(BP)	MMT2369
MMT2484	T(BP)	MMT930
MMT2857	T(BP)	MMT2857
MMT2907	T(BP)	MMT2907
MMT3014	T(BP)	MMT3014
MMT3546	T(BP)	MMT3546
MMT3798	T(BP)	MMT3798
MMT3799	T(BP)	MMT3798
MMT3823	T(BP)	MMT3823
MMT3903	T(BP)	MMT3903
MMT3904	T(BP)	MMT3903
MMT3905	T(BP)	MMT3905
MMT3906	T(BP)	MMT3905
MMT3960A	T(BP)	MMT3960A
MMT8015	T(BP)	MMT8015
MP110	T(BP)	MP110
MP110B	T(BP)	MP110B
MP500 thru MP502	T(BP)	MP500
MP504 thru MP506	T(BP)	MP500
MP525	T(BP)	MP525
MP600 thru MP603	T(BP)	MP600
MP800	T(BP)	MP800
MP801	T(BP)	MP800
MP900 thru MP902	T(BP)	MP900
MP1612,A,B	T(BP)	MP1612
MP1613	T(BP)	MP1613
MP2000A	T(BP)	MP2000A
MP2060 thru MP2063	T(BP)	MP2060
MP2100A	T(BP)	MP2000A
MP2200A	T(BP)	MP2000A
MP2300A	T(BP)	MP2000A
MP2400A	T(BP)	MP2000A
MP3730	T(BP)	MP3730
MP3731	T(BP)	MP3730
MP5692 thru MP5696	T(BP)	2N5692
MPF102	T(FE)	MPF102
MPF108	T(FE)	MPF108
MPF109	T(FE)	MPF109
MPF111	T(FE)	MPF111
MPF112	T(FE)	MPF112
MPF120	T(FE)	MPF120
MPF121	T(FE)	MPF120
MPF122	T(FE)	MPF120
MPF161	T(FE)	MPF161
MPN3202	PIN	MPN3202
MPN3208	PIN	MPN3208
MPN3209	PIN	MPN3208
MPQ3303	MD	MPQ3303
MPQ3725	MD	MPQ3725
MPS404,A	T(BP)	MPS404
MPS706,A	T(BP)	MPS706
MPS834	T(BP)	MPS834
MPS918	T(BP)	MPS918
MPS2369	T(BP)	MPS2369
MPS2711	T(BP)	MPS2711
MPS2712	T(BP)	MPS2711
MPS2713	T(BP)	MPS2713
MPS2714	T(BP)	MPS2713
MPS2923 thru MPS2925	T(BP)	MPS2923
MPS2926	T(BP)	MPS2926
MPS3392 thru MPS3395	T(BP)	MPS3392
MPS3563	T(BP)	MPS918
MPS3638,A	T(BP)	MPS3638
MPS3639	T(BP)	MPS3639
MPS3640	T(BP)	MPS3640

ALPHABETICAL INDEX OF NON-REGISTERED TYPE NUMBERS (continued)

TYPE	DEVICE IDENT.	REFERENCE
MPS3646	T(BP)	MPS3646
MPS3693	T(BP)	MPS3693
MPS3694	T(BP)	MPS3693
MPS3702	T(BP)	MPS3702
MPS3703	T(BP)	MPS3702
MPS3704 thru MPS3706	T(BP)	MPS3704
MPS3707 thru MPS3711	T(BP)	MPS3707
MPS3721	T(BP)	MPS3721
MPS5172	T(BP)	MPS5172
MPS6507	T(BP)	MPS6507
MPS6511	T(BP)	MPS6511
MPS6512 thru MPS6515	T(BP)	MPS6512
MPS6516 thru MPS6519	T(BP)	MPS6516
MPS6520 thru MPS6523	T(BP)	MPS6520
MPS6520	T(BP)	MPS6520
MPS6521	T(BP)	MPS6520
MPS6522	T(BP)	MPS6520
MPS6523	T(BP)	MPS6520
MPS6530 thru MPS6535	T(BP)	MPS6530
MPS6539	T(BP)	MPS6539
MPS6540	T(BP)	MPS6540
MPS6542	T(BP)	MPS6542
MPS6543	T(BP)	MPS6543
MPS6544	T(BP)	MPS6544
MPS6545	T(BP)	MPS6544
MPS6546	T(BP)	MPS6546
MPS6547	T(BP)	MPS6546
MPS6548	T(BP)	MPS6548
MPS6560 thru MPS6563	T(BP)	MPS6560
MPS6565	T(BP)	MPS6565
MPS6566	T(BP)	MPS6565
MPS6567	T(BP)	MPS6567
MPS6568 thru MPS6570	T(BP)	MPS6568

TYPE	DEVICE IDENT.	REFERENCE
MPS6571	T(BP)	MPS6571
MPS-A05	T(BP)	MPS-A05
MPS-A06	T(BP)	MPS-A05
MPS-A09	T(BP)	MPS-A09
MPS-A10	T(BP)	MPS-A10
MPS-A12	T(BP)	MPS-A12
MPS-A13	T(BP)	MPS-A13
MPS-A14	T(BP)	MPS-A14
MPS-A20	T(BP)	MPS-A20
MPS-A55	T(BP)	MPS-A55
MPS-A56	T(BP)	MPS-A55
MPS-A65	T(BP)	MPS-A65
MPS-A66	T(BP)	MPS-A65
MPS-A70	T(BP)	MPS-A70
MPS-H02	T(BP)	MPS-H02
MPS-H04	T(BP)	MPS-H04
MPS-H05	T(BP)	MPS-H05
MPS-H07	T(BP)	MPS-H07
MPS-H08	T(BP)	MPS-H07
MPS-H10	T(BP)	MPS-H10
MPS-H11	T(BP)	MPS-H10
MPS-H20	T(BP)	MPS-H20
MPS-H24	T(BP)	MPS-H24
MPS-H30	T(BP)	MPS-H30
MPS-H31	T(BP)	MPS-H30
MPS-H32	T(BP)	MPS-H32
MPS-H34	T(BP)	MPS-H34
MPS-H37	T(BP)	MPS-H37
MPS-H54	T(BP)	MPS-H54
MPS-H55	T(BP)	MPS-H55
MPS-K10 thru MPS-K12	T(BP)	MPS-A10
MPS-K20 thru MPS-K22	T(BP)	MPS-A20
MPS-K70 thru MPS-K72	T(BP)	MPS-A70
MPS-L01	T(BP)	MPS-L01
MPS-L07	T(BP)	MPS-L07
MPS-L08	T(BP)	MPS-L07
MPS-L51	T(BP)	MPS-L51
MPS-U01	T(BP)	MPS-U01
MPS-U02	T(BP)	MPS-U02
MPS-U03	T(BP)	MPS-U03
MPS-U04	T(BP)	MPS-U03
MPS-U05	T(BP)	MPS-U05
MPS-U06	T(BP)	MPS-U05
MPS-U10	T(BP)	MPS-U10
MPS-U51	T(BP)	MPS-U51
MPS-U52	T(BP)	MPS-U52
MPS-U55	T(BP)	MPS-U55
MPS-U56	T(BP)	MPS-U55
MPT20	DIAC	MPT20
MPT28	DIAC	MPT28
MPT32	DIAC	MPT28
MPZ5-16	SUP	MPZ5-16

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MPZ5-32 – MR1265

TYPE	DEVICE IDENT.	REFERENCE
MPZ5-32	SUP	MPZ5-16
MPZ5-180	SUP	MPZ5-16
MQ2218	T(QD)	MD2218
MQ2219	T(QD)	MD2219
MQ2904	T(QD)	MD2904
MQ2905	T(QD)	MD2905
MQ3467	T(QD)	MD3467
MQ3725	T(QD)	MD3725
MQ3762	T(QD)	MD3762
MQ3799,A	T(QD)	MD3799
MR322 thru MR328	RECT	1N3491
MR330	RECT	1N3491
MR331	RECT	1N3491
MR810 thru MR816	RECT	MR810
MR830 thru MR836	RECT	1N4933
MR840 thru MR842	RECT	MR810
MR844	RECT	MR810
MR846	RECT	MR810
MR880 thru MR882	RECT	MR810
MR884	RECT	MR810
MR886	RECT	MR810
MR890 thru MR892	RECT	MR810
MR894	RECT	MR810
MR896	RECT	MR810
MR990A thru MR996A	RECT	MR990A
MR1030 thru MR1036	RECT	1N4719
MR1038	RECT	1N4719
MR1040	RECT	1N4719
MR1120 thru MR1126	RECT	MR1120
MR1128	RECT	MR1120
MR1130	RECT	MR1120

TYPE	DEVICE IDENT.	REFERENCE
MR1200 thru MR1203	RECT	MR1200
MR1205	RECT	MR1200
MR1207 thru MR1209	RECT	MR1200
MR1210 thru MR1213	RECT	MR1210
MR1215	RECT	MR1210
MR1216	RECT	MR1210
MR1217 thru MR1219	RECT	MR1210
MR1220 thru MR1223	RECT	MR1220
MR1225	RECT	MR1220
MR1227 thru MR1229	RECT	MR1220
MR1230 thru MR1233	RECT	MR1230
MR1235	RECT	MR1230
MR1237 thru MR1239	RECT	MR1230
MR1240 thru MR1243	RECT	MR1240
MR1245	RECT	MR1240
MR1247 thru MR1249	RECT	MR1240
MR1260, thru MR1263	RECT	MR1260
MR1265	RECT	MR1260

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TYPE	DEVICE IDENT.	REFERENCE
MR1267 thru MR1269	RECT	MR1260
MR1290 thru MR1293	RECT	MR1290
MR1295	RECT	MR1290
MR1297 thru MR1299	RECT	MR1290
MR1337-1 thru MR1337-5	RECT	MR1337-1
MR1366	RECT	1N4933
MR1376	RECT	1N4933
MR1386	RECT	1N4933
MR1396	RECT	1N4933
MR1810 thru MR1819	RECT	MR1210
MR2080HA thru MR2084HA	RECT	MR2080HA
MR2100HA thru MR2104HA	RECT	MR2100HA
MR2266	RECT	MR2266
MR2271	RECT	MR2271
MR2272	RECT	MR2272
MR2273	RECT	MR2266
MRA130 thru MRA134	RECT-A	MRA130
MRA160 thru MRA164	RECT-A	MRA160
MRA330 thru MRA334	RECT-A	MRA330
MRA360 thru MRA364	RECT-A	MRA360
MRD100	PH	MRD100
MRD150	PH	MRD100
MRD200	PH	MRD200
MRD210	PH	MRD210
MRD250	PH	MRD250
MRD300	PH	MRD300
MRD310	PH	MRD310
MRD450	PH	MRD450
MRD500	PH	MRD500
MRD501	PH	MRD500
MRD600	PH	MRD600
MS10 thru MS15	See Hardware Section	
MSD6100	MD	MSD6100
MSD6101	MD	MSD6100
MSD6102	MD	MSD6102
MSD6150	MD	MSD6150
MU851 thru MU853	T(UJ)	MU851
MU4891 thru MU4894	T(UJ)	MU4891
MUS4987	SUS	MUS4987
MUS4988	SUS	MUS4987
MV830 thru MV840	VAR-T	MV830
MV1401 thru MV1405	VAR-T	MV1401
MV1620 thru MV1650	VAR-T	MV1620
MV1652 thru MV1666	VAR-T	MV1652
MV1804	VAR-M	1N4387
MV1805C	VAR-M	MV1805C
MV1806	VAR-M	1N4388
MV1806C	VAR-M	1N5149
MV1807C1	VAR-M	1N5150A
MV1808A,B,C	VAR-M	1N5151
MV1808B1,C1	VAR-M	1N5150A
MV1809C,C1	VAR-M	MV1809C
MV1810A,B	VAR-M	1N5154
MV1810B1	VAR-M	1N5150A
MV1812A,B	VAR-M	1N5156
MV1816A,A1,B,B1	VAR-M	MV1816A
MV1817A,A1,B,B1	VAR-M	MV1817A
MV1858D	VAR-T	MV1858D
MV1860D	VAR-T	MV1858D
MV1862 thru MV1866	VAR-T	MV1858D
MV1868	VAR-T	MV1858D
MV1870	VAR-T	MV1858D
MV2101 thru MV2115	VAR-T	MV2101

ALPHABETICAL INDEX OF NON-REGISTERED TYPE NUMBERS (continued)

MV2201 – XC177

TYPE	DEVICE IDENT.	REFERENCE
MV2201	VAR-T	MV2201
MV2203	VAR-T	MV2201
MV2205	VAR-T	MV2201
MV2209	VAR-T	MV2201
MZ92-2.4 thru MZ92-200	ZD	MZ92-2.4
MZ500-1 thru MZ500-40	ZD	MZ500-1
MZ605	PR.REF	MZ600
MZ610	PR.REF	MZ600
MZ620	PR.REF	MZ600
MZ640	PR.REF	MZ600
MZ805	PR.REF	MZ600
MZ810	PR REF	MZ600
MZ820	PR.REF	MZ600
MZ840	PR.REF	MZ600
MZ1000-1 thru MZ1000-37	ZD	MZ1000-1
MZ4614 thru MZ4627	ZD	1N4099
MZC1.8B10 thru MZC200B10	See Microcircuit Components Section	
MZC2.4A10 thru MZC200A10	See Microcircuit Components Section	
M4L3052 thru M4L3056	D-4L	M4L3052
XC63 XC72 XC73	See Hardware Section	
XC157 XC170 XC177	See Integrated Circuits Section	

TYPE	DEVICE IDENT.	REFERENCE

SELECTOR GUIDES

(Including Glossary)

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GLOSSARY

There are many symbols and abbreviations used to classify the performance and characteristics of semiconductors. Often a particular symbol will have different meanings, depending on the product described. To aid the reader in the understanding of the data presented in this book, the following product-categorized glossary has been prepared. Standard terms that are common to all semiconductors or have obvious meanings have been omitted.

FET PARAMETERS

MAXIMUM RATINGS

V_{DS}	Drain-Source Voltage
V_{DG}	Drain-Gate Voltage
$V_{GS(r)}$	Reverse Gate-Source Voltage
I_D	Drain Current
$I_{G(f)}$	Forward Gate Current
P_D	Total Device Dissipation
T_J	Operating Junction Temperature
T_{stg}	Storage Temperature

ELECTRICAL CHARACTERISTICS

$V_{(BR)GSS}$	Gate-Source Breakdown Voltage with drain and source shorted at a given I_G.
$V_{GS(off)}$	Gate-Source Cutoff Voltage measured at a stated V_{DS} and I_D.
I_{GSS}	Gate Reverse Current specified at a given V_{GS} (usually 1/2 to 1 times $V_{(BR)GSS}$) with a $V_{DS} = 0$.
I_{DSS}	Zero-Gate Voltage Drain Current measured at a specific V_{DS} and $V_{GS} = 0$.
V_{GS}	Gate-Source Voltage at a given V_{DS} and I_D.
R_{GS}	Input Resistance at a stated V_{GS}.
$V_{GS(th)}$	Gate-Source Threshold Voltage. V_{DS} and I_D must be given.
$I_{D(on)}$	"ON" Drain Current at a specified V_{DS} and V_{GS}.
$\|y_{fs}\|$	Magnitude of the common-source forward transfer admittance measured at $V_{GS} = 0$ (unless otherwise specified) and at a given frequency.
$R_{e(y_{fs})}$	Common-Source forward transfer conductance measured at a given frequency with dc conditions the same as for I_{DSS}.
$\|y_{os}\|$	Output Admittance specified at a given V_{DS} and I_D or V_{GS}.
C_{iss}	Common-source input capacitance with output shorted at a given V_{DS}, V_{GS}, and frequency.
C_{rss}	Reverse Transfer Capacitance at a given V_{DS}, V_{GS}, and frequency with input shorted.
NF	Common-Source Noise Figure measured with specific V_{DS}, V_{GS} or I_D, R_G (generator resistance), frequency, and bandwidth.
e_n	Equivalent Short-Circuit Input Noise Voltage with given V_{DS}, V_{GS} or I_D, R_G, frequency and bandwidth.

OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_{CBO} Collector-Base Breakdown Voltage – The minimum dc breakdown voltage, collector to base, at stated collector current and ambient temperature. (Emitter open)

BV_{CEO} Collector-Emitter Breakdown Voltage – The minimum dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open)

BV_{ECO} Emitter-Collector Breakdown Voltage – The minimum dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open)

E Luminous Flux Density (Illuminance) [lumens/ft.^{2} = ft. candles] – The radiation flux density of wavelength within the band of visible light.

H Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.

I_{CEO} Collector Dark Current – The maximum current through the collector terminal of the device measured under dark conditions, ($H \approx 0$), with a stated collector voltage, load resistance, and ambient temperature. (Base open)

P_D Power Dissipation

S_{ICBO} Collector-Base Illumination Sensitivity (μA/lumen/ft.^{2} = μA/ft. candle) – The ratio of photo-induced collector-base current to the incident luminous energy measured at the plane of the lens of the photo device under stated conditions of luminous flux density (E), collector voltage, base load resistance, and ambient temperature. (Emitter open)

S_{ICEO} Collector-Emitter Illumination Sensitivity (μA/lumen/ft.^{2} = μA/ft. candle) – The ratio of photo-induced, collector-emitter current to the incident luminous energy measured at the plane of the lens of the photodevice under stated conditions of luminous flux density (E), collector voltage, load resistance, and ambient temperature. (Base open)

S_{RCBO} Collector-Base Radiation Sensitivity (μA/mW/cm^2) – The ratio of photo-induced collector-base current to the incident radiant energy measured at the plane of the lens of the photo device under stated conditions of radiation flux density (H), collector voltage, base load resistance, and ambient temperature. (Emitter open)

S_{RCEO} Collector-Emitter Radiation Sensitivity (mA/mW/cm^2) The ratio of photo-induced, collector-emitter current to the incident radiant energy measured at the plane of the lens of the photodevice under stated conditions of radiation flux density (H), collector voltage, load resistance, and ambient temperature. (Base open)

T_A Ambient Temperature

t_f Photo Current Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the GaAs (gallium-arsenide) source pulse under stated conditions of collector voltage, load resistance and ambient temperature.

$t_{f(sat)}$ Photo Current Saturated Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the saturating xenon light source pulse under stated conditions of collector voltage, load resistance, and ambient temperature.

T_J Junction Temperature

t_r Photo Current Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when pulsed with the stated GaAs (gallium-arsenide) source under stated conditions of collector voltage, load resistance, and ambient temperature.

$t_{r(sat)}$ Photo Current Saturated Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when driven into saturation by the stated xenon source under stated conditions of collector voltage, load resistance, and ambient temperature.

T_{stg} Storage Temperature

V_{CBO} Collector-Base Voltage – The maximum allowable value of the collector-base voltage which can be applied to the device at the rated temperature. (Base open)

V_{CEO} Collector-Emitter Voltage – The maximum allowable value of collector-emitter voltage which can be applied to the device at the rated temperature. (Base open)

(continued)

V_{ECO} Emitter-Collector Voltage The maximum allowable value of emitter-collector voltage which can be applied to the device at the rated temperature. (Base open)

θ Angular Alignment The axis of maximum sensitivity shall lie within a cone of this angle with reference to the central axis of the device.

$\lambda_S(\mu m)$ Wavelength of maximum sensitivity in micro meters.

EPICAP TUNING DIODES

MAXIMUM RATINGS

V_R Reverse Voltage

P_{in} RF Power Input

P_D Total Device Dissipation

ELECTRICAL CHARACTERISTICS

BV_R Reverse Breakdown Voltage measured at a given reverse current, I_R.

R_S Series resistance at a specified reverse voltage and frequency.

C_J Junction capacitance at a specified reverse voltage and frequency.

Q Figure of Merit capacitance at a specified reverse voltage and frequency.

η Efficiency at a given input power, input frequency, and output frequency.

C_T Diode Capacitance (Junction + Case Capacitance, C_C).

POWER VARACTORS

MAXIMUM RATINGS

V_R Reverse Voltage

I_F Forward Current

P_D Device Dissipation

ELECTRICAL CHARACTERISTICS

BV_R Reverse Breakdown Voltage at a specified reverse current, I_R.

I_R Reverse Voltage Leakage Current measured at a stated reverse voltage and ambient temperature.

L_S Series Inductance measured at a given frequency and lead length. L_S can be determined from the self-resonant frequency and C_J by the formula:

$$L_S = \frac{1}{\omega^2_{res} C_J}$$

C_J Junction Capacitance

C_C Case Capacitance

C_T Diode Capacitance is $(C_C + C_J)$

TR Tuning Ratio is the ratio of C_T measured at a low voltage divided by C_T at some voltage near BV_R. The voltages are specified by a subscript of C such as C4/C25.

TC_C Diode Capacitance Temperature coefficient.

Q Figure of Merit – calculated from G and C readings of an admittance bridge at a specified frequency:

$$Q = \frac{2\pi fC}{G}$$

ZENER DIODES

The devices listed in the following tables represent a basic profile of the largest inventoried Zener diode line in the industry. These diodes may be employed where a nearly constant dc output voltage is required despite relatively large changes in input voltage or load resistance. Motorola's devices represent state-of-the-art with the superior capability of silicon-oxide passivated junction for low leakage, sharp breakdowns and long-term stability.

Nominal Zener Voltage (NOTE 1, 6)	250 MILLIWATT Cathode = Polarity Mark CASE 51 INDUSTRIAL ±5% TOLERANCE LOW NOISE LOW LEVEL	400 MILLIWATT Cathode = Polarity Mark CASE 51 INDUSTRIAL (NOTE 2, 3)	500 MILLIWATT Cathode = Polarity Mark Surmetic 20 CASE 51 INDUSTRIAL (NOTE 5)	1 WATT Cathode = Polarity Mark Surmetic 30 CASE 59 INDUSTRIAL (NOTE 2)	1 WATT Cathode to Case CASE 52 INDUSTRIAL (NOTE 2, 3)
1.8	MZ4614				
2.0	MZ4615				
2.2	MZ4616				
2.4	MZ4617	1N4370	1N5221		
2.7	MZ4618	1N4371	1N5223		
3.0	MZ4619	1N4372	1N5225		
3.3	MZ4620	1N746	1N5226	1N4728	1N3821
3.6	MZ4621	1N747	1N5227	1N4729	1N3822
3.9	MZ4622	1N748	1N5228	1N4730	1N3823
4.3	MZ4623	1N749	1N5229	1N4731	1N3824
4.7	MZ4624	1N750	1N5230	1N4732	1N3825
5.1	MZ4625	1N751	1N5231	1N4733	1N3826
5.6	MZ4626	1N752	1N5232	1N4734	1N3827
6.2	MZ4627	1N753	1N5234	1N4735	1N3828
6.8	1N4099	1N754 1N957	1N5235	1N4736	1N3829 1N3016
7.5	1N4100	1N755 1N958	1N5236	1N4737	1N3830 1N3017
8.2	1N4101	1N756 1N959	1N5237	1N4738	1N3018
9.1	1N4103	1N757 1N960	1N5239	1N4739	1N3019
10	1N4104	1N758 1N961	1N5240	1N4740	1N3020
11	1N4105	1N962	1N5241	1N4741	1N3021
12	1N4106	1N759 1N963	1N5242	1N4742	1N3022
13	1N4107	1N964	1N5243	1N4743	1N3023
15	1N4109	1N965	1N5245	1N4744	1N3024
16	1N4110	1N966	1N5246	1N4745	1N3025
18	1N4112	1N967	1N5248	1N4746	1N3026
20	1N4114	1N968	1N5250	1N4747	1N3027
22	1N4115	1N969	1N5251	1N4748	1N3028
24	1N4116	1N970	1N5252	1N4749	1N3029
27	1N4118	1N971	1N5254	1N4750	1N3030
30	1N4120	1N972	1N5256	1N4751	1N3031
33	1N4121	1N973	1N5257	1N4752	1N3032
36	1N4122	1N974	1N5258	1N4753	1N3033
39	1N4123	1N975	1N5259	1N4754	1N3034
43	1N4124	1N976	1N5260	1N4755	1N3035
47	1N4125	1N977	1N5261	1N4756	1N3036
51	1N4126	1N978	1N5262	1N4757	1N3037
56	1N4127	1N979	1N5263	1N4758	1N3038
62	1N4129	1N980	1N5265	1N4759	1N3039
68	1N4130	1N981	1N5266	1N4760	1N3040
75	1N4131	1N982	1N5267	1N4761	1N3041
82	1N4132	1N983	1N5268	1N4762	1N3042
91	1N4134	1N984	1N5270	1N4763	1N3043
100	1N4135	1N985	1N5271	1N4764	1N3044
110		1N986	1N5272	1M110ZS10	1N3045
120		1N987	1N5273	1M120ZS10	1N3046
130		1N988	1N5274	1M130ZS10	1N3047
150		1N989	1N5276	1M150ZS10	1N3048
160		1N990	1N5277	1M160ZS10	1N3049
180		1N991	1N5279	1M180ZS10	1N3050
200		1N992	1N5281	1M200ZS10	1N3051

NOTES:

1. The Zener Voltage is measured at approximately ¼ the rated power except for the MZ4614 and 1N4099 series. This series is measured with an I_{ZT} = 250 μAdc. The 1N4370 and 1N746 series is measured with an I_{ZT} = 20 mAdc.
2. No suffix denotes ±10% tolerance. "A" suffix is ±5.0% tolerance. (1N4370-4372, 1N746-759, 1N3821-30, 1N3993-4000, 1N4728-64).
3. No suffix is ±20% tolerance; "A" suffix is ±10% tolerance and "B" suffix is ±5.0% tolerance. (1N957-992; 1N3016-3051; 1N3785-3820; 1N2970&R-3015&R; 1N4549&R-4556&R; 1N4557&R-4564&R; 1N2804&R-2846&R; 1N3305&R-3350&R; 1N5333-1N5388; MZ92-2.4-MZ92-200).
4. R, RA & RB = Reverse Polarity Types Available.
5. No suffix is ±10% tolerance, "A" suffix is ±10% tolerance, "B" suffix is ±5.0% tolerance.
6. Contact your Motorola Semiconductor Representative for information on Military and Meg-A-Life II Types and intermediate voltages.

☐ JAN/JANTX and Meg-A-Life II available ±5.0% only. (Reverse polarity available on 10 W and 50 W devices)

ZENER DIODES

Nominal Zener Voltage (NOTE 1, 6)	1-1/2 WATT Cathode to Case  CASE 55 INDUSTRIAL (NOTE 3)	5 WATT Cathode = Polarity Mark  *Surmetic 40 CASE 17 INDUSTRIAL (NOTE 3)	10 WATT Cathode to Case = 1N3993 series Anode to Case = 1N2970 series  CASE 56 INDUSTRIAL (NOTE 2, 3, 4)	50 WATT Anode to Case  CASE 54 INDUSTRIAL (NOTE 3, 4)	 CASE 58 INDUSTRIAL (NOTE 3, 4)
1.8					
2.0					
2.2					
2.4					
2.7					
3.0					
3.3		1N5333			
3.6		1N5334			
3.9		1N5335	1N3993&R	1N4557&R	1N4549&R
4.3		1N5336	1N3994&R	1N4558&R	1N4550&R
4.7		1N5337	1N3995&R	1N4559&R	1N4551&R
5.1		1N5338	1N3996&R	1N4560&R	1N4552&R
5.6		1N5339	1N3997&R	1N4561&R	1N4553&R
6.2		1N5341	1N3998&R	1N4562&R	1N4554&R
6.8	1N3785	1N5342	1N3999&R	1N4563&R	1N4555&R
			1N2970&R	1N2804&R	1N3305&R
7.5	1N3786	1N5343	1N4000&R	1N4564&R	1N4556&R
			1N2971&R	1N2805&R	1N3306&R
8.2	1N3787	1N5344	1N2972&R	1N2806&R	1N3307&R
9.1	1N3788	1N5346	1N2973&R	1N2807&R	1N3308&R
10	1N3789	1N5347	1N2974&R	1N2808&R	1N3309&R
11	1N3790	1N5348	1N2975&R	1N2809&R	1N3310&R
12	1N3791	1N5349	1N2976&R	1N2810&R	1N3311&R
13	1N3792	1N5350	1N2977&R	1N2811&R	1N3312&R
15	1N3793	1N5352	1N2979&R	1N2813&R	1N3314&R
16	1N3794	1N5353	1N2980&R	1N2814&R	1N3315&R
18	1N3795	1N5355	1N2982&R	1N2816&R	1N3317&R
20	1N3796	1N5357	1N2984&R	1N2818&R	1N3319&R
22	1N3797	1N5358	1N2985&R	1N2819&R	1N3320&R
24	1N3798	1N5359	1N2986&R	1N2820&R	1N3321&R
27	1N3799	1N5361	1N2988&R	1N2822&R	1N3323&R
30	1N3800	1N5363	1N2989&R	1N2823&R	1N3324&R
33	1N3801	1N5364	1N2990&R	1N2824&R	1N3325&R
36	1N3802	1N5365	1N2991&R	1N2825&R	1N3326&R
39	1N3803	1N5366	1N2992&R	1N2826&R	1N3327&R
43	1N3804	1N5367	1N2993&R	1N2827&R	1N3328&R
47	1N3805	1N5368	1N2995&R	1N2829&R	1N3330&R
51	1N3806	1N5369	1N2997&R	1N2831&R	1N3332&R
56	1N3807	1N5370	1N2999&R	1N2832&R	1N3334&R
62	1N3808	1N5372	1N3000&R	1N2833&R	1N3335&R
68	1N3809	1N5373	1N3001&R	1N2834&R	1N3336&R
75	1N3810	1N5374	1N3002&R	1N2835&R	1N3337&R
82	1N3811	1N5375	1N3003&R	1N2836&R	1N3338&R
91	1N3812	1N5377	1N3004&R	1N2837&R	1N3339&R
100	1N3813	1N5378	1N3005&R	1N2838&R	1N3340&R
110	1N3814	1N5379	1N3007&R	1N2840&R	1N3342&R
120	1N3815	1N5380	1N3008&R	1N2841&R	1N3343&R
130	1N3816	1N5381	1N3009&R	1N2842&R	1N3344&R
150	1N3817	1N5383	1N3011&R	1N2843&R	1N3346&R
160	1N3818	1N5384	1N3012&R	1N2844&R	1N3347&R
180	1N3819	1N5386	1N3014&R	1N2845&R	1N3349&R
200	1N3820	1N5388	1N3015&R	1N2846&R	1N3350&R

500 MILLIWATT Cathode = Polarity Mark  CASE 182(1) INDUSTRIAL (NOTE 3)	UNIBLOC▲ ZENER REGULATOR DIODES Nominal Zener Voltage (NOTE 1)
MZ92-2.4	2.4
MZ92-2.5	2.5
MZ92-2.7	2.7
MZ92-2.8	2.8
MZ92-3.0	3.0
MZ92-3.3	3.3
MZ92-3.6	3.6
MZ92-3.9	3.9
MZ92-4.3	4.3
MZ92-4.7	4.7
MZ92-5.1	5.1
MZ92-5.6	5.6
MZ92-6.0	6.0
MZ92-6.2	6.2
MZ92-6.8	6.8
MZ92-7.5	7.5
MZ92-8.2	8.2
MZ92-8.7	8.7
MZ92-9.1	9.1
MZ92-10	10
MZ92-11	11
MZ92-12	12
MZ92-13	13
MZ92-14	14
MZ92-15	15
MZ92-16	16
MZ92-17	17
MZ92-18	18
MZ92-19	19
MZ92-20	20
MZ92-22	22
MZ92-24	24
MZ92-25	25
MZ92-27	27
MZ92-28	28
MZ92-30	30
MZ92-33	33
MZ92-36	36
MZ92-39	39
MZ92-43	43
MZ92-47	47
MZ92-51	51
MZ92-56	56
MZ92-60	60
MZ92-62	62
MZ92-68	68
MZ92-75	75
MZ92-82	82
MZ92-87	87
MZ92-91	91
MZ92-100	100
MZ92-110	110
MZ92-120	120
MZ92-130	130
MZ92-140	140
MZ92-150	150
MZ92-160	160
MZ92-170	170
MZ92-180	180
MZ92-190	190
MZ92-200	200

▲Trademark of Motorola Inc.

ZENER REFERENCE DIODES

For applications in which the output voltage must remain within narrow limits during changes in input voltage, load resistance, and temperature changes. These Temperature Compensated Zener Reference Diodes have low dynamic impedance and silicon oxide passivated junctions for long-term stability.

V_Z = 6.2 V

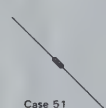


Case 51

Test Temperature
−55, 0, +25, +75, +100°C

*Type Number	∆V_Z Volts	Temp. Coeff. For Ref. %/°C
I_{ZT} = 7.5 mA		
1N821#	0.096	0.01
1N821A	0.096	0.01
1N823#	0.048	0.005
1N823A	0.048	0.005
1N825#	0.019	0.002
1N825A	0.019	0.002
1N827#	0 009	0.001
1N827A	0.009	0.001
1N829#	0.005	0.0005
1N829A	0.005	0.0005

V_Z = 6.4 V



Case 51

Test Temperature

Non-Suffix
0, +25, +75°C

"A" Suffix
−55, 0, +25, +75, +100°C

Type Number	∆V_Z Volts	Temp. Coeff. For Ref. %/°C
I_{ZT} = 0.5 mA		
1N4565	0.048	0.01
1N4565A	0.099	0.01
1N4566	0 024	0.005
1N4566A	0.050	0.005
1N4567	0.010	0.002
1N4567A	0.020	0.002
1N4568	0.005	0.001
1N4568A	0.010	0.001
1N4569	0.002	0.0005
1N4569A	0.005	0.0005
I_{ZT} = 1.0 mA		
1N4570	0.048	0.01
1N4570A	0.099	0.01
1N4571	0.024	0.005
1N4571A	0.050	0.005
1N4572	0.010	0.002
1N4572A	0.020	0.002
1N4573	0.005	0.001
1N4573A	0.010	0.001
1N4574	0.002	0.0005
1N4574A	0.005	0.0005
I_{ZT} = 2.0 mA		
1N4575	0.048	0.01
1N4575A	0.099	0.01
1N4576	0.024	0.005
1N4576A	0.050	0.005
1N4577	0.010	0.002
1N4577A	0.020	0.002
1N4578	0.005	0.001
1N4578A	0.010	0.001
1N4579	0.002	0.0005
1N4579A	0.005	0.0005
I_{ZT} = 4.0 mA		
1N4580	0.048	0.01
1N4580A	0.099	0.01
1N4581	0.024	0.005
1N4581A	0.050	0.005
1N4582	0.010	0.002
1N4582A	0.020	0.002
1N4583	0.005	0.001
1N4583A	0.010	0.001
1N4584	0.002	0.0005
1N4584A	0.005	0.0005

V_Z = 8.4 V

Case 51

Test Temperature

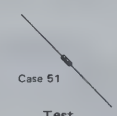
Non-Suffix
−55, 0, +25, +75, +100°C

"A" Suffix
−55, 0, +25, +75, +100, +150°C

Type Number	∆V_Z Volts	Temp. Coeff. For Ref. %/°C
I_{ZT} = 10 mA		
1N3154#	0.130	0.01
1N3154A	0.172	0.01
1N3155#	0.065	0.005
1N3155A	0.036	0.005
1N3156#	0.026	0.002
1N3156A	0.034	0.002
1N3157#	0.013	0.001
1N3157A	0.017	0.001

#Available as JAN/JANTX and MEG-A-LIFE II devices.

V_Z = 8.5 V



Case 51

Test Temperature

Non-Suffix
0, +25, +75°C

"A" Suffix
−55, 0, +25, +75, +100°C

Type Number	∆V_Z Volts	Temp. Coeff. For Ref. %/°C
I_{ZT} = 0.5 mA		
1N4775	0.064	0.01
1N4775A	0.132	0.01
1N4776	0.032	0.005
1N4776A	0.066	0.005
1N4777	0.013	0.002
1N4777A	0.026	0.002
1N4778	0.006	0.001
1N4778A	0.013	0.001
1N4779	0.003	0.0005
1N4779A	0.007	0.0005
I_{ZT} = 1.0 mA		
1N4780	0.064	0.01
1N4780A	0.132	0.01
1N4781	0.032	0.005
1N4781A	0.066	0.005
1N4782	0.013	0.002
1N4782A	0.026	0.002
1N4783	0.006	0.001
1N4783A	0.013	0.001
1N4784	0.003	0.0005
1N4784A	0.007	0.0005

V_Z = 9.0 V

Case 51

Test Temperature

Non-Suffix
0, +25, +75°C

"A" Suffix
−55, 0, +25, +75, +100°C

"B" Suffix
−55, 0, +25, +75, + 100, +150°C

Type Number	∆V_Z Volts	Temp. Coeff. For Ref. %/°C
I_{ZT} = 7.5 mA		
1N935	0.067	0.01
1N935A	0.139	0.01
1N935B#	0.184	0.01
1N936	0.033	0.005
1N936A	0.069	0.005
1N936B#	0.092	0.005
1N937	0.013	0.002
1N937A	0.027	0.002
1N937B#	0.037	0.002
1N938	0.006	0.001
1N938A	0.013	0.001
1N938B#	0.018	0.001
1N939	0.003	0.0005
1N939A	0.007	0.0005
1N939B#	0.009	0.0005

V_Z = 9.1 V



Case 51

Test Temperature

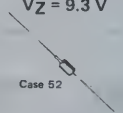
Non-Suffix
0, +25, +75°C

"A" Suffix
−55, 0, +25, +75, +100°C

Type Number	∆V_Z Volts	Temp. Coeff. For Ref. %/°C
I_{ZT} = 0.5 mA		
1N4765	0.068	0.01
1N4765A	0.141	0.01
1N4766	0.034	0.005
1N4766A	0.070	0.005
1N4767	0.014	0.002
1N4767A	0.028	0.002
1N4768	0.007	0.001
1N4768A	0.014	0.001
1N4769	0.003	0.0005
1N4769A	0.007	0.0005
I_{ZT} = 1.0 mA		
1N4770	0.068	0.01
1N4770A	0.141	0.01
1N4771	0.034	0.005
1N4771A	0.070	0.005
1N4772	0.014	0.002
1N4772A	0.028	0.002
1N4773	0.007	0.001
1N4773A	0.014	0.001
1N4774	0.003	0.0005
1N4774A	0.007	0.0005

*Non-Suffix – Z_{ZT} = 15 Ω, "A" Suffix – Z_{ZT} = 10 Ω.

V_Z = 9.3 V



Case 52

Test Temperature

Non-Suffix
0, +25, +75

"A" Suffix
−55, 0, +25, +75, +100°C

"B" Suffix
−55, 0, +25, +75, +100, +150°C

Type Number	∆V_Z Volts	Temp. Coeff. For Ref. %/°C
I_{ZT} = 10 mA		
1N2620	0.070	0.01
1N2620A	0.144	0 01
1N2620B	0.191	0.01
1N2621	0.035	0.005
1N2621A	0 072	0.005
1N2621B	0.095	0.005
1N2622	0.014	0.002
1N2622A	0.029	0.002
1N2622B	0.038	0.002
1N2623	0.007	0.001
1N2623A	0.014	0.001
1N2623B	0.019	0.001
1N2624	0.003	0.0005
1N2624A	0.007	0 0005
1N2624B	0.010	0 0005

V_Z = 9.4 ±0.4 V

(Suffix "A" ± 0.2 V)

Case 52

Test Temperature
0, +25, +70°C
−55, 0, +25, +75, +125°C
−55, 0, +25, +75, +125, +185°C

Type Number	∆V_Z Volts	Temp. Coeff. For Ref. %/°C
I_{ZT} = 10 mA		
1N2163,A	0.033	0.005
1N2166,A	0.007	0.001
1N2169,A	0.004	0.0005
1N2164,A	0.086	0.005
1N2167,A	0.017	0.001
1N2170,A	0.009	0.0005
1N2165,A	0.115	0.005
1N2168,A	0 023	0.001
1N2171,A	0.112	0.0005

V_Z = 11.7 V

Case 51 (1N941 Series)

Test Temperature

Non-Suffix
0, +25, +75°C

"A" Suffix
−55, 0, +25, +75, +100°C

"B" Suffix
−55, 0, +25, +75, +100, +150°C

Case 52 (1N3580 Series)

Type Number	∆V_Z Volts	Temp. Coeff. For Ref. %/°C
I_{ZT} = 7.5 mA		
1N941	0.088	0.01
1N941A	0.181	0.01
1N941B#	0.239	0.01
1N942	0.044	0.005
1N942A	0.090	0.005
1N942B	0.120	0.005
1N943	0.018	0 002
1N943A	0.036	0.002
1N943B#	0.047	0.002
1N944	0.009	0.001
1N944A	0.018	0.001
1N944B#	0.024	0.001
1N945	0.004	0.0005
1N945A	0.009	0.0005
1N945B	0.012	0.0005
1N3580	0.088	0.01
1N3580A	0.181	0.01
1N3580B	0.239	0.01
1N3581	0.044	0.005
1N3581A	0.090	0.005
1N3581B	0.120	0.005
1N3582	0.018	0.002
1N3582A	0.036	0.002
1N3582B	0.048	0.002
1N3583	0.008	0.001
1N3583A	0.018	0.001
1N3583B	0.023	0.001

ZENER REFERENCE DIODES

LOW NOISE REFERENCE DIODES

V_Z = 12.8 V



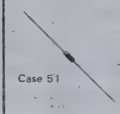
Test Temperature

Non-Suffix
+25, +75, +100°C

"A" Suffix
−55, 0, +25, +75, +100°C

Type Number	$\triangle V_Z$ Volts	Temp. Coeff. For Ref. %/°C
I_{ZT} = 0.5 mA, N_D = 0.8 $\frac{\mu V}{\sqrt{Hz}}$		
1N4896	0.096	0.01
1N4896A	0.198	0.01
1N4897	0.048	0.005
1N4897A	0.099	0.005
1N4898	0.019	0.002
1N4898A	0.040	0.002
1N4899	0.010	0.001
1N4899A	0.020	0.001
I_{ZT} = 1.0 mA, N_D = 0.4 $\frac{\mu V}{\sqrt{Hz}}$		
1N4900	0.096	0.01
1N4900A	0.198	0.01
1N4901	0.048	0.005
1N4901A	0.099	0.005
1N4902	0.019	0.002
1N4902A	0.040	0.002
1N4903	0.010	0.001
1N4903A	0.020	0.001
I_{ZT} = 2.0 mA, N_D = 0.25 $\frac{\mu V}{\sqrt{Hz}}$		
1N4904	0.096	0.01
1N4904A	0.198	0.01
1N4905	0.048	0.005
1N4905A	0.099	0.005
1N4906	0.019	0.002
1N4906A	0.040	0.002
1N4907	0.010	0.001
1N4907A	0.020	0.001
I_{ZT} = 4.0 mA, N_D = 0.22 $\frac{\mu V}{\sqrt{Hz}}$		
1N4908	0.096	0.01
1N4908A	0.198	0.01
1N4909	0.048	0.005
1N4909A	0.099	0.005
1N4910	0.019	0.002
1N4910A	0.040	0.002
1N4911	0.010	0.001
1N4911A	0.020	0.001
I_{ZT} = 7.5 mA, N_D = 0.20 $\frac{\mu V}{\sqrt{Hz}}$		
1N4912	0.096	0.01
1N4912A	0.198	0.01
1N4913	0.048	0.005
1N4913A	0.099	0.005
1N4914	0.019	0.002
1N4914A	0.040	0.002
1N4915	0.010	0.001
1N4915A	0.020	0.001

V_Z = 19.2 V



Test Temperature

Non-Suffix
+25, +75, +100°C

"A" Suffix
−55, 0, +25, +75, +100°C

Type Number	$\triangle V_Z$ Volts	Temp. Coeff. For Ref. %/°C
I_{ZT} = 0.5 mA, N_D = 1.0 $\frac{\mu V}{\sqrt{Hz}}$		
1N4916	0.144	0.01
1N4916A	0.298	0.01
1N4917	0.072	0.005
1N4917A	0.149	0.005
1N4918	0.029	0.002
1N4918A	0.060	0.002
I_{ZT} = 1.0 mA, N_D = 0.5 $\frac{\mu V}{\sqrt{Hz}}$		
1N4919	0.144	0.01
1N4919A	0.298	0.01
1N4920	0.072	0.005
1N4920A	0.149	0.005
1N4921	0.029	0.002
1N4921A	0.060	0.002
I_{ZT} = 2.0 mA, N_D = 0.25 $\frac{\mu V}{\sqrt{Hz}}$		
1N4922	0.144	0.01
1N4922A	0.298	0.01
1N4923	0.072	0.005
1N4923A	0.149	0.005
1N4924	0.029	0.002
1N4924A	0.060	0.002
I_{ZT} = 4.0 mA, N_D = 0.22 $\frac{\mu V}{\sqrt{Hz}}$		
1N4925	0.144	0.01
1N4925A	0.298	0.01
1N4926	0.072	0.005
1N4926A	0.149	0.005
1N4927	0.029	0.002
1N4927A	0.060	0.002
1N4928	0.014	0.001
1N4928A	0.030	0.001
I_{ZT} = 7.5 mA, N_D = 0.20 $\frac{\mu V}{\sqrt{Hz}}$		
1N4929	0.144	0.01
1N4929A	0.298	0.01
1N4930	0.072	0.005
1N4930A	0.149	0.005
1N4931	0.029	0.002
1N4931A	0.060	0.002
1N4932	0.014	0.001
1N4932A	0.030	0.001

PRECISION REFERENCE DIODES



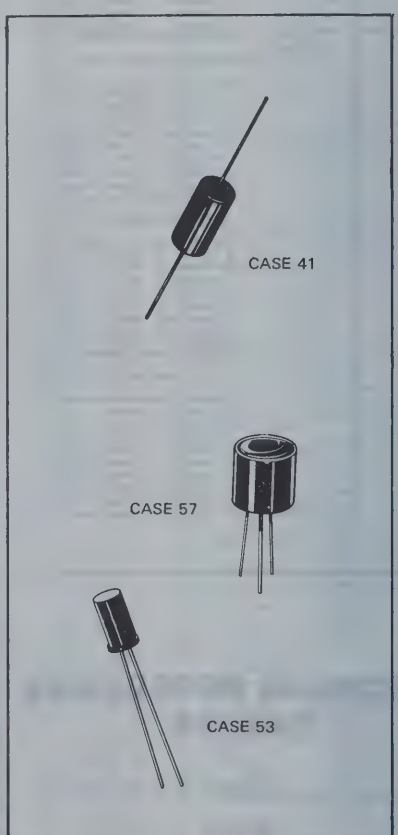
CASE 51

Case 51	Type Number	Voltage-Time Stability: Max Change µV/1000 hr	Voltage-Time Stability: Parts Per Million Change PPM/1000 hr	$\triangle V_Z$ mV Max
		I_{ZT} = 7.5 mA		
V_Z = 6.2 V ± 5.0% Test Temperature +25, +75, +100°C	MZ605	30	≤5.0	2.5
	MZ610	60	≤10	2.5
	MZ620	120	≤20	2.5
	MZ640	240	≤40	2.5
		I_{ZT} = 10 mA		
V_Z = 8.4 V ± 5.0% Test Temperature +25, +75, +100°C	MZ805	45	≤5.0	3.5
	MZ810	90	≤10	3.5
	MZ820	180	≤20	3.5
	MZ840	360	≤40	3.5

MOLDED ASSEMBLIES

	V_Z Volts	Type Number	Test I_T Temperature +25 to +100°C ΔV_Z Volts	−55 to +25°C ΔV_Z Volts	Temp. Coeff. For Ref. %/°C
			I_{ZT} = 10 mA		
Case 41-8	12.4	1N4057 1N4057A	0.047 0.019	0.050 0.020	0.005 0.002
	14.6	1N4058 1N4058A	0.055 0.022	0.058 0.023	0.005 0.002
	16.8	1N4059 1N4059A	0.063 0.025	0.067 0.027	0.005 0.002
	18.5	1N4060 1N4060A	0.069 0.028	0.074 0.030	0.005 0.002
	21.0	1N4061 1N4061A	0.079 0.032	0.084 0.034	0.005 0.002
	23.0	1N4062 1N4062A	0.086 0.035	0.092 0.037	0.005 0.002
	27.0	1N4063 1N4063A	0.101 0.041	0.108 0.043	0.005 0.002
	30.0	1N4064 1N4064A	0.113 0.045	0.120 0.048	0.005 0.002
	33.0	1N4065 1N4065A	0.124 0.050	0.132 0.053	0.005 0.002
			I_{ZT} = 7.5 mA		
	37.0	1N4066 1N4066A	0.139 0.056	0.148 0.059	0.005 0.002
	43.0	1N4067 1N4067A	0.161 0.065	0.172 0.069	0.005 0.002
	47.0	1N4068 1N4068A	0.176 0.071	0.188 0.075	0.005 0.002
			I_{ZT} = 7.5 mA		
	51.0	1N4069 1N4069A	0.191 0.077	0.204 0.082	0.005 0.002
	56.0	1N4070 1N4070A	0.210 0.084	0.224 0.090	0.005 0.002
	62.0	1N4071 1N4071A	0.232 0.093	0.248 0.099	0.005 0.002
			I_{ZT} = 5.0 mA		
Case 41-9	68.0	1N4072 1N4072A	0.255 0.102	0.272 0.109	0.005 0.002
	75.0	1N4073 1N4073A	0.281 0.113	0.300 0.120	0.005 0.002
	82.0	1N4074 1N4074A	0.307 0.123	0.328 0.131	0.005 0.002
	87.0	1N4075 1N4075A	0.326 0.131	0.348 0.139	0.005 0.002
	91.0	1N4076 1N4076A	0.341 0.137	0.364 0.146	0.005 0.002
	100	1N4077 1N4077A	0.375 0.150	0.400 0.160	0.005 0.002
			I_{ZT} = 2.5 mA		
	105	1N4078 1N4078A	0.394 0.158	0.420 0.168	0.005 0.002
	110	1N4079 1N4079A	0.413 0.165	0.440 0.176	0.005 0.002
	120	1N4080 1N4080A	0.450 0.180	0.480 0.192	0.005 0.002
			I_{ZT} = 2.5 mA		
Case 41-10	130	1N4081 1N4081A	0.488 0.195	0.520 0.208	0.005 0.002
	140	1N4082 1N4082A	0.525 0.210	0.560 0.224	0.005 0.002
	150	1N4083 1N4083A	0.563 0.225	0.600 0.240	0.005 0.002
	175	1N4084 1N4084A	0.656 0.263	0.700 0.280	0.005 0.002
	200	1N4085 1N4085A	0.750 0.300	0.800 0.320	0.005 0.002

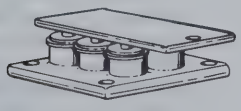
Case	V_Z Volts	Type Number	Test Temperature −55, +25, +100°C ΔV_Z Volts	Temp. Coeff. For Ref. %/°C
		I_{ZT} = 7.5 mA (*I_{ZT} = 10 mA)		
53	6.2	1N429#	0.050	0.01
41-6	6.2	1N1735	0.050	0.01
57	8.4	1N1530*	0.014	0.002
	8.4	1N1530A*#	0.007	0.001
41-3	12.4	1N1736	0.100	0.01
	12.4	1N1736A	0.050	0.005
41-5	18.6	1N1737	0.150	0.01
	18.6	1N1737A	0.075	0.005
	24.8	1N1738	0.200	0.01
	24.8	1N1738A	0.100	0.005
41-4	31.0	1N1739	0.250	0.01
	31.0	1N1739A	0.125	0.005
	37.2	1N1740	0.300	0.01
	37.2	1N1740A	0.150	0.005
	43.4	1N1741	0.350	0.01
	43.4	1N1741A	0.175	0.005
	49.6	1N1742	0.400	0.01
	49.6	1N1742A#	0.200	0.005



#Available as JAN/JANTX and MEG-A-LIFE II devices.

SILICON POWER TRANSIENT SUPPRESSORS

Power Zener diodes designed for applications requiring protection of voltage sensitive electronic devices in danger of destruction by high energy voltage transients. Individual cells are matched to insure current sharing under high current pulse conditions. Specials are available with higher power and/or voltage ratings (e.g. 1000 Wdc and 200 Vdc).



Case 119

- Transient Power Dissipation: 40 kW
  Pulse Width: 0.1 ms
- DC Power Dissipation: 350 Watts @ $T_C = 25°C$
  (Derate 2.33 W/°C above 25°C)
- Operating Junction and Storage Temperature
  Range: −65°C to +175°C
- Polarity: Anode-to-Case is Standard
  Cathode-to-Case Available Upon Request

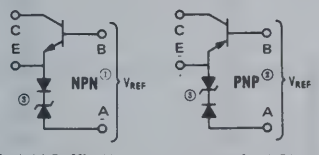
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$) ($V_F = 1.5$ V max @ 10 A for all types)

Type	Nominal Operating Voltage (Note 1) $V_{OP(PK)}$ Vdc	Nominal Operating Voltage (Note 1) $V_{OP(RMS)}$ V rms	Maximum Device Clamping Factor $CF = \frac{V_Z @ I_{Z(pulse)}}{V_Z @ I_{ZT}}$	Minimum Zener Voltage $V_{Z(min)}$ Vdc	@ I_{ZT} Adc	Maximum Zener Voltage Pulse Width = 1.0 ms $V_{Z(max)}$ Vdc	@ $I_{Z(pulse)}$ Adc	Maximum Reverse Current $I_{R(max)}$ @ $V_R = V_{OP(PK)}$ μAdc	Typical Capacitance C (typ) @ $V_R = V_{OP(PK)}$ μF
MPZ5-16A	14	10	1.25	16	0.4	24	200	50	0.025
-16B	14	10	1.25	16	0.4	20	200	↓	0.025
-32A	28	20	1.25	32	0.2	50	100	↓	0.011
-32B	28	20	1.25	32	0.2	45	100	↓	0.011
-32C	28	20	1.25	32	0.2	40	100	↓	0.011
-180A	165	117	1.14	180	0.03	250	20	↓	0.0012
-180B	165	117	1.14	180	0.03	225	20	↓	0.0012
-180C	165	117	1.14	180	0.03	205	20	50	0.0012

REFERENCE AMPLIFIERS



CASE 212-01



. . . designed for use in regulated power supplies as a combination voltage reference element and error voltage amplifier, providing temperature compensation for excellent reference voltage stability. Available with either PNP or NPN transistors for versatility of circuit design. Operation over three different temperature ranges: 0 to 75°C, −55 to 100°C, −55 to 150°C.

1 Add Suffix N to type number for NPN devices.
2 Add Suffix P to type number for PNP devices.
3 MCA1911 Series uses only zener diode and transistor.

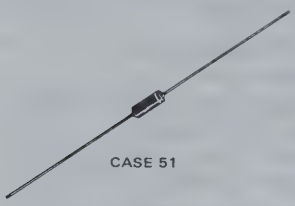
Note: Basic type numbers are listed in the table; add suffix "P" or "N" to denote specific polarity.

ELECTRICAL CHARACTERISTICS ($I_{ZT} = 5.0$ mA, $V_{CEO} = 30$ V)

Type	V_{REF} Volts	Tolerance ±%	ΔV_{REF} Volts	@ Test Temperature °C
MCA1911	6.8	10	0.051	
MCA1912	↓	↓	0.025	0, +25, +75
MCA1913	↓	↓	0.010	↓
MCA1914	↓	↓	0.005	↓
MCA1921	↓	5.0	0.105	
MCA1922	↓	↓	0.052	−55, 0, +25,
MCA1923	↓	↓	0.020	+75, +100
MCA1924	↓	↓	0.010	↓
MCA1931	↓	↓	0.139	
MCA1932	↓	↓	0.069	−55, 0, +25
MCA1933	↓	↓	0.026	+75, +100, +150
MCA1934	↓	↓	0.013	↓
MCA2011	8.6	10	0.060	
MCA2012	↓	↓	0.030	0, +25, +75
MCA2013	↓	↓	0.012	↓
MCA2014	↓	↓	0.006	↓
MCA2021	↓	5.0	0.124	
MCA2022	↓	↓	0.062	−55, 0, +25,
MCA2023	↓	↓	0.024	+75, +100
MCA2024	↓	↓	0.012	↓
MCA2031	↓	↓	0.164	
MCA2032	↓	↓	0.082	−55, 0, +25,
MCA2033	↓	↓	0.032	+75, +100, +150
MCA2034	↓	↓	0.016	↓

Type	V_{REF} Volts	Tolerance ±%	ΔV_{REF} Volts	@ Test Temperature °C
MCA2111	9.5	10	0.071	
MCA2112	↓	↓	0.035	0, +25, +75
MCA2113	↓	↓	0.014	↓
MCA2114	↓	↓	0.007	↓
MCA2121	↓	5.0	0.147	
MCA2122	↓	↓	0.073	−55, 0, +25,
MCA2123	↓	↓	0.028	+75, +100
MCA2124	↓	↓	0.014	↓
MCA2131	↓	↓	0.194	
MCA2132	↓	↓	0.097	−55, 0, +25
MCA2133	↓	↓	0.038	+75, +100, +150
MCA2134	↓	↓	0.019	↓
MCA2211	11	10	0.082	
MCA2212	↓	↓	0.041	0, +25, +75
MCA2213	↓	↓	0.016	↓
MCA2214	↓	↓	0.008	↓
MCA2221	↓	5.0	0.170	
MCA2222	↓	↓	0.085	−55, 0, +25,
MCA2223	↓	↓	0.034	+75, +100
MCA2224	↓	↓	0.017	↓
MCA2231	↓	↓	0.225	
MCA2232	↓	↓	0.112	−55, 0, +25
MCA2233	↓	↓	0.044	+75, +100, +150
MCA2234	↓	↓	0.022	↓

CURRENT REGULATOR DIODES



CASE 51

A diode is now available that works exactly the opposite of a Zener diode. It is called a current-regulator diode. Unlike a Zener, such a diode presents a constant current regardless of the terminal voltage over a wide operating range and appears as a very high circuit impedance. These devices are useful for a number of electronic applications, including overcurrent protection, transistor biasing, linear ramp and stairstep generators, differential amplifiers, precision reference voltage sources, and linear-scale ohmmeters, to name a few.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted, POV = 100 Volt max)

Type* Number Industrial	Regulator Current I_P (mA) @ V_T = 25 V			Minimum Dynamic Impedance @ V_T = 25 V Z_T (MΩ)	Minimum Knee Impedance @ V_K = 6.0 V Z_K (MΩ)	Maximum Limiting Voltage @ I_L = 0.8 I_P (min) V_L (Volts)
	nom	min	max			
1N5283	0.22	0.198	0.242	25.0	2.75	1.00
1N5284	0.24	0.216	0.264	19.0	2.35	1.00
1N5285	0.27	0.243	0.297	14.0	1.95	1.00
1N5286	0.30	0.270	0.330	9.0	1.60	1.00
1N5287	0.33	0.297	0.363	6.6	1.35	1.00
1N5288	0.39	0.351	0.429	4.10	1.00	1.05
1N5289	0.43	0.387	0.473	3.30	0.870	1.05
1N5290	0.47	0.423	0.517	2.70	0.750	1.05
1N5291	0.56	0.504	0.616	1.90	0.560	1.10
1N5292	0.62	0.558	0.682	1.55	0.470	1.13
1N5293	0.68	0.612	0.748	1.35	0.400	1.15
1N5294	0.75	0.675	0.825	1.15	0.335	1.20
1N5295	0.82	0.738	0.902	1.00	0.290	1.25
1N5296	0.91	0.819	1.001	0.880	0.240	1.29
1N5297	1.00	0.900	1.100	0.800	0.205	1.35
1N5298	1.10	0.990	1.210	0.700	0.180	1.40
1N5299	1.20	1.08	1.32	0.640	0.155	1.45
1N5300	1.30	1.17	1.43	0.580	0.135	1.50
1N5301	1.40	1.26	1.54	0.540	0.115	1.55
1N5302	1.50	1.35	1.65	0.510	0.105	1.60
1N5303	1.60	1.44	1.76	0.475	0.092	1.65
1N5304	1.80	1.62	1.98	0.420	0.074	1.75
1N5305	2.00	1.80	2.20	0.395	0.061	1.85
1N5306	2.20	1.98	2.42	0.370	0.052	1.95
1N5307	2.40	2.16	2.64	0.345	0.044	2.00
1N5308	2.70	2.43	2.97	0.320	0.035	2.15
1N5309	3.00	2.70	3.30	0.300	0.029	2.25
1N5310	3.30	2.97	3.63	0.280	0.024	2.35
1N5311	3.60	3.24	3.96	0.265	0.020	2.50
1N5312	3.90	3.51	4.29	0.255	0.017	2.60
1N5313	4.30	3.87	4.73	0.245	0.014	2.75
1N5314	4.70	4.23	5.17	0.235	0.012	2.90

*All Devices ±10% tolerance.

LOW VOLTAGE AVALANCHE ZENER REGULATOR DIODES

Highly reliable silicon regulators utilizing an oxide-passivated junction for long-term voltage stability. Ram Rod construction provides a rugged, glass-enclosed, hermetically sealed structure.



CASE 51

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted. Based on dc measurements at thermal equilibrium; V_F = 1.1 Max @ I_F = 200 mA for all types)

JEDEC Type No. (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mAdc	Max Zener Impedance B-C-D Suffix Z_{ZT} @ I_{ZT} Ohms (Note 3)	Max Reverse Leakage Current I_R μAdc (Note 4)	Max Reverse Leakage Current V_R – Volts Non & A-Suffix	Max Reverse Leakage Current V_R – Volts B-C-D Suffix	B-C-D Suffix Maximum DC Zener Current I_{ZM} mAdc (Note 5)	B-C-D Suffix Max Noise Density at I_Z = 250 μA N_D (Figure 1) (micro-volts per square root cycle)	Regulation Factor ΔV_Z Volts (Note 6)	Low V_Z Current I_{ZL} mAdc
1N5518	3.3	20	26	5.0	0.90	1.0	115	0.5	0.90	2.0
1N5519	3.6	20	24	3.0	0.90	1.0	105	0.5	0.90	2.0
1N5520	3.9	20	22	1.0	0.90	1.0	98	0.5	0.85	2.0
1N5521	4.3	20	18	3.0	1.0	1.5	88	0.5	0.75	2.0
1N5522	4.7	10	22	2.0	1.5	2.0	81	0.5	0.60	1.0
1N5523	5.1	5.0	26	2.0	2.0	2.5	75	0.5	0.65	0.25
1N5524	5.6	3.0	30	2.0	3.0	3.5	68	1.0	0.30	0.25
1N5525	6.2	1.0	30	1.0	4.5	5.0	61	1.0	0.20	0.01
1N5526	6.8	1.0	30	1.0	5.5	6.2	56	1.0	0.10	0.01
1N5527	7.5	1.0	35	0.5	6.0	6.8	51	2.0	0.05	0.01
1N5528	8.2	1.0	40	0.5	6.5	7.5	46	4.0	0.05	0.01
1N5529	9.1	1.0	45	0.1	7.0	8.2	42	4.0	0.05	0.01
1N5530	10.0	1.0	60	0.05	8.0	9.1	38	4.0	0.10	0.01
1N5531	11.0	1.0	80	0.05	9.0	9.9	35	5.0	0.20	0.01
1N5532	12.0	1.0	90	0.05	9.5	10.8	32	10	0.20	0.01
1N5533	13.0	1.0	90	0.01	10.5	11.7	29	15	0.20	0.01
1N5534	14.0	1.0	100	0.01	11.5	12.6	27	20	0.20	0.01
1N5535	15.0	1.0	100	0.01	12.5	13.5	25	20	0.20	0.01
1N5536	16.0	1.0	100	0.01	13.0	14.4	24	20	0.20	0.01
1N5537	17.0	1.0	100	0.01	14.0	15.3	22	20	0.20	0.01
1N5538	18.0	1.0	100	0.01	15.0	16.2	21	20	0.20	0.01
1N5539	19.0	1.0	100	0.01	16.0	17.1	20	20	0.20	0.01
1N5540	20.0	1.0	100	0.01	17.0	18.0	19	20	0.20	0.01
1N5541	22.0	1.0	100	0.01	18.0	19.8	17	20	0.25	0.01
1N5542	24.0	1.0	100	0.01	20.0	21.6	16	20	0.30	0.01
1N5543	25.0	1.0	100	0.01	21.0	22.4	15	20	0.35	0.01
1N5544	28.0	1.0	100	0.01	23.0	25.2	14	20	0.40	0.01
1N5545	30.0	1.0	100	0.01	24.0	27.0	13	20	0.45	0.01
1N5546	33.0	1.0	100	0.01	28.0	29.7	12	20	0.50	0.01

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

The JEDEC type numbers shown are ±20% with guaranteed limits for only V_Z, I_R, and V_F. Units with "A" suffix are ±10% with guaranteed limits for V_Z, I_R, and V_F. Units with guaranteed limits for all six parameters are indicated by a "B" suffix for ±5.0% units, "C" suffix for ±2.0% and "D" suffix for ±1.0%.

NOTE 2 – ZENER VOLTAGE (V_Z) MEASUREMENT

Nominal zener voltage is measured with the device junction in thermal equilibrium with ambient temperature of 25°C.

NOTE 3 – ZENER IMPEDANCE (Z_Z) DERIVATION

The zener impedance is derived from the 60 Hz ac voltage, which results when an ac current having an rms value equal to 10% of the dc zener current (I_{ZT}) is superimposed on I_{ZT}.

NOTE 4 – REVERSE LEAKAGE CURRENT (I_R)

Reverse leakage currents are guaranteed and are measured at V_R as shown on the table.

NOTE 5 – MAXIMUM REGULATOR CURRENT (I_{ZM})

The maximum current shown is based on the maximum voltage of a 5.0% type unit, therefore, it applies only to the "B" suffix device. The actual I_{ZM} for any device may not exceed the value of 400 milliwatts divided by the actual V_Z of the device.

NOTE 6 – MAXIMUM REGULATION FACTOR (ΔV_Z)

ΔV_Z is the maximum difference between V_Z at I_{ZT} and V_Z at I_{ZL} measured with the device junction in thermal equilibrium.

SILICON[1] RECTIFIERS

A DIGEST OF THE BROADEST LINE OF QUALITY RECTIFIERS AVAILABLE

Reverse polarity available on all types except as noted
Reversed polarity units can be obtained by adding suffix "R" to standard type number, e.g., 1N3879R.


CASE 42
(DO-5)


CASE 43
(DO-21)


CASE 52
(DO-13)


CASE 56
(DO-4)


CASE 56A
(DO-4


CASE 59
(DO-41)


CASE 60


CASE 70

I_O, AVERAGE RECTIFIED FORWARD CURRENT		1.0 A			3.0 A			6.0 A	12 A		15 A	
		Case 52 (1)	Case 59		Case 60	Case 70	Case 60 (2)	Case 56	Case 56	Case 56A	Case 42	
V_{RRM} MAX PEAK REPETITIVE REVERSE VOLTAGE	100 V	1N91	1N4934	1N4002	1N4720	1N4998	MR831	1N3880	1N3890	MR1121	1N3209	
	200 V	1N92	1N4935	1N4003	1N4721	1N4999	MR832	1N3881	1N3891	MR1122	1N3210	
	400 V		1N4936	1N4004	1N4722	1N5000	MR834	1N3883	1N3893	MR1124	1N3212	
	600 V		1N4937	1N4005	1N4723	1N5001	MR836	MR1366	MR1376	MR1126	1N3214	
	800 V			1N4006	1N4724	1N5002				MR1128		
	1000 V			1N4007	1N4725	1N5003				MR1130		
RECOVERY TYPES			f = 250 kHz t_{rr} = 0.2 μs	f = 10 kHz t_{rr} = 1.5 μs			f = 250 kHz t_{rr} = 0.2 μs	f = 250 kHz t_{rr} = 0.2 μs	f = 250 kHz t_{rr} = 0.2 μs	f = 2.0 kHz t_{rr} = 4.0 μs		

(1) Low Current Germanium Rectifiers

(2) Not available in reverse polarity.

(3) Add proper two letter suffix to type number to indicator desired package style. e.g., MR1243FL.



CASE 100



CASES 125,126,127,128
Suffix "SL"



CASES 129,130, 131,132
Suffix "SB"



CASES 133,134, 135,136
Suffix "FL"

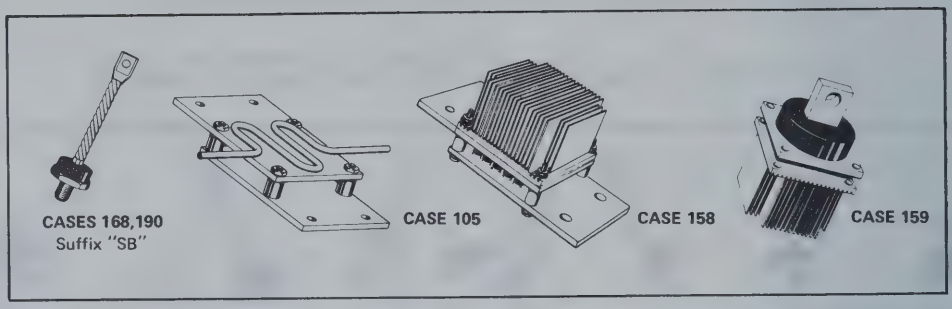


CASES 137,138,139
Suffix "FB"



CASES 167,189
Suffix "SL"

20 A		25 A	30 A		35 A	50 A	100 A		200 A	300 A	450 A
Case 42		Case 43	Case 42	Case 43	Case 42	Case 100	Case 167 Case 168 (3)	Case 189 Case 190 (3)	Case 126 Case 130 Case 133 Case 137 (3)	Case 127 Case 131 Case 134 Case 138 (3)	Case 128 Case 132 Case 135 Case 139 (3)
1N3900 1N2498	1N2498	1N3492 (MR323)	1N3910	1N3660	1N1184	MR1201FL	MR1211	MR1811	MR1221	MR1231	MR1241
1N3901	1N2508	1N3493 (MR324)	1N3911	1N3661	1N1186	MR1203FL	MR1213	MR1813	MR1223	MR1233	MR1243
1N3903	1N1196	1N3495 (MR326)	1N3913	1N3663	1N1188	MR1207FL	MR1217	MR1817	MR1227	MR1237	MR1247
MR1386	1N1198	MR328	MR1396		1N1190	MR1209FL	MR1219	MR1819	MR1229	MR1239	MR1249
		MR330									
		MR331									
f = 250 kHz t_{rr} = 0.2 μs			f = 250 kHz t_{rr} = 0.2 μs								



I_O, AVERAGE RECTIFIED FORWARD CURRENT		700 A	750 A	1000 A	1100 A
		Case 136	Case 159	Case 105	Case 158
V_{RRM} MAX PEAK REPETITIVE REVERSE VOLTAGE	100 V	MR1261	MR2081HA	MR1291	MR2101HA
	200 V	MR1263	MR2082HA	MR1293	MR2102HA
	400 V	MR1267	MR2084HA	MR1297	MR2104HA
	600 V	MR1269		MR1299	
	800 V				
	1000 V				

SILICON HIGH VOLTAGE SURMETIC RECTIFIERS

High-voltage, low-current rectifiers designed for applications where high-voltages in subminiature packages are required. These devices feature efficient high-temperature current-handling performance, high surge-current capabilities and surface passivation.



CASE 169

I_O, AVERAGE RECTIFIED FORWARD CURRENT		0.25 A
		Case 169
V_{RRM} MAX PEAK REPETITIVE REVERSE VOLTAGE	1000 V	MR990A
	1500 V	MR991A
	2000 V	MR992A
	2500 V	MR993A
	3000 V	MR994A
	4000 V	MR995A
	5000 V	MR996A

HOT-CARRIER POWER RECTIFIERS



HOT CARRIER POWER RECTIFIER

. . . utilizes the Schottky Barrier principle Barrier in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlay contact. Features are very low V_F and high-frequency capability.

Case 43(1)

Type Number	V_{RRM} Volts	Forward Current I_O $T_C = 50^oC$ Amp	Forward Current I_{FSM} Amp	I_R $T_C = 25^oC$ mA	V_F $I_F = 100$ Amp $T_C = 25^oC$ Volts
MBD5500A	20	50	800	75	0.75
f = 5.0 MHz					

(1) Available also in axial lead and DO-4 stud package.

RECTIFIER ASSEMBLIES

HIGH-VOLTAGE RECTIFIERS

Consisting of resistor-capacitor-compensated rectifier strings securely bonded and sealed into complete packages, the mounting provisions and terminal orientations of these basic legs make them adaptable for further assembly into virtually any single- and three-phase rectifier circuit configuration. Insulated mounting bars supplied with all units. See your Motorola representative for complete information.



MDA1330H
MDA1331H



MDA1332H
MDA1333H

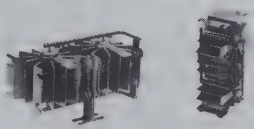
5,000 to 10,000 Volts

TYPE (1)	V_{RRM} Volts	V_r RMS Volts	I_O Amps	I_{FSM} Amps
MDA1330H	5000	3500	1.0	25
MDA1331H	10000	7000	1.0	25
MDA1332H (2)	5000	3500	2.5	250
MDA1333H (2)	10000	7000	2.5	250

(1) Add "C" for common cathode, "U" for common anode, "D" for voltage doubler.
(2) Reverse polarities available.

CIRCUIT ASSEMBLIES

Compact and thermally efficient, these medium-current rectifier stacks utilize interconnected rectifier cells securely mounted in extruded-fin aluminum heat sinks for maximum heat dissipation. Exceptional mounting versatility. Two basic circuits with more than 75 voltage-current combinations. See your Motorola representative for complete information.





Single-Phase Full-Wave Bridges
12-70 Amp, 50-700 Volts



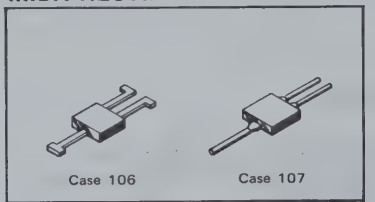
Three-Phase Full-Wave Bridges
18-88.5 Amp, 46-377 Volts

SILICON POWER RECTIFIER ASSEMBLIES

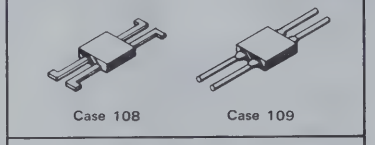
MIDA RECTIFIER ASSEMBLIES

Low-cost, standard rectifier circuits in small, integral packages providing 0.5 to 27 Amp output current with V_{RRM} ratings to 1000 Volts.

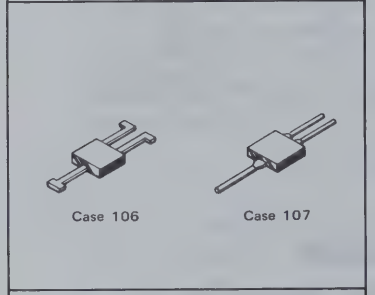
Round leads available on the MDA920 thru 950 series by adding suffix "A" to device type number (i.e. MDA920A-1).



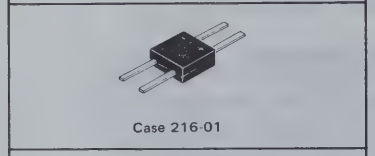
Case 106 Case 107



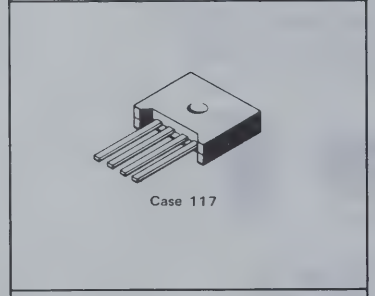
Case 108 Case 109



Case 106 Case 107



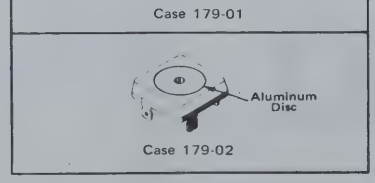
Case 216-01



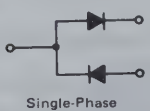
Case 117



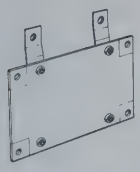
Case 179-01



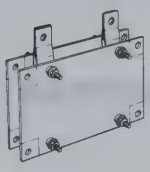
Case 179-02

CASE	TYPE		V_{RRM} Volts	I_{TSM} Amp	I_{FRM} Amp	I_{out} Amp @ °C	
106 107	 Single-Phase Voltage Doubler	MDA930-1 -2 -3 -4 -5 -6 -7	25 50 100 200 300 400 600	32	5.0	0.5	75
108 109	 Single-Phase Full-Wave Bridge	MDA920-1 -2 -3 -4 -5 -6 -7	25 50 100 200 300 400 600	32	5.0	1.0	75
106 107	 Single-Phase Center Tap Common Cathode	MDA940-1 -2 -3 -4 -5 -6 -7	25 50 100 200 300 400 600	32	5.0	1.0	75
106 107	 Single-Phase Center Tap Common Anode	MDA950-1 -2 -3 -4 -5 -6 -7	25 50 100 200 300 400 600	32	5.0	1.0	75
216 -01	 Single-Phase Full-Wave Bridge	MDA922-1 -2 -3 -4 -5 -6 -7 -8 -9	25 50 100 200 300 400 600 800 1000	60	10	1.8	40
117	 Single-Phase Full-Wave Bridge	MDA960-1 -2 -3	50 100 200	100	15	2.5	55
117	 Single-Phase Full-Wave Bridge	MDA970-1 -2 -3	50 100 200	150	25	4.0	55
179 -01	 Single-Phase Full-Wave Bridge	MDA980-1 -2 -3 -4 -5 -6	50 100 200 300 400 600	300	— — — — — —	12	55
179 -02	 Single-Phase Full-Wave Bridge	MDA990-1 -2 -3 -4 -5 -6	50 100 200 300 400 600	300	— — — — — —	27	55

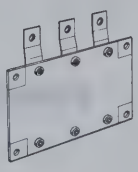
RECTIFIER ASSEMBLIES



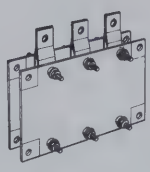
Case 154A
MRA130 Series



Case 155A
MRA130B Series



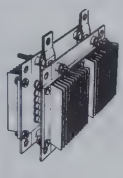
Case 154
MRA330 Series



Case 155
MRA330B Series



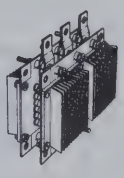
Case 156A
MRA160 Series



Case 157A
MRA160B Series



Case 156
MRA360 Series



Case 157
MRA360B Series

Table 15 — HIGH CURRENT RECTIFIER CIRCUITS

Motorola Multi-Cell II power rectifier diode circuits are air-cooled, integral-heatsink rectifier assemblies engineered for optimum diode/heatsink utilization.

TYPE	V_{RRM} Volts	DC Output Current Amperes	Configuration
MRA130 MRA131 MRA132 MRA133 MRA134	50 100 200 300 400	300 @ 1500 LFM 75 Free Convection	Single-Phase Half-Wave Bridge
MRA160 MRA161 MRA162 MRA163 MRA164	50 100 200 300 400	600 @ 1500 LFM 125 Free Convection	
MRA130B MRA131B MRA132B MRA133B MRA134B	50 100 200 300 400	300 @ 1500 LFM 75 Free Convection	Single-Phase Full-Wave Bridge
MRA160B MRA161B MRA162B MRA163B MRA164B	50 100 200 300 400	600 @ 1500 LFM 125 Free Convection	

TYPE	V_{RRM} Volts	DC Output Current Amperes	Configuration
MRA330 MRA331 MRA332 MRA333 MRA334	50 100 200 300 400	300 @ 1500 LFM 75 Free Convection	Three-Phase Half-Wave Bridge
MRA360 MRA361 MRA362 MRA363 MRA364	50 100 200 300 400	650 @ 1500 LFM 150 Free Convection	
MRA330B MRA331B MRA332B MRA333B MRA334B	50 100 200 300 400	300 @ 1500 LFM 75 Free Convection	Three-Phase Full-Wave Bridge
MRA360B MRA361B MRA362B MRA363B MRA364B	50 100 200 300 400	650 @ 1500 LFM 150 Free Convection	

Bridge assembly is designated by a "B" suffix, i.e., MRA330B. Bridges are composed of one common cathode and one common anode assembly.

Table 16 — MOLDED RECTIFIER BRIDGE ASSEMBLIES

. . . individual hermetically-sealed rectifiers interconnected and encapsulated in molded assemblies for use as single-phase and three-phase full-wave bridge configurations, with output current range from 1.5 to 16 Amp, peak reverse voltage from 50 to 600 Volts. Series MDA952, MDA962 and MDA1505 for printed circuit insertion without solder lugs (Specify "A" Suffix).



Single-Phase Full-Wave Bridge



Three-Phase Full-Wave Bridge

	 Case 110	 Case 111	 Case 112	 Case 112	 Case 113	 Case 115	 Case 116	 Case 114
V_{RRM} Volts	1.5 Amp			4.0 Amp	6.0 Amp	10 Amp	16 Amp	8.0 Amp
50	MDA942-1	MDA942A-1	MDA1491-1	MDA1591-1	MDA952-1	MDA962-1	MDA972-1	MDA1505-1
100	-2	-2	-2	-2	-2	-2	-2	-2
200	-3	-3	-3	-3	-3	-3	-3	-3
300	-4	-4	-4	-4	-4	-4	-4	-4
400	-5	-5	-5	-5	-5	-5	-5	-5
600	-6	-6	-6	-6	-6	-6		-6

POWER THYRISTORS

This List Contains Only the Most Popular Types of Thyristors Made by Motorola.

		SILICON CONTROLLED RECTIFIERS											
		1.6 AMP	4.0 AMP		8.0 AMP								
		 Case 31 Style 2 TO-5	 Plastic Case 77	 Plastic Case 90	 Plastic Case 90	 Case 85	 Case 85L	 Case 86	 Case 86L	 Case 87	 Case 87L	 Case 88	 Case 88L
BLOCKING VOLTAGE (DC OR PEAK) VOLTS	25 V	2N2322 2N4212 (1)	–	–	–	2N4151	2N4159	2N4167 MCR2315-1	2N4175	MCR2604-1	2N4183 MCR2614L-1	MCR2605-1	2N4191
	30 V	–	MCR106-1	MCR406-1 (1) MCR407-1 (2)	–	–	–	–	–	–	–	–	–
	50 V	2N1595 2N2323 (1) 2N4213 (1)	–	–	2N4441	2N4152	2N4160	2N4168 MCR2315-2	2N4176	MCR2604-2	2N4184 MCR2614L-2	MCR2605-2	2N4192
	60 V	–	MCR106-2	MCR406-2 (1) MCR407-2 (2)	–	–	–	–	–	–	–	–	–
	100 V	2N1596 2N2324 (1) 2N4214 (1)	MCR106-3	MCR406-3 (1) MCR407-3 (2)	–	2N4153	2N4161	2N4169 MCR2315-3	2N4177	MCR2604-3	2N4185 MCR2614L-3	MCR2605-3	2N4193
	150 V	2N2325 (1) 2N4215 (1)	–	–	–	–	–	–	–	–	–	–	–
	200 V	2N1597 2N2326 (1) 2N4216 (1)	MCR106-4	MCR406-4 (1) MCR407-4 (2)	2N4442	2N4154	2N4162	2N4170 MCR2315-4	2N4178	MCR2604-4	2N4186 MCR2614L-4	MCR2605-4	2N4194
	250 V	–	–	–	–	–	–	–	–	–	–	–	–
	300 V	2N1598	–	–	–	2N4155	2N4163	2N4171 MCR2315-5	2N4179	MCR2604-5	2N4187 MCR2614L-5	MCR2605-5	2N4195
	400 V	2N1599	–	–	2N4443	2N4156	2N4164	2N4172 MCR2315-6	2N4180	MCR2604-6	2N4188 MCR2614L-6	MCR2605-6	2N4196
	500 V	–	–	–	–	2N4157	2N4165	2N4173	2N4181	MCR2604-7	2N4189	MCR2605-7	2N4197
	600 V	–	–	–	2N4444	2N4158	2N4166	2N4174	2N4182	MCR2604-8	2N4190	MCR2605-8	2N4198
	700 V	–	–	–	–	–	–	–	–	–	–	–	–
	800 V	–	–	–	–	–	–	–	–	–	–	–	–

(1) Sensitive gate devices.

(2) Relaxed specification version.

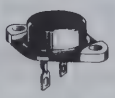
(3) Formerly MCR2818 and MCR2918, -2, -4, -6, -8 respectively.

(4) Available without lugs — Case 54, TO-3 (Pin) Package.

(5) Gate trigger specification in two modes only.

NOTES:

1. Reverse polarity available (add Suffix "R", i.e., 2N5164R).
2. MCR1907-1 thru MCR1907-6 (12 μs max t_{off}).
3. Meets (the requirements of) MIL-S-19500/372.

		SILICON CONTROLLED RECTIFIERS							
		16 AMP	20 AMP		25 AMP			35 AMP	
									
		Case 64 TO-48	Case 174	Case 175	Case 174 TO-41 (4)		Case 175 (Note 2)	Case 174	Case 175
BLOCKING VOLTAGE (DC OR PEAK) VOLTS	25 V	2N1842	MCR3818-1	MCR3918-1	MCR649-1	2N2573	2N681 MCR1907-1	MCR3835-1	MCR3935-1
	30 V	–	–	–	–	–	–	–	–
	50 V	2N1843	2N5164 (3)	2N5168 (3)	MCR649-2	2N2574	2N682 MCR1907-2	MCR3835-2	MCR3935-2
	60 V	–	–	–	–	–	–	–	–
	100 V	2N1844	MCR3818-3	MCR3918-3	MCR649-3	2N2575	2N683 MCR1907-3	MCR3835-3	MCR3935-3
	150 V	2N1845	–	–	–	–	2N684	–	–
	200 V	2N1846	2N5165 (3)	2N5169 (3)	MCR649-4	2N2576	2N685 MCR1907-4	MCR3835-4	MCR3935-4
	250 V	2N1847	–	–	–	–	2N686	–	–
	300 V	2N1848	MCR3818-5	MCR3918-5	MCR649-5	2N2577	2N687 MCR1907-5	MCR3835-5	MCR3935-5
	400 V	2N1849	2N5166 (3)	2N5170 (3)	MCR649-6	2N2578	2N688 MCR1907-6	MCR3835-6	MCR3935-6
	500 V	2N1850	MCR3818-7	MCR3918-7	MCR649-7	2N2579	2N689	MCR3835-7	MCR3935-7
	600 V	–	2N5167 (3)	2N5171 (3)	–	–	–	MCR3835-8	MCR3935-8
	700 V	–	–	–	–	–	–	–	–
	800 V	–	–	–	–	–	–	–	–

PULSE MODULATOR SCRS			
50 AMP (Pulse)	100 AMP (Pulse)	300 AMP (Pulse)	1000 AMP (Pulse)
			
Case 31 Style 2 TO-5	Fast Switching Case 63 (Note 3)		Fast Switching Case 64 TO-48
–	–	–	–
–	–	–	–
–	–	–	–
–	–	–	–
–	–	–	–
–	–	–	–
MCR2130-4	–	–	–
–	–	–	–
MCR2130-5	2N4199 / JAN2N4199	MCR1336-5	MCR1718-5
MCR2130-6	2N4200 / JAN2N4200	MCR1336-6	MCR1718-6
MCR2130-7	2N4201 / JAN2N4201	MCR1336-7	MCR1718-7
MCR2130-8	2N4202 / JAN2N4202	MCR1336-8	MCR1718-8
MCR2130-9	2N4203 / JAN2N4203	MCR1336-9	–
MCR2130-10	2N4204 / JAN2N4204	MCR1336-10	–

TRIACS – SILICON BIDIRECTIONAL THYRISTORS						
8.0 AMP	10 AMP			25 AMP		
						
Plastic Case 90	Case 85	Case 86	Case 87L	Case 174	Case 175	
MAC10-1 / MAC11-1(5)	–	–	–	MAC35-1 / MAC37-1(5)	MAC36-1	25 V
–	–	–	–	–	–	30 V
MAC10-2 / MAC11-2(5)	MAC1-2 / MAC4-2 (5)	MAC2-2 / MAC5-2 (5)	MAC3-2 / MAC6-2 (5)	MAC35-2 / MAC37-2(5)	MAC36-2	50 V
–	–	–	–	–	–	60 V
MAC10-3 / MAC11-3(5)	–	–	–	MAC35-3 / MAC37-3(5)	MAC36-3	100 V
–	–	–	–	–	–	150 V
MAC10-4 / MAC11-4(5)	MAC1-4 / MAC4-4 (5)	MAC2-4 / MAC5-4 (5)	MAC3-4 / MAC6-4 (5)	MAC35-4 / MAC37-4(5)	MAC36-4	200 V
–	–	–	–	–	–	250 V
MAC10-5 / MAC11-5(5)	–	–	–	MAC35-5 / MAC37-5(5)	MAC36-5	300 V
MAC10-6 / MAC11-6(5)	MAC1-6 / MAC4-6 (5)	MAC2-6 / MAC5-6 (5)	MAC3-6 / MAC6-6 (5)	MAC35-6 / MAC37-6(5)	MAC36-6	400 V
MAC10-7 / MAC11-7(5)	–	–	–	MAC35-7 / MAC37-7(5)	MAC36-7	500 V
MAC10-8 / MAC11-8(5)	–	–	–	–	–	600 V
–	–	–	–	–	–	700 V
–	–	–	–	–	–	800 V

(5) Gate Trigger specifications in two modes only.
Note 3 – Meets (the requirements of) MIL-S-19500/372.

SIGNAL THYRISTORS

Motorola's Signal Thyristor category covers small signal SCRs (less than 1.5 A) as well as thyristor triggering devices and unijunction transistors.

All devices are oxide passivated for superior reliability and parameter uniformity.

Motorola's unijunction transistors are manufactured by the modern Silicon Annular process. The annular process yield devices having low-emitter reverse current, fast switching time, and low peak-point currents.

The user is urged to contact the nearest Motorola regional office for any special electrical requirements as well as complete specifications for all devices listed.

For prices, contact your nearest Motorola sales office.

SMALL SIGNAL THYRISTORS (FORWARD CURRENT RMS = 800 mA)



Plastic

Case 29(10)
TO-92

TYPE NUMBER	V_{DRM} or V_{RRM} Forward or Reverse Blocking Voltage	I_H Holding Current Anode Voltage = 7.0 V		I_{GT} Gate Trigger Current Anode Voltage = 7.0 V R_L = 100 Ohms		V_{GT} Gate Trigger Voltage Anode Voltage = 7.0 V R_L = 100 Ohms		V_{GD} @ Rated V_{DRM}, R_L = 100 Ohms
		T_C = 25°C @ Max	T_C = −65°C Max	T_C = 25° @ Max	T_C = −65°C Max	T_C = 25°C @ Max	T_C = −65°C Max	T_C = 125°C Min
	Max							
	Volts	mA	mA	μAdc	μAdc	Volt	Volts	Volt
2N5060	30	5.0	10	200	350	0.8	1.2	0.1
2N5061	60	↓	↓	↓	↓	↓	↓	↓
2N5062	100							
2N5063	150							
2N5064	200							
								T_C = 85°C
MCR101	15				—			0.1
MCR102	30				—			↓
MCR103	60				—			
MCR104	100				—			
								T_C = 110°C
MCR115	150				—			0.1
MCR120	200				—			0.1

UNIJUNCTION TRANSISTORS



Case 29(9)
(TO-92)



Case 28(7)

Type Number	η Intrinsic Standoff Ratio Min	Max	I_P Peak Point Emitter Current	I_{EB20} Emitter Reverse Current	I_V Valley Point Current	V_{B2B1} Interbase Voltage	P_D Power Dissipation
			μA (Max)	μA (Max)	mA (Min)	Volts (Max)	mW (Max)
2N4870	0.56	0.75	5.0	1.0	2.0	35	300
2N4871	0.70	0.85	5.0	1.0	4.0	35	↓
MU4891	0.55	0.82	5.0	0.01	2.0	—	
MU4892	0.51	0.69	2.0	↓	↓	—	
MU4893	0.55	0.82	2.0			—	
MU4894	0.74	0.86	1.0			—	
MU851	0.56	0.75	2.0	0.1	2.0	28	200
MU852	0.70	0.85	2.0	0.1	4.0	28	200
MU853	0.70	0.85	0.4	0.05	4.0	28	200



Case 22A
(TO-18)

2N2646	0.56	0.75	5.0	12.0	4.0	35	300
2N2647	0.68	0.82	2.0	0.2	8.0	↓	300
2N3980	0.68	0.82	2.0	0.01	1.0		360
2N4851	0.56	0.75	2.0	0.1	2.0		300
2N4852	0.70	0.85	2.0	0.1	4.0		300
2N4853	0.70	0.85	0.4	0.05	6.0	35	300
2N4948	0.55	0.82	2.0	0.01	2.0	—	360
JAN2N4948 (1)	0.55	0.82	2.0	↓	↓	—	↓
2N4949	0.74	0.86	1.0			—	
JAN2N4949 (1)	0.74	0.86	1.0			—	
2N5431	0.72	0.80	0.4			35	300

(1) Meets (the requirement of) MIL-S-19500/388



Case 29



Case 51



Case 182

PROGRAMMABLE UNIJUNCTION TRANSISTORS – PUT

	Type No.	I_P Peak Current R_G = 10 kΩ μA (Min)	I_P Peak Current R_G = 1.0 MΩ μA (Max)	I_{GAO} Leakage Current @ 40 V nA (Max)	I_V Valley Current R_G = 10 kΩ μA (Min)	I_V Valley Current R_G = 1.0 MΩ μA (Max)	V_{GKF} Gate to Cathode Forward Voltage Volts (Max)	P_D mW	V_O Min Output Voltage Volts	V_F Forward Voltage Volts	V_F @ I_F mA	I_F DC Anode Current mA (Max)	$I_{F(pulse)}$ Peak Anode Current 20 μs 1.0% DC Amp (Max)	t_r Pulse Rate of Rise ns	T_J Operating Junction Temp. Range °C
Case 29-02 (TO-92)	MPU131	5.0	2.0	5.0	70	50	40	375	6.0	1.5	50	200	2.0	80	−50 to +100
	MPU132	2.0	0.3	5.0	50	50	40	375	6.0	1.5	50	200	2.0	80	
	MPU133	1.0	0.15	5.0	50	25	40	375	6.0	1.5	50	200	2.0	80	

SILICON BIDIRECTIONAL SWITCH – SBS Case 29(12)

Type	V_S Switching Voltage Vdc (Min)	V_S Switching Voltage Vdc (Max)	$\lvert V_{S1} - V_{S2} \rvert$ Switching Voltage Differential Vdc (Max)	I_S Switching Current μAdc (Max)	I_H Holding Current mAdc (Max)	V_F Forward ON-State Voltage (1) I_F = 175 mAdc (2) I_F = 200 mAdc Volts (Max)
MBS4991	6.0	10	0.5	350	1.5	1.7 (1)
MBS4992	7.5	9.0	0.2	120	0.5	1.7 (2)

SILICON UNIDIRECTIONAL SWITCH – SUS Case 29(10)

Type	V_S Switching Voltage Volts (Min)	V_S Switching Voltage Volts (Max)	I_S Switching Current μA (Max)	I_H Holding Current mA	V_F Forward Voltage I_F = 175 mA (1) I_F = 200 mA (2)	I_B @ 5.0 V Forward Blocking Current μA	P_F Power Dissipation mW	V_{AKR} Reverse Voltage Volts (Max)	V_O Peak Pulse Voltage Volts (Min)	$I_{F(rep)}$ Peak Recurrent Forward Current T_A = 100°C, tp = 10 μs 1.0% duty cycle Amp
MUS4987	6.0	10	500	1.5	1.5 (1)	1.0	300	30	3.5	1.0
MUS4988	7.5	9.0	150	0.5	1.5 (2)	0.1	350	30	3.5	1.0

BILATERAL TRIGGER DIACS Case 182

Type	$V_{(BR)}$ Breakover Voltage (Both Directions) Volts (nom)	ΔV Switchback Voltage (Both Directions) Volts (Min)	$I_{(BR)}$ Breakover Current (Both Directions) μA (Max)	I_{pulse} Peak Pulse Current @ 30 μs, 120 Hz Amp (Max)
MPT20	20	5.0	100	2.0
MPT28	28	7.0	50	2.0
MPT32	32	7.0	50	2.0

4-LAYER DIODES (PEAK PULSE CURRENT = 10 Amp @ PW = 50 μs Max, I_F = 150 mA Max) Case 51

Type	$I_{(BR)F}$ @ $V_{(BR)F}$ Switching Current T_A = 25°C μA (Max)	I_H Holding Current T_A = 25°C mA (Min)	I_H Holding Current T_A = 25°C mA (Max)	$V_{(BR)F}$ Forward Breakover Voltage T_A = 25°C Volts (Min)	$V_{(BR)F}$ Forward Breakover Voltage T_A = 25°C Volts (Max)
1N5158 (M4L3052)	50	1.0	20	8.0	10
1N5159 (M4L3053)	50	1.0	20	9.0	11
1N5160 (M4L3054)	50	1.0	20	10	12
M4L3055	50	1.0	20	11	13
M4L3056	50	1.0	20	12	14

FIELD-EFFECT TRANSISTORS

Motorola offers a line of field-effect transistors encompassing the latest technology and covering the entire gamut of potential applications. Included is a wide variety of junction FETs and MOSFETs, with N- or P-channel polarity. These FETs include devices optimized for operation from dc to UHF in switching and amplifying applications.

Moreover, an exclusive silicon-nitride passivation process now being employed on all Motorola MOSFETs has greatly improved MOSFET threshold stability with aging and temperature change. This process also reduces susceptibility to damage from static-charge buildup during handling because of its increased voltage breakdown capability. All Motorola single-gate MOSFETs have transient gate breakdown voltages of greater than ±150 Vdc peak (typical).

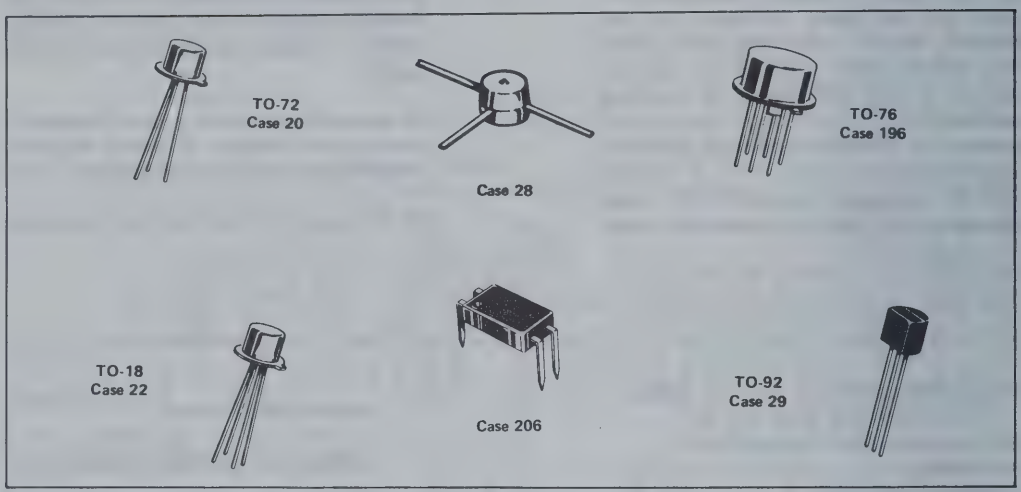
The selection tables in this guide are designed to permit a rapid selection of specific field-effect transistors for a variety of applications.

Six tables cover the major application categories:

RF Amplifiers and Mixers **Table 1** . . . high performance single and dual gate devices specifically designed for RF applications	**Table 4** **General-Purpose Switches** . . . these devices are suitable for medium-speed switching applications.
Choppers **Table 2** . . . FETs have no offset voltage, and as a result, they are particularly well suited for chopper applications.	**Matched Pairs** **Table 5** . . . pairs of carefully matched devices for critical applications such as differential-amplifier service.
General-Purpose Amplifiers **Table 3** . . . N- and P-channel field-effect transistors designed for small-signal amplification at low and moderate frequencies (to 30 MHz)	**Table 6** **Micro-T Transistor** . . . where high density packaging is required.

The information in the tables is necessarily brief to simplify selection. Complete specifications for these devices are given in the data sheet section of the Motorola Semiconductor Data Book and in individual data sheets.

INDEX to MOTOROLA FIELD-EFFECT TRANSISTORS



The following table lists the Motorola field-effect transistors with reference to selection tables. Package identification is included in this table only.

All TO-72 packages, except: † TO-18, ‡ TO-92, § TO-76, # Case 28, and *Case 206

Device Type	Table	Device Type	Table	Device Type	Table	Device Type	Table	Device Type	Table
2N3330	3	2N4392†	2	2N5461‡	3	2N5718	3	MFE3002	2
2N3796†	3	2N4393†	2	2N5462‡	3	3N124	3,4	MFE3003	2
2N3797†	3	2N4416	1	2N5463‡	3	3N125	3,4	MFE3004	1
2N3821	3	2N4856†	2	2N5464‡	3	3N126	3,4	MFE3005	1
2N3822	3	2N4856A†	2	2N5465‡	3	3N140	1	MFE3006	1
2N3823	1	2N4857†	2	2N5471	3	3N155	2,4	MFE3007	1
2N3824	4	2N4857A†	2	2N5472	3	3N155A	2,4	MFE3008	1
2N3909	3	2N4858†	2	2N5473	3	3N156	2,4	MFE3020§	2
2N3909A	3	2N4858A†	2	2N5474	3	3N156A	2,4	MFE3021§	2
2N3970†	2	2N4859†	2	2N5475	3	3N157	3	MFE4007	3
2N3971†	2	2N4859A†	2	2N5476	3	3N157A	3	MFE4008	3
2N3972†	2	2N4860†	2	2N5484‡	1,3	3N158	3	MFE4009	3
2N3993	3	2N4860A†	2	2N5485‡	1,3	3N158A	3	MFE4010	3
2N3994	3	2N4861†	2	2N5486‡	1,3	3N169	4	MFE4011	3
2N3994A	3	2N4861A†	2	2N5555‡	2,4	3N170	4	MFE4012	3
2N4066§	3	2N5265	3	2N5556	3	3N171	4	MMF1	5
2N4067§	3	2N5266	3	2N5557	3	MFE2000	1	MMF2	5
2N4091†	2	2N5267	3	2N5558	3	MFE2001	1	MMF3	5
2N4092†	2	2N5268	3	2N5592	3	MFE2004†	2	MMF4	5
2N4093†	2	2N5269	3	2N5593	3	MFE2005†	2	MMF5	5
2N4220	3,4	2N5270	3	2N5594	3	MFE2006†	2	MMF6	5
2N4220A	3,4	2N5358	3	2N5638‡	2	MFE2007†	2	MMT3823#	6
2N4221	3,4	2N5359	3	2N5639‡	2	MFE2008†	2	MPF102‡	1,3
2N4221A	3,4	2N5360	3	2N5640‡	2	MFE2009†	2	MPF108‡	1
2N4222	3,4	2N5361	3	2N5653‡	2	MFE2010†	2	MPF109‡	3
2N4222A	3,4	2N5362	3	2N5654‡	2	MFE2011†	2	MPF111‡	3
2N4223	1	2N5363	3	2N5668‡	1	MFE2012†	2	MPF112‡	3
2N4224	1	2N5364	3	2N5669‡	1	MFE2093	3,4	MPF120*	1
2N4342‡	3	2N5457‡	3	2N5670‡	1	MFE2094	3,4	MPF121*	1
2N4351	4	2N5458‡	3	2N5716	3	MFE2095	3,4	MPF122*	1
2N4352	4	2N5459‡	3	2N5717	3	MFE3001	3	MPF161‡	3
2N4391†	2	2N5460‡	3						

TABLE 1

RF AMPLIFIERS AND MIXERS

High performance single and dual gate devices specifically designed for RF applications. The transistors are listed first in order of decreasing specified test frequency; then in order of decreasing power gain (G_{ps}) and noise figure (NF).

Type Number	Test Frequency MHz	G_{ps} dB min	NF dB max	C_{rss} pF max	C_{oss} pF max	Comments
N-CHANNEL J FETs (Type A)						
2N4416	400	10	4.0	0.8	2.0	
2N5486	400	10	4.0	1.0	2.0	
2N5485	400	10	4.0	1.0	2.0	
MFE2000	400	10	4.0	1.0	2.0	
MFE2001	400	10	4.0	1.0	2.0	
2N3823	100	–	2.5	2.0	–	
2N4223	200	10	5.0	2.0	–	
2N4224	200	–	–	2.0	–	
2N5484	100	16	3.0	1.0	2.0	
2N5668	100	16	2.5	3.0	4.0	
2N5669	100	16	2.5	3.0	4.0	
2N5670	100	16	2.5	3.0	4.0	
MPF102	100	–	–	3.0	–	
MPF108	100	–	3.0	2.5	–	Box Sort, Color Coded 2:1 I_{DSS} Ratios
N-CHANNEL MOS FETs (Type B)						
MFE3005	400	10	4.5	0.2	–	
MFE3007	200	18	4.0	0.02†	3.5	Dual Gate
MPF121	200	17	5.0	0.023†	3.5	Dual Gate
3N140	200	16	4.5	0.03	–	Dual Gate
MFE3004	200	16	4.5	0.2	–	
MPF122	200	12‡	–	0.023†	4.0	Dual Gate-Mixer
MPF120	105	17	5.0	0.023†	4.0	Dual Gate
MFE3006	100	20	4.5	0.02†	4.0	Dual Gate
MFE3008	100	14‡	–	0.02†	4.0	Dual Gate – Mixer
MPF121	60	20	5.0	0.023†	3.5	Dual Gate
MPF122	60	15‡	–	0.023†	4.0	Dual Gate – Mixer

†Typical
‡Conversion Gain, Output frequency = 30 MHz

TABLE 2

CHOPPERS

Because FETs have no offset voltage they are particularly well suited for chopper applications. Devices in this table are designed for low $r_{ds(on)}$, low C_{rss} and fast switching time. The FETs are listed first in order of decreasing $V_{(BR)GSS}$, increasing $r_{ds(on)}$, then in order of increasing C_{rss} and I_{DSS}.

Type Number	$V_{(BR)GSS}$ Volts min	$r_{ds(on)}$ Ohms max	C_{rss} pF max	I_{DSS} mA min	$I_{D(off)}$ nA max
N-CHANNEL J FETs (Type A)					
2N4856A	–40	25	4.0	50	0.25
2N4856		25	8.0	50	0.25
2N4391		30	3.5	50	0.1
2N4091		30	5.0	30	0.2
2N3970		30	6.0	50	0.25
2N4857A		40	3.5	20	0.25
2N4857		40	8.0	20	0.25
2N4092		50	5.0	15	0.2
2N4392		60	3.5	25	0.1
2N4858A		60	3.5	8.0	0.25
2N3971		60	6.0	25	0.25
2N4858		60	8.0	8.0	0.25
2N4093		80	5.0	8.0	0.2
2N4393		100	3.5	5.0	0.1
2N3972		100	6.0	5.0	0.25
2N4859A	–30	25	4.0	50	0.25
2N4859		25	8.0	50	0.25
2N5638		30	4.0	50	1000
MFE2006		30	5.0	30	0.2
2N4860A		40	3.5	20	0.25
2N4860		40	8.0	20	0.25
2N5653		50	3.5	40	1.0
MFE2005		50	5.0	15	0.2
2N4861A		60	3.5	8.0	0.25
2N5639		60	4.0	25	1000
2N4861	-30	60	8.0	8.0	0.25
MFE2004		80	5.0	8.0	0.2
2N5654		100	3.5	15	1.0
2N5640		100	4.0	5.0	1000
MFE2012	–25	10	20	100	3.0
MFE2011		15	20	40	3.0
MFE2009		20	15	50	2.0
MFE2010		25	20	15	3.0
MFE2008		30	15	20	2.0
MFE2007		40	15	8.0	3.0
2N5555§		150	1.2	15	10
N-CHANNEL MOS FETs (Type C)					
MFE3002	±30	100	1.0	10†	–
3N169#	±25	200	1.3	10†	–
3N170#		200	1.3	10†	–
3N171#		200	1.3	10†	–
P-CHANNEL MOS FETs (Type C)					
3N155A*	±35	300	1.3	0.25†	–
3N156A*		300	1.3	0.25†	–
3N155*		600	1.3	1.0†	–
3N156*		600	1.3	1.0†	–
MFE3003	±30	200	1.0	10†	–
MFE3020	-25	500	1.5	10†	–
MFE3021	-25	250	1.5	10†	–

†nA max *Designers Data Sheet # Low $V_{GS(th)}$, High Speed § High Speed, $t_{(on)}$ = 10 ns max ‡$V_{(BR)DSS}$

TABLE 3

GENERAL-PURPOSE AMPLIFIERS

This table includes a wide selection of N- and P-channel field-effect transistors designed for small-signal amplification at low and moderate frequencies (to 30 MHz). The transistors are listed in order of increasing Gate-Source Breakdown Voltage [$V_{(BR)GSS}$], then in order of decreasing Zero-Gate Voltage Drain Current (I_{DSS}) and Forward Transfer Admittance (y_{fs}).

Type Number	Volts min	I_{DSS} mA min/max	$\lvert y_{fs}\rvert$ µmhos min/max	Comments
N-CHANNEL J FETs (Type A)				
MPF111	−20	0.5/20	500/—	
2N5486	−25	8.0/20	4000/8000	Formerly MPF10777
2N5459		4.0/16	2000/6000	Formerly MFP105
2N5485		4.0/10	3500/7000	Formerly MPF106
2N5458		2.0/9.0	1500/5500	Formerly MPF104
MPF102		2.0/20	2000/7500	
MPF112		1.0/25	1000/7500	
2N5457		1.0/5.0	1000/5000	Formerly MPF103
2N5484		1.0/5.0	3000/6000	
MPF109		0.5/24	800/6000	2:1 I_{DSS} Ratio Box Sort, Color Coded
2N4222	−30	5.0/15	2500/6000	
2N4222A		5.0/15	2500/6000	Low Noise
2N5558		4.0/10	1500/6500	Low Noise
2N4221		2.0/6.0	2000/5000	
2N4221A		2.0/6.0	2000/5000	Low Noise
2N5557		2.0/5.0	1500/6500	Low Noise
2N4220		0.5/3.0	1000/4000	
2N4220A		0.5/3.0	1000/4000	Low Noise
2N5556		0.5/2.5	1500/6500	Low Noise
2N5364*	−40	9.0/18	2700/6500	
2N5363*		7.0/14	2500/6000	
2N5362*		4.0/8.0	2000/5500	
2N5361*		2.5/5.0	1500/4500	2:1 I_{DSS} Ratios
2N5360*		1.5/3.0	1400/3200	
2N5359*		0.8/1.6	1200/3600	
2N5718		0.8/4.0	500/2000	
2N5358*		0.5/1.0	1000/3000	
2N5717		0.2/1.0	400/1600	
2N5716		0.05/0.25	200/1000	
3N126	−50	3.0/9.0	1200/3600	Tetrode Connected
2N3822		2.0/10	3000/6500	
3N125		1.5/4.5	800/2400	Tetrode Connected
2N5592		1.0/10	2000/7000	Low Noise
2N5593		1.0/10	2000/7000	Low Noise
2N5594		1.0/10	2000/7000	Low Noise
MFE2095		1.0/3.0	400/800	
2N3821		0.5/2.5	1500/4500	
MFE2094		0.4/1.4	350/700	
3N124		0.2/2.0	500/2000	Tetrode Connected
MFE2093		0.1/0.7	250/500	
N-CHANNEL MOS FETs (Type B)				
2N3797	±30	2.0/6.0	1500/3000	I_{GSS} = 1.0 pAdc (max)
MFE3001	±30	0.5/6.0	700/3500	
2N3796	±30	0.5/3.0	900/1800	I_{GSS} = 1.0 pAdc (max)

Type Number	Volts min	I_{DSS} mA min/max	$\lvert y_{fs}\rvert$ µmhos min/max	Comments
P-CHANNEL J FETs (Type A)				
2N3909A		1.0/15	2200/5000	
2N3909		0.3/15	1000/5000	
2N3330		—	1500/3000	
2N3993		10/—	6000/12000	
2N4342		4.0/12	2000/6000	
2N3994A		2.0/—	5000/10000	
2N3994		2.0/—	4000/10000	
MFE4012*	+40	7.0/14	2500/5000	2:1 I_{DSS} Ratio,
2N5462		4.0/16	2000/6000	Formerly MPF153
MFE4011*		4.0/8.0	2200/4500	2:1 I_{DSS} Ratio,
2N5460		1.0/5.0	1000/4000	Formerly MPF151
2N5476		0.8/2.0	260/650	
MFE4008*		0.8/1.6	1000/3000	2:1 I_{DSS} Ratio,
MPF161		0.5/14	800/6000	2:1 I_{DSS} Ratio,
MFE4007		0.5/1.0	900/2700	2:1 I_{DSS} Ratio,
2N5475		0.4/1.0	200/500	2.5:1 I_{DSS} Ratio
2N5474		0.2/0.5	160/400	2.5:1 I_{DSS} Ratio
2N5473		0.1/0.25	120/300	2.5:1 I_{DSS} Ratio
2N5472		0.05/0.12	90/225	2.5:1 I_{DSS} Ratio
2N5471		0.02/0.06	60/180	2.5:1 I_{DSS} Ratio
2N5270*	+60	7.0/14	2500/5000	2:1 I_{DSS} Ratio,
2N5465		4.0/16	2000/6000	Formerly MPF156
2N5269*		4.0/8.0	2200/4500	2:1 I_{DSS} Ratio,
2N5268*		2.5/5.0	2000/4000	2:1 I_{DSS} Ratio,
2N5464		2.0/9.0	1500/5000	Formerly MPF155
2N5267*		1.5/3.0	1500/3500	2:1 I_{DSS} Ratio,
2N5463		1.0/5.0	1000/4000	Formerly MPF154
2N5266*		0.8/1.6	1000/3000	2:1 I_{DSS} Ratio,
2N5265*		0.5/1.0	900/2700	2:1 I_{DSS} Ratio,
P-CHANNEL MOS FETs (Type C)				
3N157*	±35	−/1.0†	1000/4000	
3N158*	±35	−/1.0†	1000/4000	
2N4066	±30	−/1.0†	1500/—	Monolithic Dual
2N4067	±30	−/1.0†	2500/—	Monolithic Dual
3N157A*	±50	−/0.25†	1000/4000	
3N158A*	±50	−/0.25†	1000/4000	

†nAdc
*Designers Data Sheet

TABLE 4
GENERAL-PURPOSE SWITCHES

The devices in this table have low feedback capacitances (C_{rss}) and relatively low drain-source resistance, [$r_{ds(on)}$], making them suitable for medium-speed switching applications. The transistors are listed first in order of decreasing Gate-Source Breakdown Voltage [$V_{(BR)GSS}$], then in order of increasing $r_{ds(on)}$, decreasing gate cutoff voltage [$V_{GS(off)}$ or $V_{GS(th)}$] and decreasing I_{DSS}.

Type Number	$V_{(BR)GSS}$ Volts min	$r_{ds(on)}$ Ohms max	$V_{GS(off)}$ $V_{GS(th)}$* Volts max	I_{DSS} $I_{D(on)}$* mA min	Comments
N-CHANNEL J FETs (Type A)					
2N3824	−50	250	8.0	–	
3N126	↓	500	6.5	3.0	Tetrode Connected
3N125		750	4.0	1.5	Tetrode Connected
3N124		1000	2.5	0.2	Tetrode Connected
MFE2095		1300	5.5	1.0	
MFE2094		1600	4.5	0.4	
MFE2093		2500	2.5	0.1	
2N4222	−30	300	8.0	5.0	
2N4222A	↓	300	8.0	5.0	Low Noise
2N4221		400	6.0	2.0	
2N4221A		400	6.0	2.0	Low Noise
2N4220		500	4.0	0.5	
2N4220A		500	4.0	0.5	Low Noise
2N5555	−25	150	–	15	High Speed $t_{(on)}$ = 10 ns max
N-CHANNEL MOS FETs					
2N4351	±30	300	5.0*	3.0*	Complement to 2N4352
3N169	↓ ±25	200	1.5*	10*	Low $V_{GS(th)}$, High Speed
3N170		200	2.0*	10*	Low $V_{GS(th)}$, High Speed
3N171		200	3.0*	10*	Low $V_{GS(th)}$, High Speed
P-CHANNEL MOS FETs					
3N156A†	±35	300	5.0*	5.0*	
3N155A†	↓	300	3.2*	5.0*	
3N156†		600	5.0*	5.0*	
3N155†		600	3.2*	5.0*	
2N4352	±30	600	5.0*	3.0*	Complement to 2N4351

†Designers Data Sheet

TABLE 5
MATCHED PAIRS

Each type number in this table represents a pair of devices carefully matched for critical applications such as differential-amplifier service. Each pair is packaged in a metal clip to maintain pair identity.

I_{DSS} mA min/max	$\lvert y_{fs}\rvert$ µmhos min	$\lvert y_{os}\rvert$ µmhos max	C_{rss} pF max	NF dB max	$V_{(BR)GSS}$ Volts min
0.5/10	1500	50	2.0	2.5	30

MATCHING CHARACTERISTICS

Type Number	$\frac{\Delta\lvert V_{GS1} - V_{GS2}\rvert}{\Delta T}$ max µV/°C	$\lvert V_{GS1} - V_{GS2}\rvert$ mV max	$\lvert I_{G1} - I_{G2}\rvert$ nA max	$\frac{\lvert y_{fs1}\rvert}{\lvert y_{fs2}\rvert}$ min
MMF1	10	5.0	10	0.98
MMF2	10	↓	↓	0.98
MMF3	25			0.95
MMF4	25			↓
MMF5	50			
MMF6	50			

Note: See Index Table for package identification.

TABLE 6
MICRO-T FIELD-EFFECT TRANSISTOR N-CHANNEL

Field-Effect Transistor designed for RF amplifier applications where high density packaging is required.

N-CHANNEL J FET (Type A)

TYPE	$V_{(BR)GSS}$ min Volts	I_{DSS} min/max mA	C_{rss} typ pF	$Re(y_{is})$ typ µmhos	NF @ f typ dB	MHz
MMT3823	−30	5.0/20	1.0	500	2.0	100

GERMANIUM POWER TRANSISTORS

This selector guide reflects the "preferred" Motorola germanium power transistors and can be used as a quick reference to find the best device for your applications.

FOR MILITARY APPLICATIONS

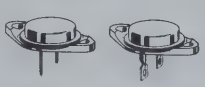
JAN 2N174A	MIL-S-19500/13	JAN 2N1412	MIL-S-19500/76	JAN 2N1554A	MIL-S-19500/331
JAN 2N297A	MIL-S-19500/36	JAN 2N1412A	MIL-S-19500/76	JAN 2N1555A	MIL-S-19500/331
JAN 2N665	MIL-S-19500/58	JAN 2N1549A	MIL-S-19500/332	JAN 2N1556A	MIL-S-19500/331
JAN 2N1011	MIL-S-19500/67	JAN 2N1550A	MIL-S-19500/332	JAN 2N2079A	MIL-S-19500/340
JAN 2N1120	MIL-S-19500/68	JAN 2N1551A	MIL-S-19500/332	JAN 2N2528	MIL-S-19500/309
JAN 2N1165	MIL-S-19500/178	JAN 2N1552A	MIL-S-19500/332	JAN 2N2834	MIL-S-19500/310
JAN 2N1358	MIL-S-19500/122	JAN 2N1553A	MIL-S-19500/331		

Also available as standard devices.

ALLOY TRANSISTORS

Low-cost devices featuring high current gain and low saturation voltage.

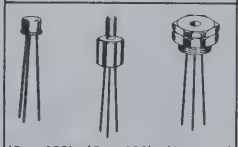
3-AMP



TO-3 (Case 11) TO-41(α) (Case 4-04)

HIGH-FREQUENCY DRIVER
LOW I_{CBO}
$P_D = 70$ W
$f_T = 0.4$ MHz

h_{FE} $I_C = 0.5$ A, $V_{CE} = 2.0$ V	V_{CES} / V_{CB}	30 V	45 V	60 V	75 V	90 V
30-60		2N2137	2N2138	2N2139	2N2140	2N2141
50-100		2N2142	2N2143	2N2144	2N2145	2N2146

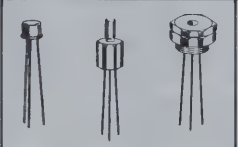


(Case 180) (Case 183) (Case 184)

HIGH-FREQUENCY DRIVER
$P_D = 20$ W

h_{FE} $I_C = 1.0$ A, $V_{CE} = 0.5$ V	V_{CEO} / V_{CB}	30 V / 40 V	40 V / 60 V	50 V / 80 V	60 V / 100 V	
20-60		2N1038	2N1039	2N1040	2N1041	
		2N2552	2N2553	2N2554	2N2555	
		2N2556	2N2557	2N2558	2N2559	

3.5 AMP



(Case 180) (Case 183) (Case 184)

HIGH-FREQUENCY DRIVER
$P_D = 20$ W

h_{FE} $I_C = 3.0$ A, $V_{CE} = 1.0$ V	V_{CEO} / V_{CB}	30 V / 40 V	40 V / 60 V	50 V / 80 V	60 V / 100 V	
20-60		2N1042	2N1043	2N1044	2N1045	
		2N2560	2N2561	2N2562	2N2563	
		2N2564	2N2565	2N2566	2N2567	

5-AMP



TO-3 (Case 11)

GENERAL-PURPOSE SWITCH AND AMPLIFIER
$P_D = 106$ W
$f_T = 0.25$ MHz

h_{FE} $I_C = 3.0$ A, $V_{CE} = 2.0$ V	V_{CES} / V_{CB}	30 V / 40 V	45 V / 60 V	60 V / 80 V	75 V / 100 V	90 V / 120 V
20-40		2N1529	2N1530	2N1531	2N1532	2N1533
35-70		2N1534	2N1535	2N1536	2N1537	2N1538



TO-41(α) (Case 4-04)

HIGH-GAIN GENERAL-PURPOSE SWITCH AND AMPLIFIER
$P_D = 106$ W
$f_T = 0.35$ MHz

h_{FE} $I_C = 3.0$ A, $V_{CE} = 2.0$ V	V_{CES} / V_{CB}	30 V / 40 V	45 V / 60 V	60 V / 80 V	75 V / 100 V	90 V / 120 V
50-100		2N1539	2N1540	2N1541	2N1542	2N1543
75-150		2N1544	2N1545	2N1546	2N1547	2N1548

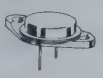
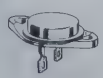
ALLOY TRANSISTORS

7-AMP

(See Notes on Page 28)

		h_{FE} $I_C = 3.0$ A, $V_{CE} = 2.0$ V	V_{CES} / V_{CB}	30 V / 40 V	45 V / 60 V	60 V / 75 V	60 V / 80 V	75 V / 90 V	75 V / 100 V
 TO-3 (Case 11)  TO-41 [3] (Case 4-04)	ECONOMY LINE GENERAL-PURPOSE AMPLIFIER AND SWITCH $P_D = 85$ W $f_T = 0.3$ MHz	30-60					2N3615		2N3616
		35-70		2N3611	2N3612				
		45-90					2N3617		2N3618
		60-120		2N3613	2N3614				
		30-200		MP2060 [4]	MP2061 [4]	MP2062 [4]		MP2063 [4]	

15-AMP

		h_{FE} $I_C = 5.0$ A, $V_{CE} = 2.0$ V	V_{CES} / V_{CB}	40 V / 40 V	50 V / 50 V	70 V / 70 V	80 V / 80 V
 TO-36 (Case 5)	GENERAL-PURPOSE SWITCH AND AMPLIFIER $P_D = 170$ W $f_T = 0.25$ MHz	20-40		2N2078	2N2077	2N2076	2N2075
		35-70		2N2082	2N2081	2N2080	2N2079
 TO-3 (Case 11A)  TO-41 [3] (Case 4-04)	HIGH-SPEED SWITCH AND AMPLIFIER $P_D = 106$ W $f_T = 0.40$ MHz	h_{FE} $I_C = 10$ A, $V_{CE} = 2.0$ V	V_{CES} / V_{CB}	30 V / 40 V	45 V / 60 V	60 V / 80 V	75 V / 100 V
		10-30		2N1549	2N1550	2N1551	2N1552
	HIGH-GAIN SWITCH AND AMPLIFIER $P_D = 106$ W $f_T = 0.35$ MHz	h_{FE} $I_C = 10$ A, $V_{CE} = 2.0$ V	V_{CES} / V_{CB}	30 V / 40 V	45 V / 60 V	60 V / 80 V	75 V / 100 V
		30-60		2N1553	2N1554	2N1555	2N1556
		50-100		2N1557	2N1558	2N1559	2N1560

25-AMP

		h_{FE} $I_C = 25$ A, $V_{CE} = 1.0$ V	V_{CES} / V_{CB}	35 V / 50 V	60 V / 80 V	75 V / 100 V
 TO-3 (Case 11A)  TO-41 [3] (Case 4-04)	HIGH-GAIN SWITCH AND AMPLIFIER $P_D = 106$ W $f_T = 0.35$ MHz	15-65		2N1162	2N1164	2N1166
				2N1163	2N1165	2N1167

30-AMP

		h_{FE} $I_C = 5.0$ A, $V_{CE} = 2.0$ V ($h_{FE} = 15$ min @ $I_C = 25$ A)	V_{CES} / V_{CB}	45 V / 45 V	60 V / 60 V	75 V / 75 V	90 V / 90 V
 TO-36 (Case 5)	MEDIUM-CURRENT SWITCH $P_D = 170$ W $f_T = 0.25$ MHz	50-100		2N2152	2N2153	2N2154	2N2155
		80-160		2N2156	2N2157	2N2158	2N2159

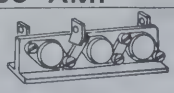
60-AMP

		h_{FE} $I_C = 15$ A, $V_{CE} = 2.0$ V ($h_{FE} = 12$ min @ $I_C = 50$ A)	V_{CES} / V_{CB}	45 V / 45 V	60 V / 60 V	75 V / 75 V	90 V / 90 V
 CASE 7	HIGH-CURRENT — HIGH-GAIN SWITCH $P_D = 170$ W $f_T = 0.25$ MHz	30-60		MP500	MP501	MP502	MP503
		50-100		MP504	MP505	MP506	MP507
	HIGH-CURRENT — HIGH-GAIN SWITCH $P_D = 170$ W $f_T = 0.45$ MHz	h_{FE} $I_C = 15$ A, $V_{CE} = 2.0$ V ($h_{FE} = 15$ min @ $I_C = 60$ A)	V_{CES} / V_{CB}	45 V / 45 V	60 V / 60 V	75 V / 75 V	
		60-120		2N4048	2N4049	2N4050	
		80-180		2N4051	2N4052	2N4053	
 TO-3 (Case 3A)  TO-41 [3] (Case 161)	ECONOMY LINE HIGH-CURRENT — HIGH-GAIN SWITCH $P_D = 170$ W $f_T = 0.4$ MHz	h_{FE} $I_C = 15$ A, $V_{CE} = 2.0$ V ($h_{FE} = 15$ min @ $I_C = 60$ A)	V_{CES} / V_{CB}	30 V / 30 V	45 V / 45 V	60 V / 60 V	75 V / 75 V
		60-120		2N4276	2N4278	2N4280	2N4282
		80-180		2N4277	2N4279	2N4281	2N4283

ALLOY TRANSISTORS (continued)

(See Notes on Page 28)

150-AMP

 CASE 118	"POWER-PAC" ASSEMBLY MEDIUM VOLTAGE SWITCH $P_D = 250$ W $\theta_{JC} = 0.33°C/W$	h_{FE} $I_C = 150$ A, $V_{CE} = 2.0$ V	V_{CES}	60 V	75 V
			V_{CEO}	45 V	60 V
		15 min		MP801[1]	MP800[1]

DIFFUSED BASE TRANSISTORS

Features graded-base profile for:

- Low emitter-base resistance and high-temperature stability
- High breakdown voltage capability
- Higher frequency response, faster switching speeds

10-AMP

 TO-3 (Case 11A)	HIGH-SPEED SWITCH $P_D = 70$ W	h_{FE} $I_C = 5.0$ A, $V_{CE} = 2.0$ V	V_{CEO}	30 V	50 V	70 V	
			V_{CB}	40 V	80 V	120 V	
		50-120		2N2291	2N2292	2N2293	
		20-60	V_{CER}	40 V	80 V	120 V	
			V_{CB}	40 V	80 V	120 V	
				2N2288	2N2289	2N2290	

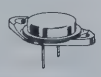
10-AMP

 TO-3 (Case 11A) TO-41[3] (Case 4-04)	HIGH-VOLTAGE SWITCH $P_D = 85$ W $f_T = 0.7$ MHz	h_{FE} $I_C = 3.0$ A, $V_{CE} = 2.0$ V	V_{CEO}	80 V	120 V		160 V
			V_{CB}	80 V	120 V		160 V
		20-50		2N2526	2N2527		2N2528
 TO-3 (Case 11)  TO-41[3] (Case 4-04)	HIGH-VOLTAGE MEDIUM-SPEED SWITCH $P_D = 56$ W $f_T = 5.5$ MHz	h_{FE}	V_{CES} V_{CEO}	200 V†	150 V	320 V†	200 V
			V_{CB}		250 V		325 V
		20-60 $I_C = 5.0$ A, $V_{CE} = 2.0$ V			2N5324		2N5325
		15 min $I_C = 2.25$ A, $V_{CE} = 4.0$ V		[4] MP3730			
		15 min $I_C = 6.0$ A, $V_{CE} = 3.0$ V				[4] MP3731	

20-AMP

 TO-3 (Case 11A) TO-41 (Case 4-04)	HIGH-SPEED HIGH-VOLTAGE SWITCH $P_D = 85$ W $f_T = 20$ MHz	h_{FE} $I_C = 10$ A, $V_{CE} = 2.0$ V	V_{CEO}	50 V	50 V	75 V	75 V	100 V	100 V
			V_{CB}	80 V	100 V	120 V	140 V	140 V	160 V
		25-100		[2] 2N2832	[4] MP1612	[2] 2N2833	[4] MP1612A	[2] 2N2834	[4] MP1612B

5-AMP

 TO-3 (Case 11A)	MEDIUM-CURRENT "ADE" [5] SWITCH HIGH-GAIN $P_D = 85$ W	h_{FE}	V_{CEO}	50 V	60 V	70 V	80 V	
		$I_C = 5.0$ A, $V_{CE} = 2.0$ V	V_{CB}	75 V	75 V	90 V	90 V	
		50 min		MP600 [4]	MP601 [4]	MP602 [4]	MP603 [1]	
 TO-41 [5] (Case 4-04)	MEDIUM-CURRENT "ADE" [5] SWITCH HIGH-VOLTAGE $P_D = 106$ W $f_T = 0.4$ MHz	h_{FE}	V_{CEO}	30 V	60 V	80 V	100 V	120 V
		$I_C = 8.0$ A, $V_{CE} = 2.0$ V	V_{CEX}	60 V	80 V	100 V	120 V	140 V
		25-100						2N5155
		25 min		MP2000A [4]	MP2100A [4]	MP2200A [4]	MP2300A [4]	MP2400A [4]

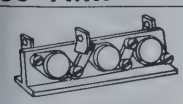
0-AMP

 CASE 3A (TO-3) 2N5692 Series  CASE 161 (TO-41) MP5692 Series	HIGH-CURRENT FAST SWITCHING "ADE" SWITCH $P_D = 120$ W $f_T = 0.2$ MHz	h_{FE}	V_{CEO}	30 V	60 V	80 V	100 V	120 V
		$I_C = 25$ A, $V_{CE} = 2.0$ V	V_{CB}	50 V	80 V	100 V	120 V	140 V
		10 min		2N5692	2N5693	2N5694	2N5695	2N5696
		$I_C = 40$ A, $V_{CE} = 2.0$ V		MP5692	MP5693	MP5694	MP5695	MP5696

0-AMP

 TO-3 (Case 3A)  TO-41 [2] (Case 161)	HIGH-CURRENT — HIGH-VOLTAGE "ADE"® SWITCH $P_D = 120$ W $f_T = 1.0$ MHz	h_{FE}	V_{CEO}	60 V	90 V	120 V
		$I_C = 25$ A, $V_{CE} = 2.0$ V	V_{CB}	80 V	110 V	140 V
		20-60 (h_{FE} = 10 min @ I_C = 60 A)		2N5435	2N5436	2N5437
		40-120 (h_{FE} = 15 min @ I_C = 60 A)		2N5438	2N5439	2N5440

50-AMP

 CASE 118	"POWER-PAC" ASSEMBLY HIGH VOLTAGE SWITCH $P_D = 250$ W $\theta_{JC} = 0.33$°C/W	h_{FE}	V_{CB}	80 V	110 V	140 V
		$I_C = 150$ A, $V_{CE} = 2.0$ V	V_{CEO}	60 V	90 V	120 V
		20 min		MP900	MP901	MP902

[1] For epoxy encapsulated "PAC" add "A" to device type (i.e. MP801A)
[2] TO-41, add the prefix "MP" in place of "2N" (i.e. MP2137)
[3] TO-41, order odd numbered devices (i.e. 2N1163)
[4] Special order for TO-41; contact your local Motorola Sales office
[5] Alloy Diffused Epitaxial Process

SILICON POWER TRANSISTORS

This Selector Guide is published by Motorola to help the designer choose the best silicon power transistors for his new equipment and find suitable replacements for devices used in older designs. It is a comprehensive listing of the industry's most complete line of PNP and NPN silicon power transistors, and contains over 200 devices rated at currents between 100 mA and 60 amperes, and at voltages up to 600 volts. The transistors are in fifteen popular cases, including two low-cost plastic packages and hermetically sealed cases capable of dissipating up to 300 watts.

TABLE OF CONTENTS

The first table of the guide is a numerical-alphabetical index to all silicon power transistors manufactured by Motorola. The number of the selection table in which each device is further characterized is also listed.

COMPLEMENTARY TRANSISTORS

One reason for the wide use of Motorola power transistors is the design flexibility that results from the large number of "off the shelf" complementary transistors in the line. For convenience in choosing complements, a table of complementary power transistors is given following the index. A selection can be made from the complements on the basis of maximum collector current, case, and voltage.

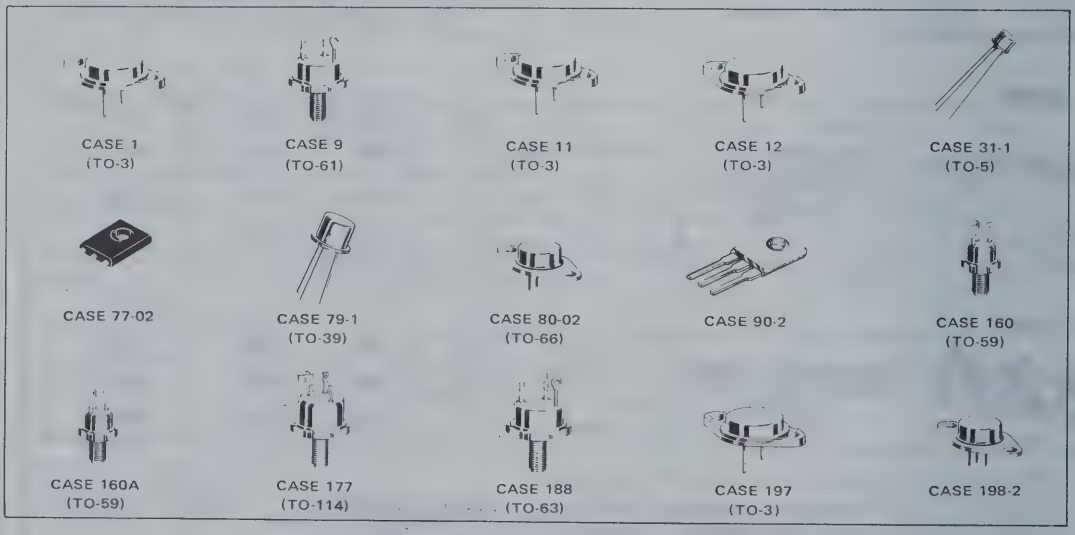
SELECTION TABLES

The major part of this guide is composed of selection tables. These tables list all Motorola silicon power transistors in an order that makes it easy for the user to find a device that satisfies his requirements. Each table contains devices in the same package, and the table is separated first into NPN and PNP devices.

Within each table, the transistors are listed first in order of increasing breakdown voltage, then in increasing order of current and h_{FE}.

The tables list only the most basic characteristics of each device. For complete information on any Motorola power transistor refer to the individual data sheet or the appropriate pages in the Semiconductor Data Book or its supplements.

If a standard part listed in this selector guide does not fulfill all requirements, a special part might be desirable. Motorola has the production capability and flexibility to supply devices especially tailored to specific OEM application needs. Where suitable power transistors cannot be selected from this guide, inquiries should be made at the nearest Motorola sales office.



INDEX

Device Type	Table #	Device Type	Table #	Device Type	Table #	Device Type	Table #	Device Type	Table #
2N1724	9	2N3867	2	2N5190	5	MJ400	4	MJ3772	1
2N1725	9	2N3868	2	2N5191	5	MJ413	1	MJ3801	7
2N3021	1	2N3902	1	5N5192	5	MJ420	2	MJ3802	7
2N3022	1	2N4231	4	2N5193	5	MJ421	2	MJ4502	1
2N3023	1	2N4232	4	2N5194	5	MJ423	1	MJ6700	8
2N3024	1	2N4233	4	2N5195	5	MJ430	2	MJ6701	8
2N3025	1	2N4234	2	2N5301	1	MJ431	1	MJ7000	10
2N3026	1	2N4235	2	2N5302	1	MJ440	2	MJ7200	11
2N3054	4	2N4236	2	2N5303	1	MJ450	1	MJ7201	11
2N3055	1	2N4237	2	2N5334	3	MJ480	1	MJ8100	3
2N3232	1	2N4238	2	2N5335	3	MJ481	1	MJ8101	3
2N3235	1	2N4239	2	2N5336	3	MJ490	1	MJ8400	1
2N3439	2	2N4348	1	2N5337	3	MJ491	1	MJ9000	1
2N3440	2	2N4398	1	2N5338	3	MJ500	8	MJE101	6
2N3441	4	2N4399	1	2N5339	3	MJ501	8	MJE102	6
2N3442	1	2N4877	3	2N5344	4	MJ802	1	MJE103	6
2N3445	1	2N4898	4	2N5345	4	MJ900	1	MJE104	6
2N3446	1	2N4899	4	2N5346	8	MJ901	1	MJE105	6
2N3447	1	2N4900	4	2N5347	8	MJ1000	1	MJE201	6
2N3448	1	2N4901	1	2N5348	8	MJ1001	1	MJE202	6
2N3487	9	2N4902	1	2N5349	8	MJ1800	1	MJE203	6
2N3488	9	2N4903	1	2N5427	4	MJ2249	4	MJE204	6
2N3489	9	2N4904	1	2N5428	4	MJ2250	4	MJE205	6
2N3490	9	2N4905	1	2N5429	4	MJ2251	4	MJE340	5
2N3491	9	2N4906	1	2N5430	4	MJ2252	4	MJE341	5
2N3492	9	2N4907	1	2N5477	8	MJ2253	4	MJE344	5
2N3713	1	2N4908	1	2N5478	8	MJ2254	4	MJE345	5
2N3714	1	2N4909	1	2N5479	8	MJ2267	1	MJE370	5
2N3715	1	2N4910	4	2N5480	8	MJ2268	1	MJE371	5
2N3716	1	2N4911	4	2N5629	1	MJ2500	1	MJE488	5
2N3719	2	2N4912	4	2N5630	1	MJ2501	1	MJE520	5
2N3720	2	2N4913	1	2N5631	1	MJ2801	1	MJE521	5
2N3738	4	2N4914	1	2N5632	1	MJ2840	1	MJE1090	6
2N3739	4	2N4915	1	2N5633	1	MJ2841	1	MJE1091	6
2N3740	4	2N4918	5	2N5634	1	MJ2901	1	MJE1092	6
2N3741	4	2N4919	5	2N5655	5	MJ2940	1	MJE1093	6
2N3766	4	2N4920	5	2N5656	5	MJ2941	1	MJE1100	6
2N3767	4	2N4921	5	2N5657	5	MJ3000	1	MJE1101	6
2N3771	1	2N4922	5	2N5679	2	MJ3001	1	MJE1102	6
2N3772	1	2N4923	5	2N5680	2	MJ3029	1	MJE1103	6
2N3773	1	2N5050	4	2N5681	2	MJ3030	1	MJE2801	6
2N3788	1	2N5051	4	2N5682	2	MJ3101	4	MJE2901	6
2N3789	1	2N5052	4	2N5683	1	MJ3201	4	MJE2955	6
2N3790	1	2N5067	1	2N5684	1	MJ3202	4	MJE3055	6
2N3791	1	2N5068	1	2N5685	1	MJ3701	4	MJE3439	5
2N3792	1	2N5069	1	2N5686	1	MJ3771	1	MJE3440	5

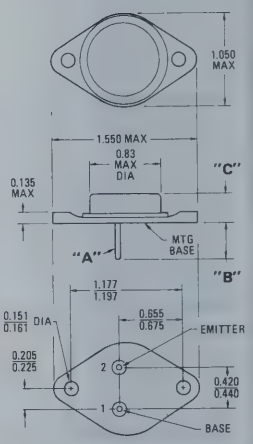
COMPLEMENTARY TRANSISTORS

I_C max	Package	BV_{CEO}	NPN	PNP	Table
1.0 A	TO-5	100	2N5681	2N5679	2
		120	2N5682	2N5680	2
3.0 A	TO-5	40	2N4237	2N4234	2
		60	2N4238	2N4235	2
		80	2N4239	2N4236	2
	Case	40	2N4921	2N4918	5
	77	60	2N4922	2N4919	5
		80	2N4923	2N4920	5
	Case	30	MJE520	MJE370	5
	77	40	MJE521	MJE371	5
4.0 A	TO-66	60	2N3766	2N3740	4
		80	2N3767	2N3741	4
	TO-66	40	2N4910	2N4898	4
		60	2N4911	2N4899	4
		80	2N4912	2N4900	4
	Case	40	2N5190	2N5193	5
	77	60	2N5191	2N5194	5
		80	2N5192	2N5195	5
	TO-3	40	MJ480	MJ490	1
		60	MJ481	MJ491	1
5.0 A	Case	40	MJE201	MJE101	6
	90	50	MJE205	MJE105	6
		60	MJE202	MJE102	6
	Case	60	MJE203	MJE103	6
	90	80	MJE204	MJE104	6
	Case	60	MJE1100	MJE1090	6
	90		MJE1101	MJE1091	6

I_C max	Package	BV_{CEO}	NPN	PNP	Table
5.0 A contd.		80	MJE1102	MJE1092	6
			MJE1103	MJE1093	6
	TO-3	40	2N5067	2N4901	1
		60	2N5068	2N4902	1
		80	2N5069	2N4903	1
	TO-3	40	2N4913	2N4904	1
		60	2N4914	2N4905	1
		80	2N4915	2N4906	1
	TO-3	60	MJ1000	MJ900	1
		80	MJ1001	MJ901	1
10 A	Case	60	MJE2801	MJE2901	6
	90	60	MJE3055	MJE2955	6
	TO-3	60	2N3713	2N3789	1
		80	2N3714	2N3790	1
	TO-3	60	2N3715	2N3791	1
		80	2N3716	2N3792	1
	TO-3	60	2N3055	2N4908	1
		60	MJ2840	MJ2940	1
		80	MJ2841	MJ2941	1
	TO-3	60	MJ3000	MJ2500	1
		80	MJ3001	MJ2501	1
	TO-3	40	MJ2801	MJ2901	1
30 A	TO-3	40	2N5301	2N4398	1
		60	2N5302	2N4399	1
		90	MJ802	MJ4502	1
50 A	TO-3	60	2N5685	2N5683	1
		80	2N5686	2N5684	1

TABLE 1 – TO-3

Device Type	BV_{CEO} Volts Max	I_C Amp Max	h_{FE} Min/Max	@ I_C Amp	$V_{CE(sat)}$ Volts Max	@ I_C Amp	P_D Watts	f_T MHz Min	Case
NPN									
MJ480	40	4.0	30/200	1.0	1.2	3.0	87.5	4.0	11
2N5067		5.0	20/180	1.0	1.5	5.0	87.5	4.0	11
2N4913		5.0	25/100	2.5	1.5	5.0	87.5	4.0	11
MJ2801		10	15/60	8.0	1.5	8.0	120	1.0	11
2N5301		30	15/60	15	3.0	30	200	2.0	12
2N3771		30	15/60	15	2.0	15	150	0.2	11
MJ3771		30	15/60	15	1.0	15	150	2.0	11
2N3235	55	10	20/70	4.0	1.1	4.0	115	1.0	11
MJ481	60	4.0	30/200	1.0	1.2	3.0	87.5	4.0	11
2N5068		5.0	20/80	1.0	1.5	5.0	87.5	4.0	11
2N4914		5.0	25/100	2.5	1.5	5.0	87.5	4.0	11
MJ900		5.0	1000/–	3.0	–	–	90	1.0	11
MJ1000		5.0	1000/–	3.0	–	–	90	1.0	11
2N3232		7.5	15/75	3.0	2.5	3.0	115	1.0	3
2N3445		7.5	20/60	3.0	1.5	3.0	115	10	11
2N3447		7.5	40/120	5.0	1.5	5.0	115	10	11
MJ3000		10	1000/–	5.0	–	–	150	1.0	11
2N3713		10	15/–	3.0	1.0	5.0	150	2.5	11
MJ2840		10	20/100	3.0	–	–	150	2.0	11
2N3715		10	30/–	3.0	0.8	5.0	150	2.5	11
2N3055		15	20/70	4.0	8.0	10	115	1.0	11
2N3772		20	15/60	10	1.4	10	150	0.2	11
MJ3772		20	15/60	10	1.0	10	150	2.0	11
2N5302		30	15/60	15	3.0	30	200	2.0	12
2N5685		50	15/60	25	1.0	25	300	2.0	197
2N5069	80	5.0	20/80	1.0	1.5	5.0	87.5	4.0	11
2N4915		5.0	25/100	2.5	1.5	5.0	87.5	4.0	11
MJ901		5.0	1000/–	3.0	–	–	90	1.0	11
MJ1001		5.0	1000/–	3.0	–	–	90	1.0	11
2N3446		7.5	20/60	3.0	1.5	3.0	115	10	11
2N3448		7.5	40/120	5.0	1.5	5.0	115	10	11
MJ3001		10	1000/–	5.0	–	–	150	1.0	11
2N3714		10	15/–	3.0	1.0	5.0	150	2.5	11
MJ2841		10	20/100	4.0	–	–	150	2.0	11
2N3716		10	30/–	3.0	0.8	5.0	150	2.5	11
2N5303		20	15/60	10	2.0	20	200	2.0	12
2N5686		50	15/60	25	1.0	25	300	2.0	197
MJ802	90	30	25/100	7.5	0.8	7.5	200	–	12
2N5632		10	25/100	5.0	2.0	10	150	1.0	11
2N5629		16	25/100	8.0	1.0	10	200	1.0	11
2N4348	120	10	15/60	5.0	2.0	10	120	0.2	11
2N5633		10	20/80	5.0	2.0	10	150	1.0	11
2N5630		16	20/80	8.0	1.0	10	200	1.0	11
2N5634		10	15/60	5.0	2.0	10	150	1.0	11
2N3442		10	20/70	3.0	5.0	10	117	–	11
2N3773		16	15/60	8.0	4.0	16	150	0.8	11
2N5631		16	15/60	8.0	1.0	10	200	1.0	11
MJ3029	250	3.5	30/–	0.4	–	–	125	–	11
MJ1800	250	5.0	40/120	0.4	–	–	100	–	11
2N3788	325	2.0	20/180	0.5	1.0	1.5	100	–	11
MJ3030		3.5	3.75/–	3.0	2.0	3.0	125	–	11
MJ423		3.5	30/90	1.0	0.8	1.0	125	2.5	11
MJ9000		10	–	–	2.0	6.0	125	–	11
MJ413		2.0	20/80	0.5	0.8	0.5	125	–	11
2N3902	400	2.5	30/90	1.0	2.5	2.5	100	–	11
MJ431	400	5.0	15/35	2.5	0.7	2.5	125	2.5	11
MJ8400	600	4.0	–	–	2.0	3.0	125	–	11
PNP									
2N3021	30	3.0	20/60	1.0	1.5	3.0	25	60	1
2N3024	30	3.0	50/180	1.0	1.0	3.0	25	60	1
MJ490	40	4.0	30/200	1.0	1.2	3.0	87.5	4.0	11
2N4901		5.0	20/80	1.0	1.5	5.0	87.5	4.0	11
MJ2267		5.0	20/100	4.0	1.0	4.0	150	3.0	11
2N4904		5.0	25/100	2.5	1.5	5.0	87.5	4.0	11
MJ2901		10	15/60	8.0	1.5	8.0	120	1.0	11
2N4907		10	20/80	4.0	2.0	10	150	4.0	11
2N4398		30	15/60	15	2.0	20	200	4.0	12
MJ450		30	20/–	10	1.0	10	150	2.0	12
2N3022	45	3.0	20/60	1.0	1.5	3.0	25	60	1
2N3025	45	3.0	50/180	1.0	1.0	3.0	25	60	1
MJ2268	55	5.0	20/100	4.0	1.0	4.0	150	3.0	11
2N3023	60	3.0	20/60	1.0	1.5	3.0	25	60	1
2N3026		3.0	50/180	1.0	1.0	3.0	25	60	1



Collector Connected to Case
TO-3

Case	Dimension	Min	Max
11	A	0.039	0.043
	B	0.44	0.48
	C	–	0.30
12	A	0.048	0.052
	B	0.44	0.48
	C	–	0.30
197	A	0.057	0.063
	B	0.44	0.48
	C	–	0.30
1	A	0.039	0.043
	B	0.32	0.42
	C	–	0.36

TABLE 1 (continued)

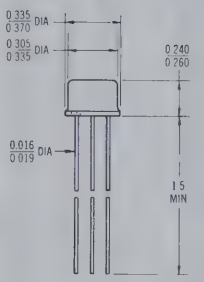
Device Type	BV_{CEO} Volts Max	I_C Amp Max	h_{FE} @ I_C Min/Max	Amp	$V_{CE(sat)}$ Volts @ I_C Max	Amp	P_D Watts	f_T MHz Min	Case
PNP									
MJ491		4.0	30/200	1.0	1.2	3.0	87.5	4.0	11
2N4902		5.0	20/80	1.0	1.5	5.0	87.5	4.0	11
2N4905		5.0	25/100	2.5	1.5	5.0	87.5	4.0	11
MJ2500		10	1000/-	5.0	—	—	150	1.0	11
2N3789		10	15/—	3.0	1.0	4.0	150	4.0	11
2N4908		10	20/80	4.0	2.0	10	150	4.0	11
MJ2940		10	20/100	3.0	—	—	150	4.0	11
2N3791		10	30/—	3.0	1.0	5.0	150	4.0	11
2N4399		30	15/60	15	2.0	20	200	4.0	12
2N5683		50	15/60	25	1.0	25	300	2.0	197
2N4903	80	5.0	20/80	1.0	1.5	3.0	87.5	4.0	11
2N4906		5.0	25/100	2.5	1.5	5.0	87.5	4.0	11
MJ2501		10	1000/—	5.0	—	—	150	1.0	11
2N3790		10	15/—	3.0	1.0	4.0	150	4.0	11
2N4909		10	20/80	4.0	2.0	10	150	4.0	11
MJ2941		10	20/100	4.0	—	—	150	4.0	11
2N3792		10	30/—	3.0	1.0	5.0	150	4.0	11
2N5684		50	15/60	25	1.0	25	300	2.0	197
MJ4502	90	30	25/100	7.5	0.8	7.5	200	—	12

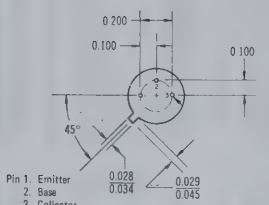
TABLE 2 – TO-5 Case 31-(1)

Device Type	BV_{CEO} Volts Max	I_C Amp Max	h_{FE} @ I_C Min/Max	Amp	$V_{CE(sat)}$ Volts @ I_C Max	Amp	P_D Watts	f_T MHz Min
NPN								
MJ440	40	1.0	25/150	0.25	0.5	0.75	6.0	3.0
2N4237	40	1.0	30/150	0.25	0.6	1.0	6.0	1.0
2N4238	60	1.0	30/150	0.25	0.6	1.0	6.0	1.0
2N4239	80	1.0	30/150	0.25	0.6	1.0	6.0	1.0
2N5681	100	1.0	40/150	0.25	0.6	0.25	10	30
2N5682	120	1.0	40/150	0.25	0.6	0.25	10	30
MJ420	250	0.1	25/250	0.03	5.0	0.03	4.0	30
2N3440	250	0.1	40/160	0.02	0.5	0.05	5.0	15
MJ421	325	0.1	25/250	0.03	5.0	0.03	4.0	30
2N3439	350	0.1	40/160	0.02	0.5	0.05	5.0	15
PNP								
MJ430	40	1.0	25/150	0.25	0.5	0.75	6.0	2.0
2N4234	40	1.0	30/150	0.25	0.6	1.0	6.0	3.0
2N3719	40	3.0	25/180	1.0	1.5	3.0	6.0	60
2N3867	40	3.0	40/200	1.5	1.3	2.5	6.0	60
2N4235	60	1.0	30/150	0.25	0.6	1.0	6.0	3.0
2N3720	60	3.0	25/180	1.0	1.5	3.0	6.0	60
2N3868	60	3.0	30/150	1.5	1.3	2.5	6.0	60
2N4236	80	1.0	30/150	0.25	0.6	1.0	6.0	3.0
2N5679	100	1.0	40/150	0.25	0.6	0.25	10	30
2N5680	120	1.0	40/150	0.25	0.6	0.25	10	30

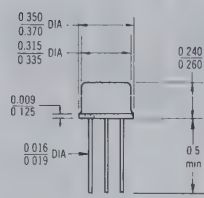
TABLE 3 – TO-39 Case 79(1)

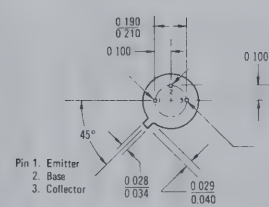
NPN								
2N5334	60	3.0	30/150	1.0	0.7	2.0	6.0	40
2N4877	60	4.0	20/100	4.0	1.0	4.0	10	4.0
2N5335	80	3.0	30/150	1.0	0.7	2.0	6.0	40
2N5336	80	5.0	30/120	2.0	1.2	5.0	6.0	30
2N5337	80	5.0	60/240	2.0	1.2	5.0	6.0	30
2N5338	100	5.0	30/120	2.0	1.2	5.0	6.0	30
2N5339	100	5.0	60/240	2.0	1.2	5.0	6.0	30
PNP								
MJ8100	60	5.0	25/180	2.0	1.2	5.0	10	30
MJ8101	80	5.0	25/180	2.0	1.2	5.0	10	30





CASE 31(1)
TO-5





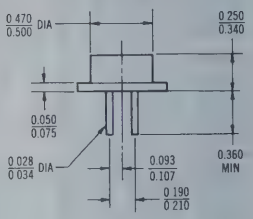
CASE 79(1)
TO-39

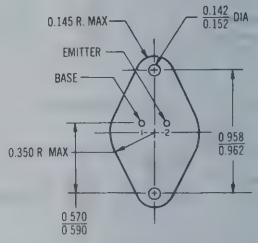
TABLE 4 — TO-66 Case 80-02

Device Type	BV_{CEO} Volts Max	I_C Amp Max	h_{FE} @ I_C Min/Max	Amp	$V_{CE(sat)}$ Volts @ I_C Max	Amp	P_D Watts	f_T MHz Min
NPN								
2N4910	40	1.0	20/100	0.5	0.6	1.0	25	3.0
MJ3101	40	2.0	25/200	0.5	1.0	0.5	20	15
2N4231	40	4.0	25/150	1.5	2.0	3.0	35	4.0
2N3054	55	4.0	25/100	0.5	1.0	0.5	25	4.0
2N4911	60	1.0	20/100	0.5	0.6	1.0	25	3.0
MJ2249	↓	2.0	25/200	0.5	1.0	0.5	20	15
2N3766	↓	3.0	40/160	0.5	2.5	1.0	20	10
2N4232	↓	4.0	25/150	1.5	2.0	3.0	35	4.0
2N4912	80	1.0	20/100	0.5	0.6	1.0	25	3.0
MJ2250	↓	2.0	25/200	0.5	1.0	0.5	20	15
2N3767	↓	3.0	40/160	0.5	2.5	1.0	20	10
2N4233	↓	4.0	25/150	1.5	2.0	3.0	35	4.0
2N5427	↓	7.0	30/120	2.0	1.2	7.0	40	30
2N5428	↓	7.0	60/240	2.0	1.2	7.0	40	30
2N5429	100	7.0	30/120	2.0	1.2	7.0	40	30
2N5430	100	7.0	60/240	2.0	1.2	7.0	40	30
2N5050	125	2.0	25/100	0.75	1.0	0.75	40	10
2N3441	140	3.0	20/80	0.5	6.0	2.7	25	0.2
2N5051	150	2.0	25/100	0.75	1.0	0.75	40	10
2N5052	200	2.0	25/100	0.75	1.0	0.75	40	10
MJ2251	225	0.5	25/200	0.05	—	—	10*	10
MJ3201	225	0.1	30/200	0.05	5.0	0.05	15	15
2N3738	225	0.25	50/200	0.1	2.5	0.25	15	10
MJ3202	300	0.1	30/200	0.05	5.0	0.05	15	15
MJ2252	300	0.5	25/200	0.05	—	—	10*	10
2N3739	300	0.25	50/200	0.1	2.5	0.25	15	10
MJ400	325	0.25	30/300	0.05	5.0	0.05	6.67*	15
PNP								
2N4898	40	1.0	20/100	0.5	0.6	1.0	25	3.0
MJ3701	40	3.0	20/100	0.25	0.6	1.0	25	3.0
2N4899	60	1.0	20/100	0.5	0.6	1.0	25	3.0
2N3740	60	1.0	30/100	0.25	0.6	1.0	25	4.0
MJ2253	60	3.0	20/100	0.25	0.6	1.0	25	3.0
2N4900	80	1.0	20/100	0.5	0.6	1.0	25	3.0
2N3741	80	1.0	30/100	0.25	0.6	1.0	25	4.0
MJ2254	80	3.0	20/100	0.25	0.6	1.0	25	3.0
2N5344	250	1.0	25/100	0.5	3.0	1.0	40	60
2N5345	300	1.0	25/100	0.5	3.0	1.0	40	60

* @T_C = 70° C

Collector Connected to Case



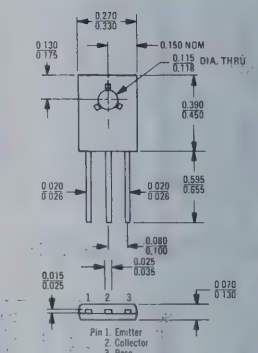


CASE 80-02
TO-66.

TABLE 5 — Case 77-02

NPN

MJE520	30	3.0	25/—	1.0	—	—	20	—
2N4921	40	3.0	20/100	0.5	0.6	1.0	30	3.0
MJE521	40	3.0	40/—	1.0	—	—	20	—
2N5190	40	4.0	25/100	1.5	1.4	4.0	40	2.0
MJE488	50	4.0	30/—	1.0	0.5	1.0	40	4.0
2N4922	60	3.0	20/100	0.5	0.6	1.0	30	3.0
2N5191	60	4.0	25/100	1.5	1.4	4.0	40	2.0
2N4923	80	3.0	20/100	0.5	0.6	1.0	30	3.0
2N5192	80	4.0	20/80	1.5	1.4	4.0	40	2.0
MJE341	150	0.5	25/200	0.05	1.0	0.05	20.8	15
MJE344	200	0.5	30/300	0.05	1.0	0.05	20.8	15
MJE3440	250	0.3	40/160	0.02	0.5	0.05	15	15
2N5655	250	0.5	30/250	0.05	1.0	0.1	20	10
MJE340	300	0.5	30/240	0.05	—	—	20.8	15
2N5656	300	0.5	30/250	0.05	1.0	0.1	20	10
MJE345	325	0.5	30/300	0.05	5.0	0.05	20.8	15
MJE3439	350	0.3	40/160	0.02	0.5	0.05	15	15
2N5657	350	0.5	30/250	0.05	1.0	0.1	20	10



CASE 77-02

TABLE 5 (continued)

Case 77

Device Type	BV_{CEO} Volts Max	I_C Amp Max	h_{FE} @ I_C Min/Max	Amp	$V_{CE(sat)}$ Volts @ I_C Max	Amp	P_D Watts	f_T MHz Min
PNP								
MJE370	30	3.0	25/–	1.0	–	–	20	–
2N4918	40	3.0	20/100	0.5	0.6	1.0	30	3.0
MJE371	40	3.0	40/–	1.0	–	–	20	–
2N5193	40	4.0	25/100	1.5	1.4	4.0	40	2.0
2N4919	60	3.0	20/100	0.5	0.6	1.0	30	3.0
2N5194	60	4.0	25/100	1.5	1.4	4.0	40	2.0
2N4920	80	3.0	20/100	0.5	0.6	1.0	30	3.0
2N5195	80	4.0	20/80	1.5	1.4	4.0	40	2.0

TABLE 6 – Case 90(2)

NPN

MJE201	40	5.0	25/150	2.0	2.0	5.0	75	2.0
MJE205	50	5.0	25/100	2.0	–	–	65	–
MJE202	60	5.0	25/150	2.0	2.0	5.0	75	2.0
MJE203	60	5.0	30/150	1.0	1.5	5.0	75	2.0
MJE1100	60	5.0	750/–	3.0	–	–	70	1.0
MJE1101	60	5.0	750/–	4.0	–	–	70	1.0
MJE3055	60	10	20/70	4.0	8.0	10	90	2.0
MJE2801	60	10	25/100	3.0	–	–	90	–
MJE204	80	5.0	30/150	1.0	1.5	5.0	75	2.0
MJE1102	80	5.0	750/–	3.0	–	–	70	1.0
MJE1103	80	5.0	750/–	4.0	–	–	70	1.0

PNP

MJE101	40	5.0	25/150	2.0	2.0	5.0	75	2.0
MJE105	50	5.0	25/100	2.0	–	–	65	–
MJE102	60	5.0	25/150	2.0	2.0	5.0	75	2.0
MJE103	60	5.0	30/150	1.0	1.5	5.0	75	2.0
MJE1090	60	5.0	750/–	3.0	–	–	70	1.0
MJE1091	60	5.0	750/–	4.0	–	–	70	1.0
MJE2955	60	10	20/70	4.0	8.0	10	90	2.0
MJE2901	60	10	25/100	3.0	–	–	90	–
MJE104	80	5.0	30/150	1.0	1.5	5.0	75	2.0
MJE1092	80	5.0	750/–	3.0	–	–	70	1.0
MJE1093	80	5.0	750/–	4.0	–	–	70	1.0

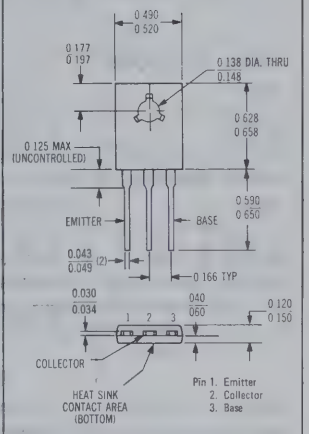
TABLE 7 – Case 198(2)

NPN

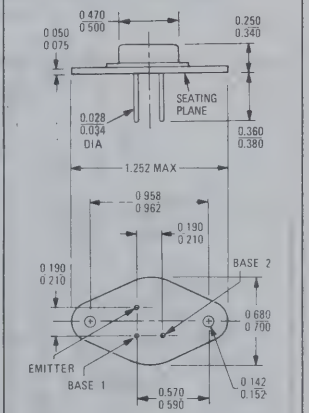
MJ3802	80	10	1k/20k	6.0	1.5	6.0	40	50
MJ3801	80	10	10k/60k	6.0	1.5	6.0	40	50

TABLE 8 – TO-59

Device Type	BV_{CEO} Volts Max	I_C Amp Max	h_{FE} @ I_C Min/Max	Amp	$V_{CE(sat)}$ Volts @ I_C Max	Amp	P_D Watts	f_T MHz Min	Case
NPN									
2N5346	80	7.0	30/120	2.0	1.2	7.0	60	30	160
2N5477	80	7.0	30/120	2.0	1.2	7.0	60	30	160A
2N5347	80	7.0	60/240	2.0	1.2	7.0	60	30	160
2N5478	80	7.0	60/240	2.0	1.2	7.0	60	30	160A
2N5348	100	7.0	30/120	2.0	1.2	7.0	60	30	160
2N5479	100	7.0	30/120	2.0	1.2	7.0	60	30	160A
2N5349	100	7.0	60/240	2.0	1.2	7.0	60	30	160
2N5480	100	7.0	60/240	2.0	1.2	7.0	60	30	160A
PNP									
MJ500	60	7.0	25/180	2.0	0.7	2.0	60	30	160A
MJ6700	60	7.0	25/180	2.0	0.7	2.0	60	30	160
MJ501	80	7.0	25/180	2.0	0.7	2.0	60	30	160A
MJ6701	80	7.0	25/180	2.0	0.7	2.0	60	30	160



CASE 90 (2)



CASE 198 (2)

TABLE 9 – TO-61

Device Type	BV_{CEO} Volts Max	I_C Amp Max	h_{FE} @ I_C Min/Max	Amp	$V_{CE(sat)}$ Volts @ I_C Max	Amp	P_D Watts	f_T MHz Min	Case
NPN									
2N1724	80	5.0	20/90	2.0	1.0	2.0	115	10	9
2N1725	80	5.0	50/150	2.0	1.0	2.0	115	10	9
2N3487	80	7.5	20/60	3.0	1.2	3.0	115	10	9
2N3490	80	7.5	40/120	5.0	1.0	3.0	115	10	9
2N3488	100	7.5	20/60	3.0	1.2	3.0	115	10	9
2N3491	100	7.5	40/120	5.0	1.0	3.0	115	10	9
2N3489	120	7.5	15/45	3.0	1.2	3.0	115	10	9
2N3492	120	7.5	30/90	5.0	1.0	3.0	115	10	9

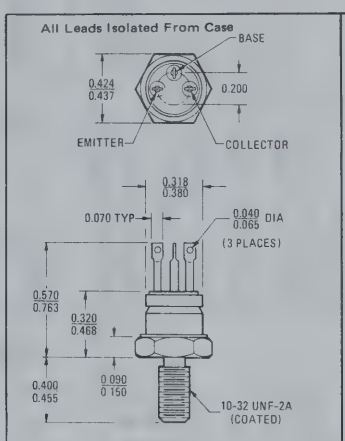
TABLE 10 – TO-63

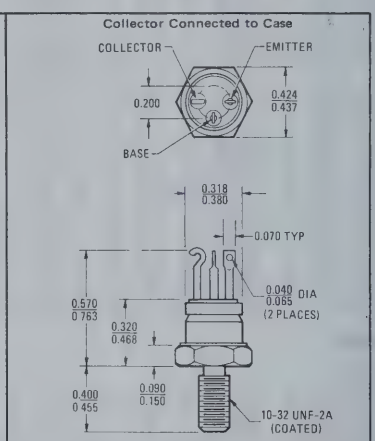
NPN									
MJ7000	100	30	20/100	10	1.0	10	150	30	188

TABLE 11 – TO-114

NPN									
MJ7200	80	60	20/100	20	1.0	20	300	20	177
MJ7201	100	60	20/100	20	1.0	20	300	20	177

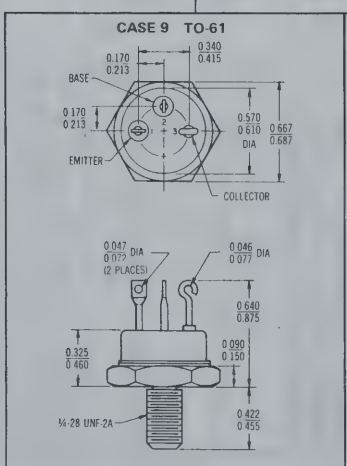
CASE 160
TO-59



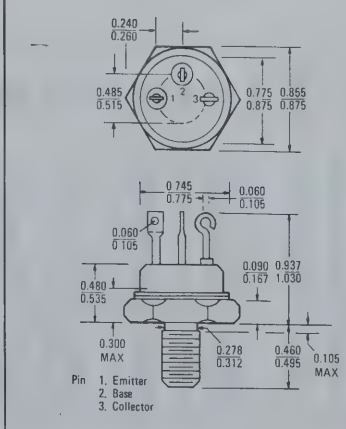


CASE 160A
TO-59

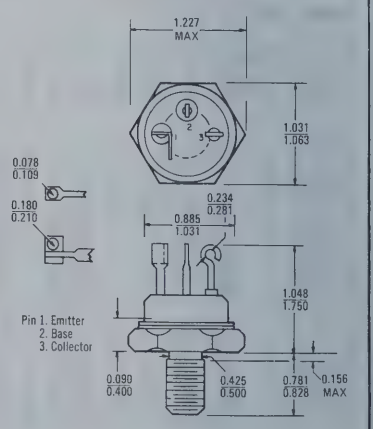
CASE 9 TO-61



CASE 188 TO-63



CASE 177 TO-114



PLASTIC-ENCAPSULATED SMALL-SIGNAL TRANSISTORS

Plastic-Encapsulated Small-Signal Silicon Transistors for Industrial Applications

Motorola plastic-encapsulated transistors offer the features the designer of industrial electronics equipment requires – *reliability, performance, convenience,* and *economy.*

RELIABILITY has been well proven by extensive environmental and life testing, and by hundreds of millions of these transistors in use for industrial and consumer applications. Industrial plastic transistors are encapsulated by a high-temperature pressure-molded process that produces a rugged one-piece package resistant to humidity and shock.

PERFORMANCE is assured by careful design and testing. Geometric design and diffusion profiles are optimized to excel in specified applications such as high-speed switching, high-frequency amplification, and low-noise amplification. Motorola plastic transistors are 100% performance tested on high-speed, computer-controlled equipment, before shipment, to assure conformance to specifications.

CONVENIENCE in use is enhanced by a number of package variations – the popular D-shaped, Unibloc package which can dissipate 310 mW at an ambient temperature of 25°C, and the Uniwatt package used for applications requiring up to 8 watts dissipation.

ECONOMY is a prime concern of the industrial designer. Motorola's highly efficient plastic product lines are the most advanced in the industry. Devices are produced by strip-line techniques on highly mechanized equipment that reduces labor costs and provides high uniformity and quality.

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PACKAGE OUTLINES
Medium and low-power packages add flexibility to Motorola plastic-encapsulated transistor lines

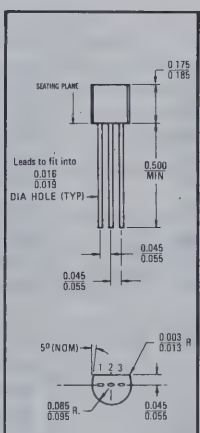
DESIGN STOCK
A recommended list of 10 devices that handle almost all prototype design requirements

INDEX TO MOTOROLA PLASTIC-ENCAPSULATED TRANSISTORS
Complete alpha-numeric index of Motorola devices

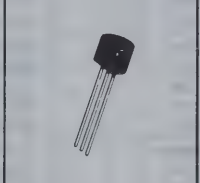
DEVICE SELECTION TABLES
Short-form specifications of devices intended for specific applications. (For complete information, send for appropriate data sheet or refer to the Semiconductor Data Book.)

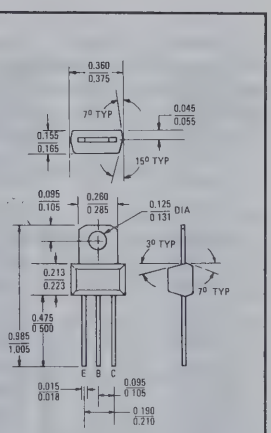
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High-Speed Saturated Switching Transistors	Table 2
General-Purpose Amplifier Transistors	Table 3
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MOTOROLA PLASTIC PACKAGE OUTLINES



Case 29 (TO-92)
Low-Power package for all Unibloc devices





Collector connected to tab

Case 152
Medium-Power package for Uniwatt devices



DESIGN STOCK

The transistor requirements of most small-signal industrial circuits can be met by a limited number of versatile devices. The ten inexpensive transistors listed below can satisfy most design requirements, while minimizing the number of transistors that must be stocked.

GENERAL-PURPOSE SWITCHES AND AMPLIFIERS

LOW-CURRENT – TO 100 mA

	NPN	PNP
LOW GAIN	2N3903	2N3905
HIGH GAIN	2N3904	2N3906

HIGH CURRENT – TO 500 mA
(these types generate Low Noise at Low Currents)

	NPN	PNP
LOW GAIN	2N4400	2N4402
HIGH GAIN	2N4401	2N4403

HIGH SPEED SATURATED SWITCHES

	NPN
LOW GAIN	2N4264
HIGH GAIN	2N4265

INDEX TO MOTOROLA PLASTIC-ENCAPSULATED SMALL-SIGNAL TRANSISTORS

This index includes all plastic-encapsulated small-signal transistors available from Motorola. Devices for which no Table Number is given are recommended for exact replacement purposes only and should not be considered for new designs.

Device	Table	Device	Table	Device	Table	Device	Table	Device	Table
2N3903	1,3,5	2N5401	6	MPS3646	2	MPS6534	3	MPS-A65	4
2N3904	1,3,5	2N5550	6	MPS3693	3	MPS6535	3	MPS-A66	4
2N3905	1,3,5	2N5551	6	MPS3694	3	MPS6539	–	MPS-A70	3
2N3906	1,3,5	MPS5006	3	MPS3702	–	MPS6540	–	MPS-H02	3
2N4123	1,3	MPS404	1	MPS3703	–	MPS6542	–	MPS-H04,5	3
2N4124	1,3	MPS404A	1	MPS3704	–	MPS6543	–	MPS-H07	3
2N4125	1,3	MPS706	2	MPS3705	–	MPS6544	–	MPS-H08	3
2N4126	1,3	MPS706A	2	MPS3706	–	MPS6545	–	MPS-H10	3
2N4264	2	MPS708	–	MPS3707	–	MPS6546	–	MPS-H11	3
2N4265	2	MPS834	2	MPS3708	–	MPS6547	–	MPS-H20	3
2N4400	1,3	MPS835	2	MPS3709	–	MPS6548	–	MPS-H24	3
2N4401	1,3	MPS918	–	MPS3710	–	MPS6560	3	MPS-H30	3
2N4402	1,3	MPS2369	2	MPS3711	–	MPS6561	3	MPS-H31	3
2N4403	1,3	MPS2711	–	MPS3721	3	MPS6562	3	MPS-H32	3
2N4409	6	MPS2712	–	MPS5172	3	MPS6563	3	MPS-H34	3
2N4410	6	MPS2713	–	MPS6507	–	MPS6565	3,5	MPS-H37	3
2N5086	3,5	MPS2714	–	MPS6511	3	MPS6566	3,5	MPS-H54	3
2N5087	3,5	MPS2923	–	MPS6512	3	MPS6567	–	MPS-H55	3
2N5088	3,5	MPS2924	–	MPS6513	3	MPS6568	–	MPS-L01	6
2N5089	3,5	MPS2925	–	MPS6514	3	MPS6568A	3	MPS-L07	2
2N5208	–	MPS2926	–	MPS6515	3	MPS6569	–	MPS-L08	2
2N5209	3,5	MPS3390	–	MPS6516	3	MPS6570	–	MPS-L51	6
2N5210	3,5	MPS3391	–	MPS6517	3	MPS6571	5	MPS-U01	7
2N5219	–	MPS3391A	–	MPS6518	3	MPS-A05	3	MPS-U02	7
2N5220	–	MPS3392	–	MPS6519	3	MPS-A06	3	MPS-U03	7
2N5221	–	MPS3393	–	MPS6520	5	MPS-A09	3,5	MPS-U04	7
2N5222	–	MPS3394	–	MPS6521	5	MPS-A10	3	MPS-U05	7
2N5223	–	MPS3395	–	MPS6522	5	MPS-A12	4	MPS-U06	7
2N5224	–	MPS3563	–	MPS6523	5	MPS-A13	4	MPS-U10	7
2N5225	–	MPS3638	1,3	MPS6530	3	MPS-A14	4	MPS-U51	7
2N5226	–	MPS3638A	1,3	MPS6531	3	MPS-A20	3	MPS-U52	7
2N5227	–	MPS3639	2	MPS6532	3	MPS-A55	3	MPS-U55	7
2N5228	–	MPS3640	2	MPS6533	3	MPS-A56	3	MPS-U56	7
2N5400	6								

TABLE 1
GENERAL-PURPOSE SATURATED SWITCHING TRANSISTORS

The transistors in this table are characterized for general medium-voltage, medium-speed switching applications. These transistors also may be used as general-purpose amplifiers. All have base-emitter voltages of 4 to 6 volts, output capacitances of 4 to 20 pF, and power dissipation ratings of 310 mW. The devices are listed in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing collector test current (I_C).

Type	BV_{CEO} Volts	Collector Test Current for h_{FE} I_C in mA	h_{FE} min	$V_{CE(sat)}$ @ I_C max Volts	mA	f_T @ I_C min MHz	mA	Switching Times @ I_C/I_B ns max t_{on}	t_{off}	mA	Complement
NPN											
2N4401	40	150	100	0.75	500	250	20	35	255	150/15	2N4403
2N4400	40	150	50	0.75	500	200	20	35	255	150/15	2N4402
2N3904	40	10	100	0.3	50	300	10	70	250	10/1.0	2N3906
2N3903	40	10	50	0.3	50	250	10	70	225	10/1.0	2N3905
2N4123	30	2.0	50	0.3	50	250	10	37*	136*	10/1.0	2N4125
2N4124	25	2.0	120	0.3	50	300	10	37*	136*	10/1.0	2N4126
PNP											
2N4403	40	150	100	0.75	500	200	20	35	255	150/15	2N3903
2N4402	40	150	50	0.75	500	150	20	35	255	150/15	2N4400
2N3906	40	10	100	0.4	50	250	10	70	300	10/1.0	2N3904
2N3905	40	10	50	0.4	50	200	10	70	260	10/1.0	2N3903
MPS404A‡	35	12	30	0.2	24	–	–	265	385	10/1.0	
2N4125	30	2.0	50	0.4	50	200	10	43*	155*	10/1.0	2N4123
MPS3638A	25	50	100	2.0	300	150	50	90	210	300/30	
MPS3638	25	50	30	1.0	300	100	50	90	210	300/30	
2N4126	25	2.0	120	0.4	50	250	10	43*	155*	10/1.0	2N4124
MPS404†	24	12	30	0.2	24	–	–	265	385	10/1.0	

*Typical †V_{EB} = 12 Vdc ‡V_{EB} = 24 Vdc

TABLE 2
HIGH-SPEED SATURATED SWITCHING TRANSISTORS

The transistors listed in this table are optimized for high-speed saturated switching. They are heavily gold doped and otherwise processed to provide very short storage times and low capacitance. (Output capacitances below 6 pF). The power dissipation is rated at 310 mW. The transistors are listed in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing collector test current (I_C).

Type	BV_{CEO} Volts	Collector Test Current for h_{FE} I_C in mA	h_{FE} min	$V_{CE(sat)}$ @ I_C max Volts	mA	f_T @ I_C min MHz	mA	Switching Times @ I_C/I_B ns max t_{on}	t_{off}	mA
NPN										
MPS834	30	10	25	0.25	10	350	10	16	30	10/3.0
MPS835	20	10	20	0.3	10	300	10	20	35	10/3.0
2N4264	15	30	40	0.35	100	300	10	23	35	100/10
MPS3646	15	30	30	0.5	300	350	30	25	35	300/30
MPS2369	15	10	40	0.25	10	–	–	12	18	10/3.0
MPS706,A	15	10	20	0.6	10	200	10	40	75	10/–
2N4265	12	10	100	0.35	100	300	10	23	35	100/10
PNP										
MPS3640	12	10	30	0.2	10	500	10	40	32	50/5.0
MPS-L08	12	10	30	0.15	10	700	10	20	40	10/1.0
MPS3639	6.0	10	30	0.16	10	500	10	40	32	50/5.0
MPS-L07	6.0	10	30	0.15	10	500	10	20	40	10/1.0

TABLE 3
GENERAL-PURPOSE AMPLIFIER TRANSISTORS

These general-purpose transistors are designed for small-signal amplification from dc to low radio frequencies. They are also useful as oscillators and general-purpose switches. The transistors are listed in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing collector test current (I_C). P_D = 310 mW at T_A = 25°C unless otherwise specified.

Type	BV_{CEO} Volts	Collector Test Current for h_{FE} I_C in mA	h_{FE} min/max	f_T @ I_C min MHz	mA	Complement
NPN						
MPS-A06*	80	10	50/–	50	100	MPS-A56
MPS-A05*	60	10	50/–	50	100	MPS-A55
MPS-H05***	80	1.5	30/150	80	1.5	MPS-H55
MPS-H04***	80	1.5	30/120	80	1.5	MPS-H54
2N5210	50	1.0	250/–	30	0.5	2N5087
2N5209	50	1.0	150/–	30	0.5	2N5086
MPS-A09	50	0.1	100/600	30	0.5	
MPS-H34*	45	20	15/–	500	15	
MPS6566	45	10	100/400	200	10	
MPS6565	45	10	40/160	200	10	
2N4400	40	150	100/300	200	20	2N4402
2N4401	40	150	50/150	250	20	2N4403
MPS6531	40	100	90/270	390†	50	MPS6534
MPS6530	40	100	40/120	390†	50	MPS6533
2N3904	40	10	100/300	300	10	2N3906
2N3903	40	10	50/150	250	10	2N3905
MPS-A10**	40	5.0	40/400	20	5.0	
MPS-A20***	40	5.0	40/400	125	5.0	
MPS-H37	40	5.0	25/–	300	5.0	
MPM5006	40	4.0	30/–	400	4.0	
MPS6532	30	100	30/–	390†	50	MPS6535
MPS-H24*	30	8.0	30/–	400	50	
MPS-H20	30	4.0	25/–	400	4.0	
MPS-H32*	30	4.0	27/200	300	4.0	
MPS-H07*	30	3.0	20/–	400	3.0	
MPS-H08*	30	3.0	20/–	500	3.0	
MPS6513	30	2.0	90/180	250†	2.0	MPS6517
2N4123	30	2.0	50/150	250	10	2N4125
MPS6512	30	2.0	50/100	250†	2.0	MPS6516
2N5088	30	1.0	350/–	50	0.5	
MPS5172**	25	10	100/500	120†	2.0	
MPS-H10	25	4.0	60/–	650	4.0	
MPS-H11	25	4.0	60/–	650	4.0	
MPS6515	25	2.0	25[illegible]00	390†	2.0	MPS6519
MPS6514	25	2.0	150/300	390†	2.0	MPS6518
2N4124	25	2.0	120/360	300	10	2N4126
2N5089	25	1.0	450/–	50	0.5	
MPS6560*	20	500	50/200	60	10	MPS6562
MPS6561*	20	350	50/200	60	10	MPS6563
MPS6568	20	4.0	20/200	375	4.0	
MPS6568A	20	4.0	20/200	375	4.0	
MPS-H02*	20	4.0	20/200	375	4.0	
MPS-H30	20	4.0	20/200	300	4.0	
MPS-H31	20	4.0	20/200	300	4.0	
MPS3721	18	2.0	60/660‡	–	–	
PNP						
MPS-A56*	80	10	50/–	50	100	MPS-A06
MPS-H54***	80	1.5	30/120	80	1.5	MPS-H04
MPS-H55***	80	1.5	30/150	80	1.5	MPS-H05
MPS-A55*	60	10	50/–	50	100	MPS-A05
2N5087	50	1.0	250/–	40	0.5	2N5210
2N5086	50	1.0	150/–	40	0.5	2N5209
2N4403	40	150	100/300	200	20	2N4401
2N4402	40	150	50/150	150	20	2N4400
MPS6534	40	100	90/270	260†	50	MPS6531
MPS6533	40	100	40/120	260†	50	MPS6530
2N3906	40	10	100/300	250	10	2N3904
2N3905	40	10	50/150	200	10	3N3903
MPS-A70***	40	5.0	40/400	125	5.0	
MPS6518	40	2.0	150/300	340†	2.0	MPS6514
MPS6517	40	2.0	90/180	200†	2.0	MPS6513
MPS6516	40	2.0	50/100	200†	2.0	MPS6512
MPS6535	30	100	30/–	260†	50	MPS6532
2N4125	30	2.0	50/150	200	10	2N4123
MPS3638A	25	50	100/–	150	50	
MPS3638	25	50	30/–	100	50	
MPS6519	25	2.0	250/500	340†	2.0	MPS6515
2N4126	25	2.0	120/360	250	10	2N4124
MPS6562*	20	500	50/200	60	10	MPS6560
MPS6563*	20	350	50/200	60	10	MPS6561

*P_D = 500 mW @ T_A = 25°C †Typical ‡h_{fe} @ f = 1.0 kHz **P_D = 210 mW @ T_A = 25°C ***P_D = 300 mW @ T_A = 25°C

TABLE 4
DARLINGTON AMPLIFIER TRANSISTORS

Darlington amplifiers are compound-connected transistors that provide extremely high current gain and input impedance. Power dissipation is rated at 500 mW. These devices are listed in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing collector test current (I_C).

Type	BV_{CES} Volts	Collector Test Current for h_{FE} I_C in mA	h_{FE} min	f_T @ I_C min MHz	mA
NPN					
MPS-A14	30	10	10,000	125	10
MPS-A13	30	10	5,000	125	10
MPS-A12	20	10	20,000	–	–
PNP					
MPS-A66	30	10	75,000	100	10
MPS-A65	30	10	50,000	100	10

TABLE 5
LOW-NOISE AMPLIFIER TRANSISTORS

The small-signal transistors listed in this table are characterized for low-noise amplification at low frequencies. The power dissipation is rated at 310 mW. The transistors are listed in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing collector test current (I_C).

Type	BV_{CEO} Volts	Collector Test Current for h_{FE} I_C in mA	h_{FE} min/max	Noise Figure @ I_C @ f NF max dB	μA	Hz	f_T @ I_C min MHz	mA
NPN								
2N5210	50	0.1	200/600	3.0	20	1.0 kHz	30	0.5
2N5209	50	0.1	100/300	4.0	20	1.0 kHz	30	0.5
MPS-A09	50	0.1	100/600	1.4*	100	1.0 kHz	30	0.5
MPS6566	45	10	100/400	4.0*	100	10 Hz-15.7 kHz	100	10
MPS6565	45	10	40/160	4.0*	100	10 Hz-15.7 kHz	40	10
2N3904	40	0.1	40/–	5.0	100	10 Hz-15.7 kHz	300	10
2N3903	40	0.1	20/-	6.0	100	10 Hz-15.7 kHz	300	10
2N5088	30	0.1	300/900	3.0	100	10 Hz-15.7 kHz	50	0.5
2N5089	25	0.1	400/1200	2.0	100	10 Hz-15.7 kHz	50	0.5
MPS6521	25	0.1	150/–	3.0	10	10 Hz-10 kHz	480*	10
MPS6520	25	0.1	100/–	3.0	10	10 Hz-10 kHz	480*	10
MPS6571	20	0.1	250/1000	1.2*	100	100 Hz	50	0.5
PNP								
2N5087	50	0.1	250/800	2.0	20	10 Hz-15.7 kHz	40	0.5
2N5086	50	0.1	150/500	3.0	20	10 Hz-15.7 kHz	40	0.5
2N3906	40	0.1	60/–	4.0	100	10 Hz-15.7 kHz	250	10
2N3905	40	0.1	30/–	5.0	100	10 Hz-15.7 kHz	200	10
MPS6523	25	0.1	150/–	3.0	10	10 Hz-15.7 kHz	420*	10
MPS6522	25	0.1	100/–	3.0	10	10 Hz-15.7 kHz	420*	10

*Typical

TABLE 6
HIGH-VOLTAGE TRANSISTORS

These high-voltage transistors are designed for driving neon bulbs and Nixie® indicator tubes, for direct line operation, and for other applications requiring high-voltage capability at relatively low collector current. See Table 7—Medium-Power (Uniwatt) Transistors also. Power Dissipation is rated at 310 mW. These devices are listed in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing collector test current (I_C).

Type	BV_{CEO} Volts	Collector Test Current for h_{FE} I_C in mA	h_{FE} min/max	$V_{CE(sat)}$ @ I_C max Volts	mA	f_T @ I_C min/max MHz	mA
NPN							
2N5551	160	10	80/250	0.15	10	100/300	10
2N5550	140	10	60/250	0.15	10	100/300	10
MPS-L01	120	10	50/300	0.2	10	60/–	10
2N4410	80	1.0	60/400	0.2	1.0	60/300	10
2N4409	50	1.0	60/400	0.2	1.0	60/300	10
PNP							
2N5401	150	10	60/240	0.2	10	150/300	10
2N5400	120	10	40/180	0.2	10	100/400	10
MPS-L51	100	50	40/250	0.25	10	60/–	10

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TABLE 7
MEDIUM-POWER (UNIWATT) TRANSISTORS

For applications requiring higher power dissipation than that of the standard Unibloc package, Motorola has developed the Uniwatt case. In this plastic-encapsulated package, which is slightly larger than the small-signal case, the collector is mounted on a metal tab that extends out of the plastic. The tab can be attached to a heat sink to conduct heat away from the junction. With a satisfactory sink, Uniwatt transistors can dissipate 5 to 8 watts. Without a heat sink, power dissipation at an ambient temperature of 25°C is 1 watt. The transistors are listed in order of decreasing collector test current (I_C).

Type	BV_{CEO} Volts	Collector Test Current for h_{FE} I_C in mA	h_{FE} min/max	$V_{CE(sat)}$ @ I_C max Volts	mA	f_T @ I_C min MHz	mA	P_D Watts T_C = 25°C	Complement	Comments
NPN										
MPS-U10	300	10	40/–	1.5	20	60	10	1.0*		High-Voltage Amplifier
MPS-U04	180	10	40/–	0.5	200	100	50	5.0		High-Voltage Amplifier
MPS-U03	120	10	40/–	0.5	200	100	50	5.0		High-Voltage Amplifier
MPS-U06	80	250	100/–	0.6	250	50	250	5.0	MPS-U56	General Purpose
MPS-U05	60	250	100/–	0.6	250	50	250	5.0	MPS-U55	General Purpose
MPS-U02	40	150	50/300	0.4	150	150	20	6.0	MPS-U52	General Purpose
MPS-U01	30	150	70/–	1.0	1000	50	50	8.0	MPS-U51	Audio Transistor
PNP										
MPS-U56	80	250	100/–	0.6	250	50	250	5.0	MPS-U06	General Purpose
MPS-U55	60	250	100/–	0.6	250	50	250	5.0	MPS-U05	General Purpose
MPS-U52	40	150	50/300	0.4	150	150	20	6.0	MPS-U02	General Purpose
MPS-U51	30	150	70/–	1.0	1000	50	50	8.0	MPS-U01	Audio Transistor

*@ T_A = 25°C

SILICON SMALL-SIGNAL HERMETIC ANNULAR TRANSISTORS

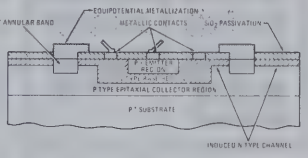
This Selector Guide covers Motorola's broad line of silicon hermetic Annular transistors. It includes over 160 proven transistors suitable for all low-level switching and amplifying applications: transistors with PNP and NPN polarities, breakdown voltages to 400 V, capacitances below 3.0 pF, and collector current ratings to 3.0 amperes. For maximum convenience, transistors are available in all popular metal cases, and in ceramic and metal packages containing two and four transistors. Many of the transistors are high-reliability devices that meet the requirements of military and aerospace specifications.

MOTOROLA ANNULAR TRANSISTORS

Motorola small-signal silicon transistors have demonstrated exceptional long-term stability and reliability in the life test laboratory and in thousands of applications. Their reliability is well demonstrated by the extensive listings of JAN and JAN TX parts in this guide.

The variety, excellent characteristics and stability of Motorola transistors are made possible by such developments as Motorola's Annular process, which produces an annular band around the active geometry of transistors to eliminate channeling in the bulk material of the semiconductor material. This results in very low leakage and high reliability. Motorola's Field Relief Electrode (Equipotential Ring), stabilizes the surface of the transistor, and Motorola's Epitaxial Structure permits ultra-high speed devices and low collector resistance. In addition, the geometries of Motorola transistors are designed to provide optimum characteristics for the use intended.

CROSS SECTION OF
AN ANNULAR TRANSISTOR STRUCTURE



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Table 9	Complementary Transistor Pairs
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QUICK SELECTION GUIDE

This table lists the best all-around choices for given applications:

General-Purpose Switching and Amplifier Transistors	NPN – 2N2222A PNP – 2N2907A
High-Speed Saturated Switching Transistors	NPN – 2N2369A PNP – 2N3546
High-Voltage, High-Speed Core-Driver Transistors	NPN – 2N3735 PNP – 2N3468
Current-Mode Switching Transistors	NPN – 2N3960 PNP – 2N4261
Low-Level Chopper Transistors	NPN – 2N2331 PNP – 2N5230
Low-Noise Amplifier Transistors	NPN – MM2484 PNP – 2N3799
High-Voltage Amplifier Transistors	NPN – 2N4927 PNP – 2N5357
Matched Dual Transistors	NPN – 2N2060A PNP – 2N3726
Dual Transistors (Un-matched)	NPN – MD2219A PNP – MD2905A
Darlington Amplifier Transistors	NPN – 2N999 PNP – 2N4974
Complementary Transistor Pairs	2N3838
Quad Transistors	NPN – MQ2219A PNP – MQ2905A

HIGH RELIABILITY TRANSISTORS

Motorola produces many semiconductors that meet military specification MIL-S-19500. These devices have proven themselves by their reliability and stability in the most demanding defense and aerospace applications. All of the following types are available from Motorola.

JAN Transistors (TX version)

NPN	PNP
JAN TX2N708	JAN TX2N2904
JAN TX2N718A	JAN TX2N2904A
JAN TX2N914	JAN TX2N2905
JAN TX2N918	JAN TX2N2905A
JAN TX2N929	JAN TX2N2906
JAN TX2N930	JAN TX2N2906A
JAN TX2N2060*	JAN TX2N2907
JAN TX2N2218	JAN TX2N2907A
JAN TX2N2218A	JAN TX2N3250A
JAN TX2N2219	JAN TX2N3251A
JAN TX2N2219A	JAN TX2N3485A
JAN TX2N2221	JAN TX2N3486A
JAN TX2N2221A	JAN TX2N3634
JAN TX2N2222	JAN TX2N3635
JAN TX2N2222A	JAN TX2N3636
JAN TX2N2369A	JAN TX2N3637
JAN TX2N2481	
JAN TX2N2857	

*Dual Transistor

JAN Transistors (MIL-STD-701 types)

NPN		PNP
JAN 2N708	JAN 2N2222	JAN 2N2904
JAN 2N718A	JAN2N2222A	JAN 2N2904A
JAN 2N869A	JAN 2N2369A	JAN 2N2905
JAN 2N914	JAN 2N2481	JAN 2N2905A
JAN 2N916	JAN 2N2857	JAN 2N2906
JAN 2N918	JAN 2N3253	JAN 2N2906A
JAN 2N930	JAN 2N3444	JAN 2N2907
JAN 2N1613	JAN 2N3498	JAN 2N2907A
JAN 2N2060*	JAN 2N3499	JAN 2N3251A
JAN 2N2218	JAN 2N3500	JAN 2N3467
JAN 2N2218A	JAN 2N3501	JAN 2N3468
JAN 2N2219	JAN 2N3506	JAN 2N3634
JAN 2N2219A	JAN 2N3507	JAN 2N3635
JAN 2N2221		JAN 2N3636
JAN 2N2221A		JAN 2N3637
		JAN 2N3810*
		JAN 2N3811*

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Device Type	Table	Device Type	Table	Device Type	Table	Device Type	Table	Device Type	Table
2N720A	1	2N2973	10	2N3723	3	2N4931	6	MD7021	9
2N869A	3	2N2975	7	2N3724	8	2N4974	8	MD8003	10
2N930A	5	2N2979	7	2N3725	3	2N4975	8	MM1605	2
2N998	8	2N3013	3	2N3726	7	2N5146	11	MM1748A	3
2N999	8	2N3014	3	2N3734	3	2N5229	4	MM2484	5
2N2060A	7	2N3019	1	2N3735	3	2N5230-31	4	MM3005	1
2N2218A	1	2N3020	1	2N3736	3	2N5332	1	MM3006	1
2N2219A	1	2N3043	7	2N3737	3	2N5357	6	MM3007	6
2N2221A	1	2N3053	1	2N3742	6	2N5581	1	MM3903	1
2N2222A	1	2N3114	6	2N3743	6	2N5582	1	MM3904	1
2N2330	4	2N3250A	1	2N3762	3	2N5583	2	MM3905	1
2N2331	4	2N3251A	1	2N3763	3	2N5763	1	MM3906	1
2N2369A	3	2N3303	3	2N3764	3	MD708	7	MM4049	2
2N2501	3	2N3444	3	2N3765	3	MD918	10	MM4052	4
2N2604	5	2N3467	3	2N3798	6	MD918A	7	MM4261H	3
2N2605	5	2N3468	3	2N3799	5	MD918AF	7	MM4545	6
2N2723	8	2N3485A	1	2N3810A	7	MD986	9	MM4546	6
2N2724	8	2N3486A	1	2N3811A	7	MD986F	9	MM4547	6
2N2725	8	2N3494	1	2N3816A	7	MD2218A	10	MM4645	6
2N2785	8	2N3495	6	2N3817A	7	MD2219A	10	MM4646	6
2N2848	3	2N3496	1	2N3838	9	MD2369	10	MM4647	6
2N2896	1	2N3497	6	2N3946	1	MD2369A	7	MM5005	1
2N2904A	1	2N3498	6	2N3947	1	MD2904A	10	MM5006	1
2N2905A	1	2N3499	6	2N3960	2	MD2905A	10	MM5007	1
2N2906A	1	2N3500	6	2N4014	3	MD3250	10	MQ930	11
2N2907A	1	2N3501	6	2N4261	2	MD3251	10	MQ2218	11
2N2913	10	2N3507	3	2N4404	1	MD3251A	7	MQ2219A	11
2N2914	10	2N3509	3	2N4405	1	MD3467	10	MQ2484	11
2N2919	7	2N3518	7	2N4406	1	MD3725	10	MQ2904	11
2N2920	7	2N3546	3	2N4407	1	MD4957	10	MQ2905A	11
2N2944	4	2N3635	6	2N4854	9	MD5000	10	MQ3251	11
2N2945	4	2N3636	6	2N4890	1	MD5000A	7	MQ3467	11
2N2945A	4	2N3637	6	2N4926	6	MD6002	9	MQ3725	11
2N2946	4	2N3648	3	2N4927	6	MD6100	9	MQ3762	11
2N2946A	4	2N3712	6	2N4929	6	MD7002	10	MQ3799	11
2N2972	10	2N3722	3	2N4930	6	MD7003	10	MQ3799A	11



TO-5
Case 31 (1)



TO-18
Case 22 (1)



TO-39
Case 79 (1)



TO-46
Case 26



TO-52
Case 27



TO-72
Case 20 (10)

TABLE 1 – GENERAL-PURPOSE SWITCHING AND AMPLIFIER TRANSISTORS

The transistors in this table are characterized for use as medium-voltage, medium-speed switches and general-purpose, small-signal amplifiers at dc and low to medium frequencies. The transistors are listed first in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing maximum collector current (I_C max) and dc current gain (h_{FE}). High voltage transistors (BV_{CEO} over 90 V) are listed in Table 6.

Type	BV_{CEO} Volts min	I_C mA max	h_{FE} & $V_{CE(sat)}$ @ I_C min/max	Volts max	mA	f_T MHz min	t_{on} ns max	t_{off} ns max	Package
NPN									
2N2896	90	1000	60/120	0.6	150	120	–	–	TO-18
2N3019	80	1000	100/300	0.2	150	100	–	–	TO-5
MM3006	80	1000	50/250	0.4	200	50	120	500	TO-39
2N3020	80	1000	40/120	0.2	150	80	–	–	TO-5
2N720A	80	1000	40/120	5.0	150	50	–	–	TO-18
MM3005	60	1000	50/250	0.35	150	50	120	500	TO-39
2N2219A, 2N2222A, 2N5582	40	800	100/300	0.3	150	300	35	250	TO-5, TO-18, TO-46
2N2218A, 2N2221A, 2N5581	40	800	40/120	0.3	150	250	35	250	TO-5, TO-18, TO-46
2N3053	40	700	50/250	1.4	150	100	–	–	TO-5
2N3947	40	200	100/300	0.2	10	300	70	400	TO-18
2N3946	40	200	50/150	0.2	10	250	70	375	TO-18
MM3903	40	200	50/150	0.2	10	250	70	225	TO-52
MM3904	40	200	100/300	0.2	10	300	70	250	TO-52
PNP									
MM5007	100	2000	50/250	0.5	250	30	–	–	TO-39
MM5006	80	2000	50/250	0.5	200	30	–	–	TO-39
2N4407	80	2000	75/225	0.2	150	150	75	225	TO-39
2N4406	80	2000	25/100	0.2	150	150	75	225	TO-39
2N4405	80	1000	100/300	0.2	150	200	40	200	TO-5
2N4404	80	1000	40/120	0.2	150	200	40	200	TO-5
2N3494	80	100	40/–	0.3	10	200	300	450	TO-5
2N3496	80	100	40/–	0.3	10	200	300	450	TO-18
MM5005	60	200	50/250	0.5	150	30	–	–	TO-39
2N2905A, 2N2907A, 2N3486A	60	600	100/300	0.4	150	200	45	100	TO-5, TO-18, TO-46
2N2904A, 2N2906A, 2N3485A	60	600	40/120	0.4	150	200	45	100	TO-5, TO-18, TO-46
2N5763	60	600	35/–	0.4	150	200	50	200	TO-18
2N3251A	60	200	100/300	0.25	10	300	70	200	TO-18
2N3250A	60	200	50/150	0.25	10	250	70	175	TO-18
2N4890	40	700	50/250	1.4	150	100	100	270	TO-39
MM3905	40	200	50/150	0.25	10	200	70	260	TO-52
MM3906	40	200	100/300	0.25	10	250	70	300	TO-52
2N5332	12	100	20/80	0.2	20	600	20	86	TO-46

TABLE 2 – CURRENT-MODE SWITCHING TRANSISTORS

The transistors in this table are current-mode switches for use in emitter-coupled (nonsaturated) logic circuitry. The transistors are listed first in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing maximum collector current (I_C max) and dc current gain (h_{FE}).

Type	BV_{CEO} Volts min	I_C mA max	h_{FE} @ I_C min/max	mA	C_{ob} pF max	f_T MHz typ	t_{on} ns typ	t_{off} ns typ	Package
NPN									
2N3960	12	50	40/200	10	2.5	2000	5.0	5.0	TO-18
MM1605	10	300	25/200	25	1.0	2500	5.0	5.0	TO-72
PNP									
2N5583	30	500	25/100	100	5.0	1600	0.8	4.0	TO-39
2N4261	15	30	30/150	10	2.5	3000	0.5	2.0	TO-72
MM4049	10	30	20/80	25	1.25	4.0*	–	–	TO-72

*Min GHz

TABLE 3 – HIGH-SPEED SATURATED SWITCHING TRANSISTORS

The transistors are optimized for high-speed saturated switching. They are heavily gold doped to provide very short switching times and low capacitances. These devices are listed first in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing maximum collector current (I_C max) and dc current gain (h_{FE}). High voltage transistors (BV_{CEO} over 90 V) are listed in Table 6.

Type	BV_{CEO} Volts min	I_C mA max	h_{FE} & $V_{CE(sat)}$ @ I_C min/max	Volts max	mA	f_T MHz min	t_{on} ns max	t_{off} ns max	Package
NPN									
2N3723	80	800	40/150	0.28	100	300	70	130	TO-5
2N3722	60	800	40/150	0.25	100	300	50	100	TO-5
2N3507	50	3000	30/150	1.0	1500	60	45	90	TO-5
2N3735	50	1500	20/80	0.9	1000	250	48	60	TO-5
2N3737	50	1500	20/80	0.9	1000	250	48	60	TO-46
2N3725 2N4014	50	1000	35/–	0.52	500	300	35	60	TO-5 TO-18
2N3444	50	1000	20/60	0.6	500	175	50	70	TO-5
2N3734	30	1500	30/120	0.9	1000	250	48	60	TO-5
2N3736	30	1500	30/120	0.9	1000	250	48	60	TO-46
2N2848	30	800	30/–	1.0	500	250	40	40	TO-5
2N3509	20	500	100/300	0.25	10	500	12	18	TO-46
2N2501	20	500	50/150	0.2	10	350	20	25	TO-18
2N3014	20	500	30/120	0.18	30	350	16	25	TO-52
2N2369A	15	500	40/120	0.2	10	500	12	18	TO-18
2N3013	15	500	30/120	0.18	30	350	15	25	TO-52
2N3648	15	500	30/120	0.4	150	450	16	18	TO-46
2N3303	12	1000	30/120	0.33	300	450	15	25	Case 94
MM1748A	6.0	100	30/90	0.3	10	800	15	15	TO-52
PNP									
2N3763 2N3765	60	1500	20/80	0.9	1000	150	43	105	TO-5 TO-46
2N3468	50	1000	25/75	0.6	500	150	40	90	TO-5
2N3762 2N3764	40	1500	30/120	0.9	1000	180	43	105	TO-46 TO-5
2N3467	40	1000	40/120	0.5	500	175	40	90	TO-5
2N869A	18	200	40/120	0.15	10	400	50	80	TO-18
MM4261H*	15	30	30/150	0.35	10	2000	5.0	5.0	TO-72
2N3546	12	200	30/120	0.15	10	700	40	30	TO-18

*Radiation Resistant

TABLE 4 – CHOPPER TRANSISTORS

Transistors designed for chopper applications have low offset currents, low "on" voltage, high "off" resistance, and fast switching times. These devices are listed first in decreasing order of breakdown voltage (BV_{CEO}), then in order of decreasing maximum collector current (I_C max) and dc current gain (h_{FE}).

Type	BV_{ECO} Volts min	I_C mA max	h_{FE} min	BV_{EBO} Volts min	h_{FE} (inv)	$V_{EC(off)}$ mVdc max	f_T MHz typ	$r_{ec(on)}$ Ohms max	Package
NPN									
2N2330	20	500	50	7.0	–	3.0	250	–	TO-5
2N2331	20	500	50	7.0	–	3.0	250	–	TO-18
PNP									
2N2946A	35	100	50	40	20	0.8	14	8.0	TO-46
2N2946	35	100	30	40	3.0	0.8	14	45	TO-46
MM4052	30	500	20	30	3.0	2.0	12*	2.0	TO-46
2N5231	30	100	50	50	15	0.8	14	10	TO-46
2N2945A	20	100	70	25	30	0.5	16	6.0	TO-46
2N5230	20	100	50	30	15	0.5	14	8.0	TO-46
2N2945	20	100	40	25	4.0	0.5	14	35	TO-46
2N2944	10	100	80	15	6.0	0.3	16	20	TO-46
2N5229	10	100	50	15	15	0.5	14	6.0	TO-46

*Min


TO-5
Case 31 (1)


TO-18
Case 22 (1)


TO-46
Case 26


TO-52
Case 27


TO-72
Case 20 (10)


Case 94



TO-5
Case 31 (1)



TO-18
Case 22 (1)



TO-37
Case 39



TO-39
Case 79 (1)



TO-46
Case 26

TABLE 5 – LOW-NOISE AMPLIFIER TRANSISTORS

These transistors are characterized for low-noise amplification at low frequencies. The transistors are listed first in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing maximum collector current (I_C max) and dc current gain (h_{FE}).

Type	BV_{CEO} Volts min	I_C mA max	h_{FE} @ I_C min/max	mA	C_{ob} pF max	NF dB max	f_T MHz typ	Package
NPN								
MM2484	60	50	100/500	0.01	6.0	3.0	70	TO-18
2N930A	45	30	100/300	0.01	6.0	3.0	70	TO-18
PNP								
2N3799	60	50	300/900	0.5	4.0	2.5	150	TO-18
2N3798	60	50	150/450	0.5	4.0	3.5	150	TO-18
2N2605	45	30	100/300	0.01	6.0	3.0	60	TO-46
2N2604	45	30	40/120	0.01	6.0	4.0	60	TO-46

TABLE 6 – HIGH-VOLTAGE TRANSISTORS

These high-voltage transistors are designed for general-purpose amplifiers, dc to ac converters, relay drivers, motor controls and for other applications requiring high-voltage direct line operation capability. These transistors are listed first in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing maximum collector current (I_C max) and dc current gain (h_{FE}).

Type	BV_{CEO} Volts min	I_C mA max	h_{FE} & $V_{CE(sat)}$ @ I_C min/max	Volts max	& $V_{BE(sat)}$ @ I_C Volts max	mA	f_T MHz typ	Package
NPN								
2N3742	300	50	20/200	5.0	1.2	30	60	TO-5
2N4927	250	50	20/200	2.0	1.5	30	80	TO-5
2N4926	200	50	20/200	2.0	1.5	30	80	TO-5
2N3501	150	300	100/300	0.4	1.2	150	180	TO-5
2N3500	150	300	40/120	0.4	1.2	150	180	TO-5
2N3712	150	200	30/150	2.0	0.9	30	100	TO-5
2N3114	150	200	30/120	1.0	0.9	30	60	TO-5
MM3007	100	1000	30/250	0.45	–	150	120	TO-39
2N3499	100	500	100/300	0.4	1.2	150	180	TO-5
2N3498	100	500	40/120	0.4	1.2	150	180	TO-5
PNP								
MM4547	400	2500	20/–	1.5	–	500	30*	TO-37
MM4647	400	2500	20/–	1.5	–	500	30*	TO-39
2N5357	300	2500	25/100	1.0	1.3	500	55	TO-37
MM4546	300	2500	20/–	1.2	–	500	40*	TO-37
MM4646	300	2500	20/–	1.2	–	500	40*	TO-39
2N3743	300	50	25/250	8.0	1.2	30	40	TO-5
2N4931	250	500	20/200	5.0	1.0	10	40	TO-39
MM4545	200	2500	20/–	1.0	–	500	40*	TO-37
MM4645	200	2500	20/–	1.0	–	500	40*	TO-39
2N4930	200	500	20/200	5.0	1.0	10	40	TO-39
2N3637	175	1000	100/300	0.5	0.9	50	230	TO-5
2N3636	175	1000	50/150	0.5	0.9	50	180	TO-5
2N4929	150	500	25/200	0.5	1.0	10	100	TO-39
2N3635	140	1000	100/300	0.5	–	–	200	TO-5
2N3497	120	100	40/–	0.35	0.9	10	180	TO-18
2N3495	120	100	40/–	0.35	0.9	10	180	TO-5

*Min

TABLE 7 – MATCHED DUAL TRANSISTORS

Matched dual transistors find their widest application as differential amplifiers, where they maintain tight tracking with widely varying temperatures. The transistors are listed first in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing maximum collector current (I_C max) and dc current gain (h_{FE}).

Type	BV_{CEO} Volts min	I_C mA max	h_{FE} & $\frac{h_{FE1}}{h_{FE2}}$ min/max	$\frac{h_{FE1}}{h_{FE2}}$ min	$V_{BE1} - V_{BE2}$ @ I_C mV max	mA	f_T MHz typ	Package
NPN								
2N3518	60	500	50/200	0.9	3.0	1.0	200	TO-89
2N2060A	60	500	30/90	0.9	3.0	0.1	200	TO-78
2N2920	60	30	300/–	0.9	3.0	1.0	70	TO-78
2N2979	60	30	150/600	0.9	3.0	0.01	70	TO-78
2N2919	60	30	150/–	0.9	3.0	1.0	200	TO-78
2N2975	45	30	150/600	0.9	3.0	0.01	70	TO-71
2N3043	45	30	100/300	0.9	5.0	0.01	70	TO-89
MD2369A	15	500	40/140	0.9	5.0	3.0	600	TO-78
MD708A	15	200	40/200	0.9	5.0	10	450	TO-78
MD918A / MD918AF	15	50	50/–	0.9	5.0	1.0	700	TO-78 / TO-89
PNP								
2N3811A / 2N3817A	60	50	300/900	0.95	1.5	0.1	120	TO-78 / TO-89
2N3810A / 2N3816A	60	50	150/450	0.95	1.5	0.1	120	TO-78 / TO-89
2N3726	45	300	120/–	0.9	5.0	0.1	200	TO-78
MD3251A	40	50	100/300	0.9	3.0	0.1	375	TO-78
MD5000A	15	50	20/–	0.9	5.0	4.0	700	TO-78

TO-78 also listed as RO131C

TABLE 8 – DARLINGTON AMPLIFIER TRANSISTORS

Darlington amplifiers are compound-connected dual transistors used in applications requiring very high current gain and input impedance. The transistors are listed first in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing maximum collector current (I_C max) and dc current gain (h_{FE}).

Type	BV_{CEO} Volts min	I_C mA max	h_{FE} & min/max	$V_{CE(sat)}$ @ Volts max	I_C mA	C_{ob} pF max	f_T MHz typ	Package
NPN								
2N999	60	500	7000/70000	–	100	20	200	TO-72
2N998	60	500	1600/8000	–	10	30	200	TO-72
2N2724	60	40	7000/50000	1.0	10	10	150	TO-72
2N2723	60	40	2000/10000	1.0	10	10	150	TO-72
2N2725	45	30	2000/10000	1.0	0.1	10	150	TO-72
2N2785	40	200	1200/–	1.0	10	30	150	TO-72
PNP								
2N4974	30	1000	15000/–	2.0	500	8.0	200	TO-12
2N4975	30	1000	5000/–	2.0	500	8.0	200	TO-12

TABLE 9 – COMPLEMENTARY TRANSISTOR PAIRS

Each of these space-saving complementary transistor pair contains one NPN and one PNP transistor with similar specifications. These devices are listed first in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing maximum collector current (I_C max) and dc current gain (h_{FE}).

Type	BV_{CEO} Volts min	I_C mA max	h_{FE} & min/max	$V_{CE(sat)}$ @ Volts max	I_C mA	t_{off} ns	f_T MHz typ	Package
MD6100	45	50	150/–	0.25	1.0	–	60	TO-78
2N3838 / 2N4854	40	600	100/300	0.4	150	250	250	TO-89 / TO-78
MD7021	40	30	50/–	0.35	10	–	230	TO-78
MD6002	30	300	100/300	0.4	150	250	250	TO-78
MD986 / MD986F	15	200	25/–	0.3	10	–	230	TO-78 / TO-89

TO-78 also listed as RO131C



TO-12
Case 34A



TO-71
Case 35



TO-72
Case 20 (10)



TO-89
Case 33



TO-78
Case 32-02

TABLE 10 – DUAL TRANSISTORS

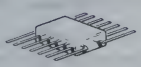
Dual transistors contain two similar general-purpose switching and amplifying transistors. They are space-saving direct replacements for two single devices. These devices are listed first in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing maximum collector current (I_C max) and dc current gain (h_{FE}).



TO-71
Case 35

Type	BV_{CEO} Volts min	I_C mA max	h_{FE} & $V_{CE(sat)}$ @ I_C min/max	Volts max	mA	C_{ob} pF max	f_T MHz typ	Package
NPN								
MD8003	60	30	100/–	–	1.0	3.0	70	TO-78
2N2914 / 2N2973	45	30	300/–	0.35	1.0	6.0	70	TO-78 / TO-71
2N2913 / 2N2972	45	30	150/–	0.35	1.0	6.0	70	TO-78 / TO-71
MD3725	40	1000	30/–	0.52	500	10	300	TO-78
MD2218A	40	600	100/300	0.3	150	8.0	260	TO-78
MD2218A	40	600	40/120	0.4	150	8.0	240	TO-78
MD7002	40	30	40/–	–	0.1	6.0	220	TO-78
MD2369	15	500	40/140	0.25	10	4.0	600	TO-78
MD708	15	200	40/200	0.2	10	5.0	450	TO-78
MD918	15	50	50/–	0.2	10	1.7	700	TO-78
PNP								
MD2905A	60	600	100/300	0.4	150	8.0	250	TO-78
MD2904A	60	600	40/120	0.4	150	8.0	250	TO-78
MD3251	40	50	100/300	–	0.1	6.0	275	TO-78
MD3250	40	50	50/150	–	0.1	6.0	225	TO-78
MD7003	40	30	40/–	–	0.01	6.0	230	TO-78
MD3467	40	1000	20/–	0.5	500	20	200	TO-78
MD4957	30	30	20/150	–	2.0	0.8	1200	TO-78
MD5000	15	50	20/–	0.4	10	1.7	650	TO-78

TO-78 also listed as RO131C



TO-86
Case 83

TABLE 11 – QUAD TRANSISTORS

Each quad transistor contains four similar transistors that can be used to reduce space requirements. These transistors are listed first in order of decreasing breakdown voltage (BV_{CEO}), then in order of decreasing maximum collector current (I_C max) and dc current gain (h_{FE}).



TO-78
Case 32-02

Type	BV_{CEO} Volts min	I_C mA max	h_{FE} & $V_{CE(sat)}$ @ I_C min/max	Volts max	mA	t_{on} ns max	t_{off} ns max	f_T MHz typ	Package
NPN									
MQ2484	60	30	250/–	0.35	1.0	–	–	70	TO-86
MQ930	45	30	150/–	0.35	1.0	–	–	70	TO-86
MQ3725	40	1000	30/–	0.52	500	45	75	300	TO-86
MQ2219A	40	600	100/300	0.3	150	60	350	270	TO-86
MQ2218	30	600	40/120	0.4	150	60	350	220	TO-86
PNP									
MQ2905A	60	600	100/300	0.4	150	45	130	225	TO-86
MQ3799	60	50	300/900	0.2	0.1	–	–	130	TO-86
MQ3799A*	60	50	300/900	0.2	0.1	–	–	130	TO-86
MQ3762 / 2N5146	40	1500	20/–	1.0	1000	40	120	200	TO-86
MQ3467	40	1000	20/–	0.5	500	40	120	200	TO-86
MQ2904	40	600	40/120	0.4	150	45	130	225	TO-86
MQ3251	40	50	100/300	0.25	10	–	–	350	TO-86

*Matched Quad

SILICON RF TRANSISTORS

Motorola offers the industry's most complete selection of silicon RF transistors. In addition to NPN and PNP low-noise small-signal transistors and ultra-fast current-mode switches, Motorola can provide RF power transistors for all communications bands at frequencies to 1.0 GHz. Transistors are available for most applications in either polarity, NPN or PNP, with a wide range of power levels. Families of RF power transistors designed for optimum operation from a 12-volt supply are available for mobile communications applications.

Many of Motorola's RF power transistors are Balanced Emitter Transistors (BET). These multiple-emitter devices feature a thin-film nichrome resistor in series with each of the individual emitters. The effect of these resistors is to distribute the current equally among the emitters and reduce the localized heating that leads to second breakdown and destruction of the transistor. Thus the Balanced Emitter Transistors make ideal output devices by virtue of their ability to withstand large mismatches without danger of second breakdown.

This Selector Guide presents information on most of Motorola's small signal devices with f_T greater than 300 MHz and RF power devices with RF power outputs greater than 1.0 Watt at frequencies greater than 2.0 MHz. Other transistors for RF applications may be found in the Selector Guides for Silicon Small-Signal Hermetic Annular Transistors and Plastic Encapsulated Small-Signal Transistors.

Four tables in this Selector Guide cover the major application categories:

RF Power Amplifiers **Table 1**
. . . a wide variety of devices for communications and general amplifier applications.

Low-Noise Small-Signal Amplifiers **Table 2**
. . . including devices designed specifically for CATV applications.

UHF and Microwave Oscillators **Table 3**
. . . provide high outputs at frequencies to 2.0 GHz.

High-Speed Current-Mode Switches **Table 4**
. . . ultra-fast switching for instrumentation applications.

INDEX

The following table is a numerical-alphabetical index to Silicon RF transistors manufactured by Motorola. The number of the selection table in which each device is further characterized is also listed.

DEVICE TYPE	PACKAGE	TABLE	DEVICE TYPE	PACKAGE	TABLE	DEVICE TYPE	PACKAGE	TABLE
2N2857	TO-72	2,3	2N4957	TO-72	2	MM1500	TO-107	3
2N2947	TO-3	1	2N4958	TO-72	2	MM1501	TO-107	3
2N2948	TO-3	1	2N4959	TO-72	2	MM1552	145C-01	1
2N2949	TO-107	1	2N5016	TO-60	1	MM1553	145C-01	1
2N2950	TO-102	1	2N5024	TO-72	4	MM1619	145A-01	1
2N3137	TO-5	1	2N5031	TO-72	2	MM1620	145A-02	1
2N3287	TO-72	2	2N5032	TO-72	2	MM1665	145A-01	1
2N3288	TO-72	2	2N5090	TO-60	1	MM3375	TO-60	1
2N3289	TO-72	2	2N5108	TO-39	1,3	MM3375A	TO-60	1
2N3290	TO-72	2	2N5160	TO-39	1	MM4018	TO-39	1
2N3291	TO-72	2	2N5161	TO-60	1	MM4019	TO-39	1
2N3292	TO-72	2	2N5162	TO-60	1	MM4020	208-01	1
2N3293	TO-72	3	2N5179	TO-72	2,3	MM4021	208-01	1
2N3294	TO-72	2	2N5583	TO-39	4	MM4022	208-01	1
2N3296	TO-102	1	2N5589	144B-02	1	MM4023	208-01	1
2N3297	TO-3	1	2N5590	145A-01	1	MM4049	TO-72	4
2N3375	TO-60	1	2N5591	145A-01	1	MM4429	145A-01	1
2N3553	TO-39	1	2N5635	144B-02	1	MM4430	145A-01	1
2N3632	TO-60	1	2N5636	144B-02	1	MM8000	TO-39	2
2N3733	TO-60	1	2N5637	145A-01	1	MM8001	TO-39	2
2N3866	TO-39	1,2	2N5641	144B-02	1	MM8002	TO-39	2
2N3924	TO-39	1	2N5642	145A-01	1	MM8003	144B-02	2
2N3925	TO-102	1	2N5643	145A-01	1	MM8004	TO-39	1
2N3926	TO-60	1	2N5644	145A-01	1	MM8006	TO-72	2
2N3927	TO-60	1	2N5645	145A-01	1	MM8007	TO-72	2
2N3948	TO-39	1	2N5646	145A-01	1	MM8008	TO-107	3
2N3950	TO-60	1	2N5829	TO-72	2	MM8009	TO-39	1,3
2N3959	TO-18	4	2N5835	TO-72	4	MM8010	TO-107	3
2N3960	TO-18	4	2N5836	TO-46	4	MM8011	TO-107	3
2N3961	TO-102	1	2N5837	TO-46	4	MM8012	144D-01	2
2N4012	TO-60	1	2N5841	TO-72	4	MMT8015	28(1)	2
2N4072	TO-18	1	2N5842	TO-72	4			
2N4073	TO-5	1	2N5846	TO-102	1			
2N4427	TO-39	1	2N5847	145A-01	1			
2N4428	TO-39	1	2N5849	145A-02	1			

TABLE 1 – RF POWER AMPLIFIERS

A wide variety of devices for communications and general amplifier applications. The transistors are listed first in order of increasing test frequency; then in order of increasing output power rating.

Device Type	Test Conditions f MHz	& V_{CC} Volts	P_{out} Watts Min	Power Gain dB Min	BV_{CBO} Volts Min	Package
NPN						
MM8004	27	12.5	3.5	10	60	TO-39
2N3296	30	30	3.0PEP	16	60	TO-102
2N3297	30	30	12PEP	10	60	TO-3
2N2948	30	25	15	7.0	40	TO-3
2N5846	50	12.5	3.5	10	36	TO-102
2N2949	50	25	3.5	10	60	TO-107
2N2950	50	25	3.5	10	60	TO-102
2N5847	50	12.5	8.0	10	36	145A-01
2N2947	50	25	15	7.0	60	TO-3
MM1619	50	12.5	25	9.2	48	145A-01
2N5849	50	12.5	40	7.5	48	145A-02
MM1620	50	12.5	40	8.2	48	145A-02
2N3950	50	28	50	8.0	65	TO-60
2N3375†	100	28	7.5	8.8	65	TO-60
MM3375	100	28	8.0	9.0	65	TO-60
MM3375A	100	28	10	10	65	TO-60
MM1552	150	27	75	7.0	65	145C-01
MM1553	150	44	75	8.2	100	145C-01
2N4072	175	13.6	0.25	10	40	TO-18
2N4073	175	13.6	0.5	10	40	TO-5
2N4427	175	12	1.0	10	40	TO-39
2N3553†	175	28	2.5	10	65	TO-39
2N5589	175	13.6	3.0	8.2	36	144B-02
2N3924	175	13.6	4.0	6.0	36	TO-39
2N3961	175	28	4.0	9.0	65	TO-102
2N3925	175	13.6	5.0	5.9	36	TO-102
2N3926	175	13.6	7.0	5.5	36	TO-60
2N5641	175	28	7.0	8.4	65	144B-02
2N5590	175	13.6	10	5.2	36	145A-01
2N3927	175	13.6	12	4.8	36	TO-60
2N3632	175	28	13.5	5.9	65	TO-60
2N5642	175	28	20	8.2	65	145A-01
2N5591	175	13.6	25	4.4	36	145A-01
2N5643	175	28	40	7.6	65	145A-01
2N3137	250	20	0.4	6.0	40	TO-5
2N3866	400	28	1.0	10	55	TO-39
2N3948	400	13.6	1.0	6.0	36	TO-39
2N5090	400	28	1.2	5.5	55	TO-60
2N5635	400	28	2.5	6.2	60	144B-02
2N5636	400	28	7.5	5.7	60	144B-02
2N3733	400	28	10	4.0	65	TO-60
2N5016	400	28	15	4.8	65	TO-60
2N5637	400	28	20	4.6	60	145A-01
2N5644	470	12.5	1.0	7.0	36	145A-01
2N5645	470	12.5	4.0	6.0	36	145A-01
2N5646	470	12.5	12	4.7	36	145A-01
MM1665	470	12.5	25	3.5	36	145A-01
2N4428	500	28	0.75	10	55	TO-39
MM8009	1000	28	0.9	4.5	55	TO-39
MM4429	1000	28	1.0	5.2	55	145A-01
2N5108	1000	28	1.0	5.0	55	TO-39
MM4430	1000	28	2.5	4.8	55	145A-01
2N4012	1000	28	2.5‡	—	65	TO-60
PNP						
MM4018	175	12.5	0.5	10	40	TO-39
MM4019	175	28	2.5	10	60	TO-39
MM4020	175	12.5	3.5	11.5	36	208-01
2N5161	175	28	7.5	8.8	60	TO-60
MM4021	175	12.5	15	7.0	36	208-01
MM4022	175	12.5	25	5.5	36	208-01
2N5162	175	28	30	6.0	60	TO-60
MM4023	175	12.5	40	4.5	36	208-01
2N5160	400	28	1.0	8.0	60	TO-39

†JAN Types Also Available

†BV_{CES} ‡Tripler Output

TABLE 2 – LOW-NOISE SMALL-SIGNAL AMPLIFIERS

Including devices designed specifically for CATV applications. The transistors are listed first in order of increasing test frequency, then in order of increasing noise figure.

Device Type	Test Conditions f MHz	& V_{CE} Volts	NF dB Max	Power Gain dB Min	f_T MHz Min	Package
NPN						
MM8000	200	15	2.7*	11.4*	700	TO-39
MM8001	200	15	2.7*	11.4*	900	TO-39
MM8002	200	15	2.7*	11.4*	1200	TO-39
MM8003	200	15	2.7*	11.4*	1200	144B-02
MM8012	200	15	2.7*	11.4*	1200	144D-01
2N5179	200	6.0	4.5	15	900	TO-72
2N3287	200	10	6.0	17	350	TO-72
2N3288	200	10	6.0	17	350	TO-72
2N3289	200	10	7.0	17	300	TO-72
2N3290	200	10	7.0	17	300	TO-72
2N3294	200	10	7.0*	14	250	TO-72
2N3291	200	10	8.0	16	250	TO-72
2N3292	200	10	9.0	16	250	TO-72
NPN (continued)						
2N5031	450	6.0	2.5	14	1000	TO-72
2N5032	450	6.0	3.0	14	1000	TO-72
MM8006	450	6.0	3.8	14	1000	TO-72
2N2857†	450	6.0	4.5	12.5	1000	TO-72
MM8007	450	6.0	5.0	12	1000	TO-72
MMT8015	1000	6.0	4.0	7.0	1000	28(1)
PNP						
2N5829	450	10	2.5	17	1200	TO-72
2N4957	450	10	3.0	17	1200	TO-72
2N4958	450	10	3.3	16	1000	TO-72
2N4959	450	10	3.8	15	1000	TO-72

*Typical †JAN Type Also Available.

TABLE 3 – UHF and MICROWAVE OSCILLATORS

The transistors are listed first in order of increasing test frequency; then in order of increasing oscillator output power.

Device Type	Test Conditions f (MHz)	& V_{CE} (Volts)	P_{out} (Oscillator) mW Min	f_T MHz Min	BV_{CBO} Volts Min	Package
NPN						
2N3293	257	10	2.0	250	20	TO-72
2N5179	500	10	20	900	20	TO-72
2N2857†	500	10	30	1000	30	TO-72
MM1501	1500	20	150	1000*	30	TO-107
MM1500	1500	20	250	1500*	30	TO-107
MM8009	1680	20	300*	1000	55	TO-39
2N5108	1680	20	300*	1200	55	TO-39
MM8011	2000	20	100	1100*	35	TO-107
MM8010	2000	20	200	1100*	35	TO-107
MM8008	2000	20	300	1100*	35	TO-107

*Typical †JAN Type Also Available.

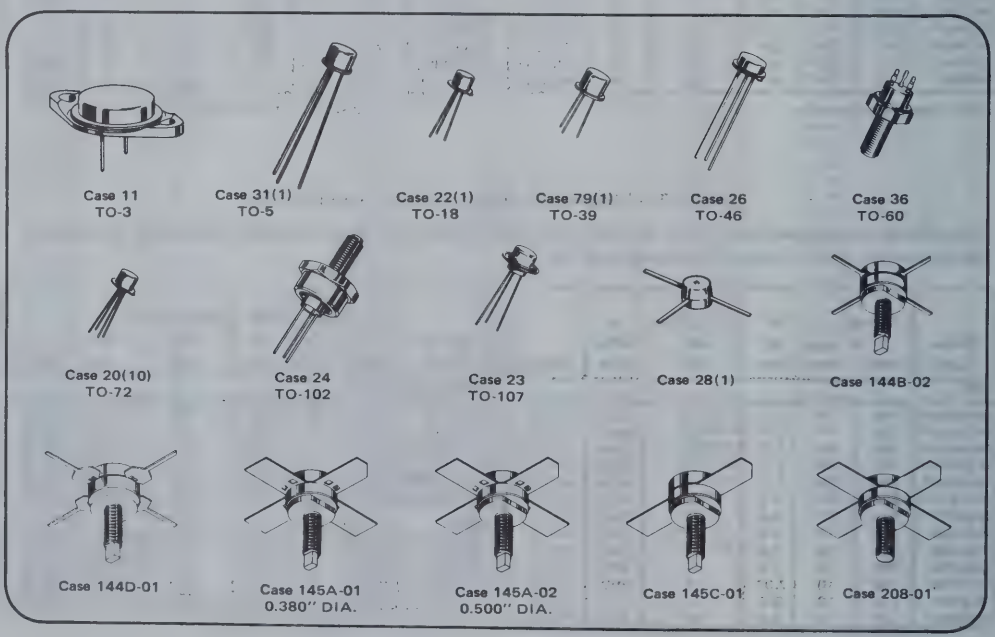
TABLE 4 – HIGH-SPEED CURRENT MODE SWITCHES

Ultra-fast switching for instrumentation applications is provided by these devices which feature high f_T and low $r_b'C_c$ over a wide range of collector current. The transistors are listed first in order of increasing collector current (test) and then in order of increasing f_T.

Device Type	Test Conditions I_C (mA)	& V_{CE} (Volts)	f_T MHz Min	$r_b'C_c$ ps Max	C_{cb} pF Max	Package
NPN						
2N3959†	10	10	1300	25	2.5**	TO-18
2N5024	10	4.0	1300	50	1.5	TO-72
2N3960†	10	10	1600	40	2.5**	TO-18
2N5835	10	6.0	2500	10	0.8	TO-72
2N5842	25	4.0	1700	40	1.5	TO-72
2N5841	25	4.0	2200	25	1.5	TO-72
2N5836	50	6.0	2000	10	3.5	TO-46
2N5837	100	3.0	1700	10	5.0	TO-46
PNP						
MM4049	25	5.0	4000	15	1.25**	TO-72
2N5583	100	10	1300	8.0*	5.0	TO-39

*Typical **C_{ob} †JAN Types Also Available.

RF transistors are available in a variety of packages for many applications.



RF SEMICONDUCTORS

SMALL SIGNAL

FREQUENCY	PNP Ge	NPN Si	PNP Si	P-CHANNEL JFET	N-CHANNEL JFET	N-CHANNEL MOSFET	INTEGRATED CIRCUIT	DUAL TRANSISTOR
2 MHz ↕ 76 MHz	2N700 2N1141A 2N1142A 2N1143 2N1195	2N918 2N2857 2N3287 2N3288 2N3289	2N3307 2N3308 2N3905 2N3906 2N4125	2N5265 2N5266 2N5267 2N5268 2N5269	2N3821 2N3822 2N3823 2N3824 2N4220A	MFE3004 MFE3005 MFE3006	MC1550	MD918B MD918BF MD4957 MD5000B
	2N2415 2N2416 2N2929 2N2996 2N2997	2N3290 2N3839 2N3903 2N3904 2N4123	2N4126 2N4957 2N4958 2N4959 2N5208	2N5270 2N5460 2N5461 2N5462 2N5463	2N4221A 2N4222A 2N4223 2N4224 2N4416			
	2N2998 2N3127 2N3279 2N3280 2N3281	2N4124 MPS918 MM8000 MM8001 MM8002		2N5464 2N5465 MPF161 MFE4007 MFE4008	2N5358 2N5359 2N5360 2N5361 2N5362			
	2N3282 2N3783 2N3784 2N3785 AF239	MM8003 MMT918 2N5222 2N3127 MM1605		MFE4009 MFE4010 MFE4011 MFE4012	2N5363 2N5364 2N5457 2N5458 2N5459			
	MM5000 MM5001 MM5002 MM5043 MM5044	MM1606 MM1607			2N5484 2N5485 2N5486 3N124 3N125			
	2N2273				3N126 MFE2000 MFE2001 MPF102			
76 MHz ↕ 250 MHz	2N700 2N1141A 2N1142A 2N1143 2N1195	2N918 2N2857 2N3287 2N3288 2N3289	2N3307 2N3308 2N4957 2N4958 2N4959	MFE2002	2N3823 2N4223 2N4224 2N4416 2N5484	MFE3004 MFE3005 MFE3006	MC1550	MD918B MD918BF MD4957 MD5000B
	2N2415 2N2416 2N2929 2N2996 2N2997	2N3290 2N3839 MPS918 MM8000 MM8001	2N5208		2N5485 2N5486 MFE2000 MFE2001 MPF102			
	2N2998 2N3127 2N3279 2N3280 2N3281	MM8002 MM8003 MMT918 2N5222 2N3127						
	2N3282 2N3783 2N3784 2N3785 AF239							
	MM5000 MM5001 MM5002 MM5043 MM5044							
250 MHz ↕ 500 MHz	2N1141A 2N1142A 2N1143 2N1195 2N2415	2N918 2N2857 2N3287 2N3288 2N3289	2N3307 2N3308 2N4957 2N4958 2N4959		2N4416 2N5484 2N5485 2N5486	MFE3004 MFE3005 MFE3006		MD918B MD918BF MD4957 MD5000B
	2N2416 2N2929 2N2996 2N2997 2N2998	2N3290 2N3839 MPS918 MMT918 MM1605	2N5208					
	2N3127 2N3279 2N3280 2N3281 2N3282	MM1606 MM1607						
	2N3783 2N3784 2N3785 AF239 MM5000							
	MM5001 MM5002 MM5043 MM5044							
500 MHz ↕ UP	2N2415 2N2416 2N2997 2N2998 2N3783	2N2857 2N3839	2N4957 2N4958 2N4959					MD4957
	2N3784 2N3785 AF239 MM5000 MM5001							
	Mm5002 MM5043 MM5044							

MICROWAVE DEVICES

The Microwave Devices category includes a very broad line of step-recovery varactor multipliers, a wide range of microwave PIN switching diodes plus hot-carrier diodes for microwave mixer and detector applications.

Motorola's varactor multipliers provide high doubler and tripler efficiency over a wide range of microwave frequencies.

Table 1 — POWER VARACTOR MULTIPLIERS

Basic Type Numbers See Table 2 for Package Variations		Maximum P_D @ $T_C = 75°C$ (1) @ $T_A = 75°C$	ELECTRICAL CHARACTERISTICS								
			100% Functional Test				θ_{JC}	BV_R $I_R = 10\ \mu A$	R_S $V_R = 6.0$ V $f = 50$ MHz	C_T $V_R = 6.0$ V $f = 1.0$ MHz	
			f_{out}	P_{out} min	f_{in}	P_{in}				pF	
	JEDEC Variations	Watts	MHz	Watts	MHz	Watts	°C/W max	Volts min	Ohms typ	min	max
MV1812		3.3	10000	1.0	5000	2.6	38	20	1.0	0.5	1.0
	1N5156	3.3	10000	1.0	5000	2.6	38	20	1.0	0.5	1.0
	1N5157	3.3	10000	1.0	5000	2.6	38	20	1.0	0.5	1.0
MV1817-1		5.0	6400	0.25	800	1.0	25	35	0.8	0.9	1.1
MV1817		3.6	6400	0.20	800	1.0	35	35	0.8	0.8	1.2
MV1810-1		6.2	6000	2.0	2000	5.0	20	35	0.9	1.71	2.09
	1N5155A	6.2	6000	2.0	2000	5.0	20	35	0.9	1.71	2.09
MV1810		3.5	6000	2.0	2000	5.0	35	35	0.9	1.0	3.0
	1N5154	3.5	6000	2.0	2000	5.0	35	35	0.9	1.0	3.0
	1N5155	3.5	6000	2.0	2000	5.0	35	35	0.9	1.0	3.0
MV1811-1		8.2	4000	7.2	2000	12	15	35	0.5	4.5	5.5
MV1811		6.2	4000	5.0	2000	10	20	35	0.5	4.0	6.0
MV1816-1		8.2	2400	0.75	300	3.0	15	75	0.6	2.7	3.3
MV1816		5.3	2400	0.6	300	3.0	23	75	0.6	2.4	3.6
MV1809-1		14	2000	14.5	1000	25	9.0	75	0.25	10.8	13.2
MV1809		9.0	2000	10.4	1000	20	14	75	0.25	9.6	14.4
MV1808-1		8.4	2000	7.2	1000	12	15	75	0.5	5.4	6.6
	1N5152A	8.4	2000	7.2	1000	12	15	75	0.5	5.4	6.6
	1N5153A	8.4	2000	7.2	1000	12	15	75	0.5	5.4	6.6
MV1808		5.5	2000	6.0	1000	12	23	75	0.5	5.0	7.5
	1N5151	5.5	2000	6.0	1000	12	23	75	0.5	5.0	7.5
	1N5152	5.5	2000	6.0	1000	12	23	75	0.5	5.0	7.5
	1N5153	5.5	2000	6.0	1000	12	23	75	0.5	5.0	7.5
MV1807-1		21	1000	25.1	500	37	6.0	80	0.25	10.8	13.2
	1N5150A	21	1000	25.1	500	37	6.0	80	0.25	10.8	13.2
MV1807		14 (1)	1000	24	500	37	9.0	80	0.25	5.0	20
	1N5150	14 (1)	1000	24	500	37	9.0	80	0.25	5.0	20
MV1806		10 (1)	1000	11	500	20	9.0	80	0.25	5.0	20
	1N5149	10 (1)	1000	11	500	20	9.0	80	0.25	5.0	20
	1N4388	10	1000	11	500	20	9.0	100	0.25	—	20
MV1805		18 (1)	750	26	250	40	7.0	80	0.2	20	30
MV1804		20	450	15	150	30	5.0	150	0.7	—	35
	1N4387	20	450	15	150	30	5.0	150	0.7	—	35

Typical case capacitance for A, B, and C packages are 0.25 pF, 0.15 pF, and 0.47 pF respectively.

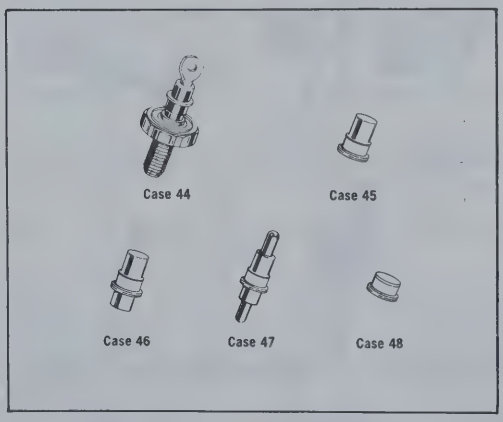


Table 2 — PACKAGE CONFIGURATIONS AND DESCRIPTIONS

MOTOROLA TYPE NO.	(A) (Pill) 48	(B) (Pill or Prongs) 46	(C) (Cartridge) 47	(D) 45	(J) (Stud) 44
MV1804			●		1N4387
MV1805			●		●
MV1806			1N5149		1N4388
MV1807 MV1807-1			1N5150 1N5150A		● ●
MV1808 MV1808-1	1N5151 ●	1N5152 1N5152A	1N5163 1N5153A	● ●	● ●
MV1809 MV1809-1			● ●		● ●
MV1810 MV1810-1	1N5154 ●	1N5155 1N5155A		● ●	
MV1811 MV1811-1	● ●	● ●	● ●	● ●	● ●
MV1812	1N5156	1N5157		●	
MV1816 MV1816-1	● ●	● ●		● ●	
MV1817 MV1817-1	● ●	● ●		● ●	

Key to columnar designations opposite type numbers: "●" indicates availability, specific type number (i.e., "1N5149") indicates availability of JEDEC-type. When ordering, follow type number by alphabetical identification of package type required (i.e., "MV1805C").

FIGURE 1 – Typical Doubling Performance

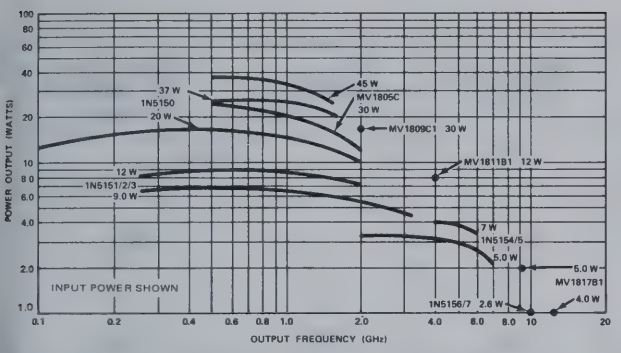
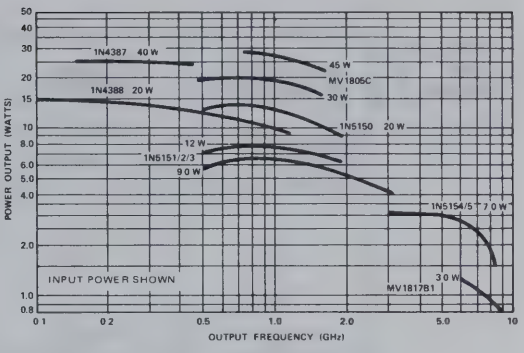


FIGURE 2 – Typical Tripling Performance



Case 46
MPN3202



Case 229-01
MPN3208-09



The P-I-N silicon oxide passivated construction enables the diode to operate over a wide range of series resistance and have very low capacitance. The fast switching time capability makes this device ideal for R-F power control, such as phase shifter, R-F switches, duplexers, voltage-controlled attenuators, modulators and many more.

MICROWAVE PIN SWITCHING DIODES

	ELECTRICAL CHARACTERISTICS						
TYPE	$V_{(BR)R}$ $I_R = 10\ \mu Adc$ Volts min	R_S $I_F = 100$ mAdc (1) $f = 1.0$ GHz (1) $I_F = 150$ mAdc (2) $f = 3.0$ GHz (2) ohm max	C_T $V_R = 50$ V (3) $f = 1.0$ MHz (3) $V_R = 250$ V (4) $f = 1.0$ MHz (4) pF max	τ $I_F = 50$ mAdc ns typ	L_S $f = 250$ MHz nH typ	C_C $f = 1.0$ MHz pF typ	θ_{JC} Thermal Resistance Junction to Case °C/W max
MPN3202	200	1.00 (1)	0.40 (3)	150	0.85	0.18	25
MPN3208	800	0.40 (2)	4.0 (4)	—	—	—	4.0
MPN3209	900	0.40 (2)	4.0 (4)	—	—	—	4.0

PLASTIC HOT CARRIER DIODES

Hot-Carrier diodes are ideal for VHF and UHF mixer and detector applications as well as many higher microwave frequencie applications. They provide stable electrical characteristics by eliminating the point-contact diode presently used in many applications. Motorola has the capability of supplying these devices in a variety of packages.



Case 182-01

	ELECTRICAL CHARACTERISTICS CASE 182-01					
TYPE	$V_{(BR)R}$ Reverse Breakdown Voltage $I_R = 10\ \mu A$ Volts min	C_T Diode Capacitance $V_R = 0$ V, $f = 1.0$ MHz (1) $V_R = 20$ V, $f = 1.0$ MHz (2) pF max	V_F Forward Voltage $I_F = 10$ mA Volts max	I_R Reverse Leakage $V_R = 3.0$ V (3) $V_R = 25$ V (4) $V_R = 35$ V (5) μA max	NF Noise Figure dB max	T_{rr} (Note 1) Reverse Recovery ps max
MBD101	4.0	1.0 (1)	0.6	0.25 (3)	7.0	—
MBD501	50	1.0 (2)	1.2	0.20 (4)	—	100
MBD701	70	1.0 (2)	1.2	0.20 (5)	—	100

NOTE 1: Krakauer method.

EPICAP TUNING DEVICES

LINE HIGHLIGHTS

LOW CAPACITANCE MICROWAVE OPERATION MICROWAVE PACKAGE HIGH Q	HIGH Q CAPACITANCE TOLERANCE – 10% AND 5.0%	HIGH Q GUARANTEED AT 4.0 V AND 60 V CONTROLLED TR	THE PREMIUM GLASS LINE VERY HIGH Q GUARANTEED HIGH TR CAPACITANCE TOLERANCE – 10%, 5.0% AND 2.0%	HIGH Q CAPACITANCE TOLERANCE – 10%, 5.0% AND 2.0% CONTROLLED TR

MAXIMUM WORKING VOLTAGE		60 VOLTS								30 VOLTS					
		 Case 45			 Case 51 DO-7			 Case 51 DO-7			 Case 51 DO-7			 Case 51 DO-7		
C_T NOMINAL CAPACITANCE pF ±10% @ V_R = 4.0 V f = 1.0 MHz		Type	Tuning Ratio C_4/C_{60} pF min/typ	Q @ 4.0 V 100 MHz min	Type (3)	Tuning Ratio C_4/C_{60} pF min/typ	Q @ 4.0 V 50 MHz min	Type	Tuning Ratio C_4/C_{60} pF min/max	Q @ 4.0 V 50 MHz min	Type (4)	Tuning Ratio C_2/C_{30} pF min/max	Q @ 4.0 V 50 MHz min	Type (4)	Tuning Ratio C_2/C_{30} pF min/max	Q @ 4.0 V 50 MHz min
	1.0	MV1858D (1)	2.1/2.3	350												
	2.2	MV1860D (2)	2.5/2.7	350												
	3.3	MV1862D	2.6/2.8	300												
	4.7	MV1863D	2.6/2.8	300												
	6.8	MV1864D	2.7/2.9	300	1N5139	2.7/2.9	350				1N5461A	2.7/3.1	600	1N5441A	2.5/3.1	450
	8.2	MV1865D	2.7/2.9	300							1N5462A	2.8/3.1	600	1N5442A	2.5/3.1	450
	10	MV1866D	2.8/3.0	250	1N5140	2.8/3.0	300	MV1866	2.8/3.2	300	1N5463A	2.8/3.1	550	1N5443A	2.6/3.1	400
	12	MV1868D	2.8/3.0	200	1N5141	2.8/3.0	300	MV1868	2.8/3.2	300	1N5464A	2.8/3.1	550	1N5444A	2.6/3.1	400
	15	MV1870D	2.8/3.0	200	1N5142	2.8/3.0	250	MV1870	2.8/3.2	250	1N5465A	2.8/3.1	550	1N5445A	2.6/3.1	400
	18				1N5143	2.8/3.0	250	MV1871	3.2/3.6	200	1N5466A	2.9/3.1	500	1N5446A	2.6/3.1	350
	20										1N5467A	2.9/3.1	500	1N5447A	2.6/3.1	350
	22				1N5144	3.2/3.4	200	MV1872	3.2/3.6	200	1N5468A	2.9/3.2	500	1N5448A	2.6/3.2	350
	27				1N5145	3.2/3.4	200	MV1874	3.2/3.6	200	1N5469A	2.9/3.2	500	1N5449A	2.6/3.2	350
	33				1N5146	3.2/3.4	200	MV1876	3.2/3.6	200	1N5470A	2.9/3.2	500	1N5450A	2.6/3.2	350
	39				1N5147	3.2/3.4	200	MV1877	3.2/3.6	200	1N5471A	2.9/3.2	450	1N5451A	2.6/3.2	300
	47				1N5148	3.2/3.4	200	MV1878	3.2/3.6	200	1N5472A	2.9/3.2	400	1N5452A	2.6/3.2	250
	56										1N5473A	2.9/3.3	300	1N5453A	2.6/3.3	200
	68										1N5474A	2.9/3.3	250	1N5454A	2.7/3.3	175
	82										1N5475A	2.9/3.3	225	1N5455A	2.7/3.3	175
	100										1N5476A	2.9/3.3	200	1N5456A	2.7/3.3	175
	120															
	150															
	180															
	200															
	220															
	250															
	270															
	330															

(1) C_T = ±30% (2) C_T = ±20% (3) Add Suffix "A" for ±5.0% C_T tolerance (4) Substitute "B" Suffix for ±5.0% C_T, "C" Suffix for ±2.0% C_T (5) Tuning Ratio is C_2/C_{15}

HYPER-ABRUPT JUNCTION TUNING DIODES

Type Number	C_T, DIODE CAPACITANCE		TR, TUNING RATIO		Q, FIGURE OF MERIT
	V_R = 1.0 Vdc f = 1.0 MHz pF nom ±15%	V_R = 2.0 Vdc f = 1.0 MHz pF nom ±20%	C_1/C_{10} f = 1.0 MHz min	C_2/C_{10} f = 1.0 MHz min	V_R = 2.0 Vdc f = 1.0 MHz min
MV1401	550	–	14	–	200
MV1403	–	175	–	10	200
MV1404	–	120	–	10	200
MV1405	–	250	–	10	200

Hyper-Abrupt Junction Tuning Diodes have a greater capacitance change per bias voltage change than abrupt junction diodes. A capacitance change of greater than TEN TIMES for a bias change from 2 to 10 volts is achieved.



MV1401

CASE 146 (DO-14)



MV1403
MV1404
MV1405

CASE 51 (DO-7)

PLASTIC PACKAGE LOW COST, HIGH VOLUME			GENERAL PURPOSE			PLASTIC PACKAGE LOW COST, HIGH VOLUME			GENERAL PURPOSE			HIGH CAPACITANCE GENERAL PURPOSE		
30 VOLTS						25 VOLTS			20 VOLTS					
 Case 182 (1)			 Case 51 DO-7			 Case 182 (1)			 Case 51 DO-7			 Case 146 DO-14		
Type	Tuning Ratio C_2/C_{30} pF min/max	Q @ 4.0 V 50 MHz min	Type	Tuning Ratio C_4/C_{25} pF min/typ	Q @ 4.0 V 50 MHz min	Type	Tuning Ratio C_1/C_{10} pF min/max	Q @ 4.0 V 50 MHz min	Type	Tuning Ratio C_2/C_{20} pF min/typ	Q @ 4.0 V 50 MHz min	Type	Tuning Ratio C_2/C_{20} pF typ	Q @ 4.0 V 20 MHz min
MV2101	2.5/3.2	450				MV2201	1.9/2.3	300	MV1620	2.0/2.2	300			
MV2102	2.5/3.2	450							MV1622	2.0/2.2	300			
MV2103	2.5/3.2	400				MV2203	2.0/2.4	200	MV1624	2.0/2.3	300			
MV2104	2.5/3.2	400							MV1626	2.0/2.3	300			
MV2105	2.5/3.2	400	MV830	1.8/2.00	30	MV2205	2.1/2.5	200	MV1628	2.0/2.3	250			
MV2106	2.5/3.2	350	MV831	1.8/2.00	25				MV1630	2.0/2.3	250			
									MV1632	2.0/2.3	250			
MV2107	2.5/3.2	350	MV832	1.8/2.10	25				MV1634	2.0/2.3	250			
MV2108	2.5/3.2	300	MV833	1.8/2.10	25				MV1636	2.0/2.3	200			
MV2109	2.5/3.2	200	MV834	1.9/2.12	20	MV2209	2.1/2.5	150	MV1638	2.0/2.4	200			
MV2110	2.5/3.2	150	MV835	1.9/2.12	20				MV1640	2.0/2.4	200			
MV2111	2.5/3.2	150	MV836	1.9/2.15	15				MV1642	2.0/2.4	200			
MV2112	2.6/3.3	150	MV837	1.9/2.15	15				MV1644	2.0/2.4	150			
MV2113	2.6/3.3	150	MV838	2.0/2.18	15				MV1646	2.0/2.4	150			
MV2114	2.6/3.3	100	MV839	2.0/2.18	10				MV1648	2.0/2.4	150			
MV2115	2.6/3.3	100	MV840	2.0/2.18	10				MV1650	2.0/2.4	150			
												MV1652	2.6	250
												MV1654	2.6	250
												MV1656	2.6	200
												MV1658	2.6	200
												MV1660	2.6	150
												MV1662 (5)	2.3	150
												MV1664 (5)	2.3	100
												MV1666 (5)	2.3	100

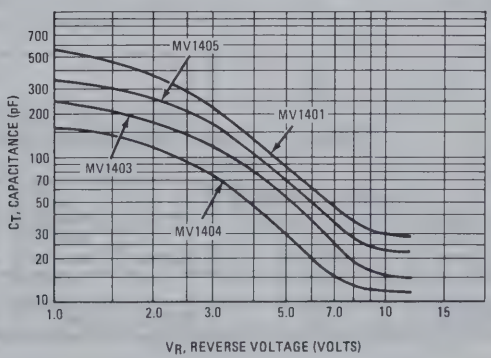
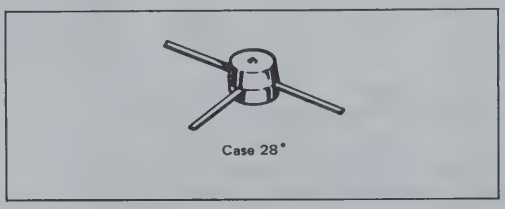


FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE

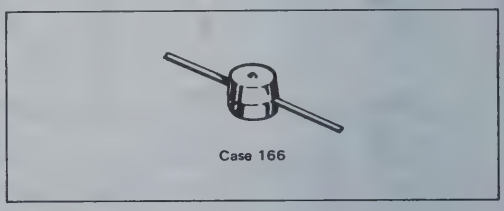
MICRO-T TRANSISTORS AND DIODES

The Micro-T package is a tiny (0.085 inch diameter) injection-molded plastic package for applications requiring extremely high component mounting density. Micro-T transistors and diodes are also useful in hybrid circuits – being easier to mount than unencapsulated semiconductor chips, without special equipment and special operator training.

The following tables list the major characteristics of Motorola transistors and diodes in Micro-T packages. Devices are grouped in applications categories to simplify device selection. For more detailed information, refer to the individual data sheet.



Case 28*



Case 166

TABLE I – GENERAL-PURPOSE AMPLIFIER AND SWITCHING TRANSISTORS

Case 28 (1)

Type	V_{CEO} Volts Max	Collector Test Current for Optimum h_{FE} I_C in mA	h_{FE} Min/Max	$V_{CE(sat)}$ @ I_C Volts Max	mA	f_T @ I_C MHz Min	mA	Switching Times ns (Typ) @ $I_C/I_{B1}/I_{B2}$ t_d	t_r	t_s	t_f	mA
NPN												
MMT3904	40	10	100/300	0.2	10	300	10	24	13	125	11	10/1.0/1.0
MMT3903	40	10	50/150	0.2	10	250	10	24	13	125	11	10/1.0/1.0
MMT2222	30	150	100/300	0.4	150	200	20	t_{on} = 16, t_{off} = 160				150/15 /15
PNP												
MMT2907	40	150	100/300	0.4	150	200	50	t_{on} = 20, t_{off} = 150				150/15 /15
MMT3906	40	10	100/300	0.25	10	250	10	25	18	140	15	10/1.0/1.0
MMT3905	40	10	50/150	0.25	10	200	10	25	18	140	15	10/1.0/1.0

TABLE II – HIGH SPEED SATURATED SWITCHING TRANSISTORS

Case 28 (1)

Type	V_{CEO} Volts Max	Collector Test Current for Optimum h_{FE} I_C in mA	h_{FE} Min/Max	$V_{CE(sat)}$ @ I_C Volts Max	mA	f_T @ I_C MHz Min	mA	Switching Times ns (Max) @ I_C/I_B t_d	t_r	t_s	t_f	mA
NPN												
MMT2369	15	10	40/120	0.25	10	500	10	t_{on} = 12, t_{off} = 18				10/3.0
MMT3014	20	30	50/200	0.22	30	350	30	t_{on} = 16, t_{off} = 25				30/3.0
PNP												
MMT3546	12	10	30/–	0.15	10	700	10	10	15	20	15	50/5.0
MMT73	5.0	10	30/–	0.2	10	400	10	t_{on} = 30, t_{off} = 30				10/1.0

TABLE III – HIGH-SPEED NON-SATURATED SWITCHING TRANSISTORS

Case 28 (1)

Type	V_{CEO} Volts Max	Collector Test Current for Optimum h_{FE} I_C in mA	h_{FE} Min/Max	$V_{CE(sat)}$ @ I_C Volts Max	mA	f_T @ I_C MHz Min	mA	Switching Times ns (Typ) @ I_C t_d	t_r	t_s	t_f	mA
NPN												
MMT3960A	8.0	10	30/200	0.2	10	1600	30	1.0	0.75	1.1	0.85	20

TABLE IV – LOW NOISE AMPLIFIER TRANSISTORS

Case 28 (1)

Type	V_{CEO} Volts Max	Collector Test Current for Optimum h_{FE} I_C in mA	h_{FE} Min/Max	f_T @ I_C MHz Min	I_C μA	NF @ I_C and f dB Max	I_C μA	f MHz
NPN								
MMT2484	60	1.0	250/–	60	500	3.0	10	10 Hz to 10 kHz
MMT930	45	1.0	150/–	60	500	–	–	–
PNP								
MMT3799	60	0.1	300/900	40	500	2.5	100	10 Hz to 15.7 kHz
MMT3798	60	0.1	150/450	40	500	3.5	100	10 Hz to 15.7 kHz

TABLE V – RF AMPLIFIER AND OSCILLATOR TRANSISTORS

Case 28 (1)

Type	V_{CEO} Volts Max	Collector Test Current for Optimum h_{FE} I_C in mA	h_{FE} Min	NF @ I_C and f dB Max	mA	MHz	f_T @ I_C MHz Min	mA	Feedback Capacitance @ V_{CB} = 10 Vdc pF Max
NPN									
MMT2857	15	3.0	30	3.8*	1.5	450	1000	4.0	1.0
MMT918	15	3.0	20	6.0	1.0	60	600	10	1.7
MMT8015	10	1.0	25	4.0	1.0	1000	1000	6.0	–

*Typical

TABLE VI – N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS FOR RF AND MIXER APPLICATIONS

Type	$V_{(BR)GSS}$ Volts Min	I_{DSS} mA Min/Max	C_{iss} pF Typ	$Re(y_{is})$ μmhos Typ	NF @ f Typ dB	MHz	Case
MMT3823	-30	5.0/20	4.0	500	2.0	100	28 (5)

TABLE VII – SWITCHING DIODES

Type	$V_{(BR)}$ @ $I_{(BR)}$ Volts Min	μA	I_R @ V_R μA Max	Volts	V_F @ I_F Volts Min/Max	mA	C @ V_R = 0 pF Max	t_{rr} ns Max	Case	Description
MMD6050	70	100	0.1	50	0.55/0.7	1.0	2.0	5.0	166	Single
MMD6100	70	100	0.1	50	0.55/0.7	1.0	2.0	5.0	28 (2)	Common-Cathode
MMD6150	70	100	0.1	50	0.55/0.7	1.0	2.0	5.0	28 (3)	Common-Anode
MMD7000	70	100	0.1	50	0.55/0.7	1.0	2.0	5.0	28 (4)	Series
MMD7001	45	10	0.1	30	–/1.05	300	3.5	3.2*	28 (4)	Series

*Typical

OPTOELECTRONICS

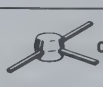
Optoelectronic devices are designed for use in computer, industrial, and consumer equipment. The most popular are the discrete phototransistors. Also available are custom phototransistor arrays using these discrete devices, and monolithic arrays for applications requiring very high density and exceptional alignment.

Phototransistors are high-quality passivated Annular devices providing a high order of stability and reliability. They are sensitive throughout the visible and near-infrared spectral range with peak sensitivity at a typical wavelength of 0.8 micrometers. Much faster than the conventional photocells or mechanical contacts, these phototransistors have a maximum rise time of 2.5 microseconds, and a maximum fall time of 4.0 microseconds when pulsed with a gallium arsenide light-emitting diode. The devices fall in two major categories, dependent on applications: (1) high-density mounting (subminiature size) and (2) low-density mounting (miniature size).

Subminiature NPN silicon phototransistors designed for use in card and tape readers, pattern and character recognition, shaft encoders, or any design requiring radiation sensitivity, stable characteristics and high stability for these applications. The unique, clear-plastic Micro-T package in both three and two leaded configurations (MRD100 and MRD150) combines reliability, medium sensitivity, and small size for high-density mounting in an economical package.

Table 75 — HIGH DENSITY NPN SILICON PHOTOTRANSISTORS

V_{CC} = 20 Volts, T_A = 25°C

Case Number	Device Type	S_{RCEO} Collector-Emitter Radiation Sensitivity @ H = 5.0 mW/cm² mA/mW/cm² (min) Note 4	I_L Light Current @ H = 5.0 mW/cm² mA (min) Note 4	I_{CEO} Dark Current @ H = 0 μA (max)
For use with circuit boards less than 1/16" thick.				
 CASE 81 Hemispheric Lens — Actual Size	MRD200	0.25	1.25	0.025
	MRD210	0.05	0.25	0.025
 CASE 81A-02 Low Profile Lens — Actual Size	MRD600	0.04 Note 2	0.8 Note 2	0.025 Note 3
For use with circuit boards at least 1/16" thick.				
 CASE 81A Low Profile Lens — Actual Size	MRD250	0.1	0.5	0.025
For use with circuit boards less than 1/16" thick.				
 CASE 172 — Actual Size	MRD100 Note 1	0.04	0.2	0.1
 CASE 173 — Actual Size	MRD150	0.04	0.2	0.1

NOTES: 1. Base connection provided
2. MRD600 conditions: V_{CC} = 5 Volts, H = 20 mW/cm², R_L = 100 Ω
3. MRD600 conditions: V_{CC} = 30 Volts, H = 0, R_L = 1 MΩ
4. H is radiation flux density emitted from a tungsten source at 2870 K

High-sensitivity NPN silicon photo-transistors designed for use in industrial inspection, processing and control, counters, sorters, switching and logic circuits or any design requiring radiation sensitivity, stable characteristics, and moderate mounting density in arrays or single device applications. The TO-18 type,hermetically sealed package (MRD300 and MRD310) is recommended for high reliability, high stability, and high sensitivity desired in these applications, while the clear plastic MRD450 provides high, uniform sensitivity in an economical package.

Table 76 — LOW DENSITY NPN SILICON PHOTOTRANSISTORS

V_{CC} = 20 Volts, T_A = 25°C

Case Number	Device Type	S_{RCEO} Collector-Emitter Radiation Sensitivity @ H = 5.0 mW/cm² mA/mW/cm² (min) Note 1	I_L Light Current @ H = 5.0 mW/cm² mA (min) Note 1	I_{CEO} Dark Current @ H = 0 μA (max)
 CASE 82 TO-18	MRD300	0.8	4.0	0.025
	MRD310	0.2	1.0	0.025
 CASE 171(1)	MRD450	0.2	1.0	0.1

NOTE 1: H is radiation flux density emitted from a tungsten source at 2870 K.

P-I-N silicon photo diodes are designed for application in laser detection, light demodulation, detection of visible and near infrared light emitting diodes, shaft or position encoders, switching and logic circuits; or any design requiring radiation sensitivity and stable characteristics. They are extremely high speed devices with typical response time of less than 1.0 ns.

Table 77 — PIN SILICON PHOTO DIODES

Case Number	Device Type	S_R Radiation Sensitivity @ H = 5.0 mW/cm² μA/mW/cm² Min Note 1	I_D Dark Current @ H ≈ 0 nA (max)	S(λ = 0.8 μm) μA/mW/cm² Typ
 Convex Lens CASE 209-1	MRD500	1.2	2.0	6.6
 Flat glass CASE 210-1	MRD510	0.3	2.0	1.5

NOTE 1: H is radiation flux density emitted from a tungsten source at 2870 K.

This device is used in panel and circuit condition indicators, light modulators, shaft or position encoders, punched card readers, optical switching, and logic circuits. It is designed for applications requiring high visibility, low drive power and very fast response time.

Table 78 — LIGHT-EMITTING DIODE (VISIBLE RED) — PN Gallium Arsenide Phosphide

Case Number	Device Type	V_F Forward Voltage I_F = 20 mA Volts (Max)	B Brightness (1) I_F = 20 mA fL (Typ)	λ_P Peak Emission Wavelength nm (Typ)	$\Delta\lambda$ Spectral Line Width nm (Typ)
 Case 171(2)	MLED600	1.8	4590	660	20

(1) Measured with photo Research Spectra Spot Brightness Meter, Model UB 1° with "Spectar" L-175 lens.

1N... JEDEC REGISTERED DEVICE SPECIFICATIONS

DIODES
- Reference
- Zener
- Signal

RECTIFIERS
- Fast Recovery

POWER VARACTORS
- Tuning Diodes

ASSEMBLIES

1N-NUMBERED DEVICES for MILITARY APPLICATIONS

The following tables list devices that comply with military specifications.

SILICON ZENER DIODES ±5% SERIES

MIL-S-19500/127

†JAN 1N746A . . thru . . JAN 1N759A

MIL-S-19500/117

†JAN 1N962B . . thru . . JAN 1N992B

***MIL-S-19500/114**

†JAN 1N2804B . . thru . . JAN 1N2811B
†JAN 1N2813B . . . . . .
†JAN 1N2814B . . . . . .
†JAN 1N2816B . . . . . .
†JAN 1N2818B . . thru . . JAN 1N2820B
†JAN 1N2822B . . thru . . JAN 1N2827B
†JAN 1N2829B . . . . . .
†JAN 1N2831B . . thru . . JAN 1N2838B
†JAN 1N2840B . . thru . . JAN 1N2846B

***MIL-S-19500/124**

†JAN 1N2970B . . thru . . JAN 1N2977B
†JAN 1N2979B . . . . . .
†JAN 1N2980B . . . . . .
†JAN 1N2982B . . . . . .
†JAN 1N2984B . . thru . . JAN 1N2986B
†JAN 1N2988B . . thru . . JAN 1N2993B
†JAN 1N2995B . . . . . .
†JAN 1N2997B . . . . . .
†JAN 1N2999B . . thru . . JAN 1N3005B
†JAN 1N3007B . . thru . . JAN 1N3009B
†JAN 1N3011B . . . . . .
†JAN 1N3012B . . . . . .
†JAN 1N3014B . . . . . .
†JAN 1N3015B . . . . . .

MIL-S-19500/115

†JAN 1N3016B . . thru . . JAN 1N3051B

***MIL-S-19500/358B**

†JAN 1N3305B . . thru . . JAN 1N3312B
†JAN 1N3314B . . . . . .
†JAN 1N3315B . . . . . .
†JAN 1N3317B . . . . . .
†JAN 1N3319B . . thru . . JAN 1N3321B
†JAN 1N3323B . . thru . . JAN 1N3325B
†JAN 1N3326B . . thru . . JAN 1N3328B
†JAN 1N3330B . . . . . .
†JAN 1N3332B . . . . . .
†JAN 1N3334B . . thru . . JAN 1N3340B
†JAN 1N3343B . . thru . . JAN 1N3344B
†JAN 1N3346B . . . . . .
†JAN 1N3347B . . . . . .
†JAN 1N3349B . . . . . .
†JAN 1N3350B . . . . . .

MIL-S-19500/115

†JAN 1N3821A . . thru . . JAN 1N3828A

****MIL-S-19500/272**

JAN 1N3993A . . thru . . JAN 1N4000A

MIL-S-19500/127

†JAN 1N4370A . . thru . . JAN 1N4372A

MIL-S-19500/358B

†JAN 1N4549B . . thru . . JAN 1N4554B

*Reverse Polarities (Suffix RB) are available.
**Reverse Polarities (Suffix RA) are available.

TC REFERENCE DIODES

MIL-S-19500

JAN 1N429 . . . . . /299
†JAN 1N821 . . . . . /159
†JAN 1N823 . . . . . /159
†JAN 1N825 . . . . . /159
†JAN 1N827 . . . . . /159
†JAN 1N829 . . . . . /159
†JAN 1N935B . . . . . /156
†JAN 1N937B . . . . . /156
†JAN 1N938B . . . . . /156
†JAN 1N939B . . . . . /156
†JAN 1N941B . . . . . /157
†JAN 1N943B . . . . . /157
†JAN 1N944B . . . . . /157
†JAN 1N3154 . . . . . /158
†JAN 1N3155 . . . . . /158
†JAN 1N3156 . . . . . /158
†JAN 1N3157 . . . . . /158

DIODE ASSEMBLIES

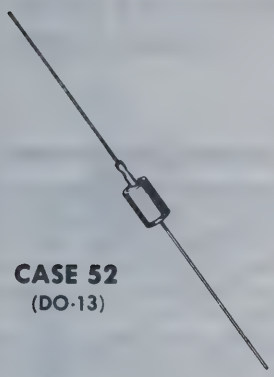
MIL-S-19500

JAN 1N1530A . . . . . /320
JAN 1N1742A . . . . . /298

†Recommended TX Devices.

1N91 thru 1N93 (GERMANIUM)

$V_R = 100 - 300$ V
$I_O = 1.0$ A



CASE 52
(DO-13)

Low-current germanium rectifiers for applications requiring extremely low forward voltage drop, low power dissipation,and high rectification efficiency, such as biasing and battery charging circuits.

MAXIMUM RATINGS*

Rating	Symbol	1N91	1N92	1N93	Unit
Peak Repetitive Reverse Voltage (Rated I_O, $T_A \leq 55°C$, see Figure 2)	$V_{RM(rep)}$	100	200	300	Volts
DC Blocking Voltage $T_A \leq 80°C$	V_R	100	200	300	Volts
$T_A \geq 80°C$		Derate V_R 6.7%/°C above 80°C			
Average Rectified Forward Current (Single Phase, Resistive Load, 60 Hz) $T_A = 55°C$, 100% V_{RM}	I_O	1.0			Amp
$T_A = 75°C$, 50% V_{RM}		0.25			
Non-Repetitive Peak Surge Current (Surge Applied at Rated Load Conditions, see Figure 4)	$I_{FM(surge)}$	30			Amp
Operating Junction Temperature Range	T_J	-65 to +95			°C
Storage Temperature Range	T_{stg}	-65 to +125			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient 1 inch Leads	θ_{JA}	100	°C/W
1/4 inch Leads		70	

ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Peak Forward Voltage Drop (I_F = 150 mAdc, T_A = 25°C, see Figure 1)	V_F	0.45	Volts
DC Reverse Current (Rated V_R, T_A = 25°C, see Figure 3)	I_R	0.22	mA

* These ratings and characteristics as specified may surpass those specified in the original JEDEC registration for these device types.

FIGURE 1 — FORWARD CHARACTERISTICS

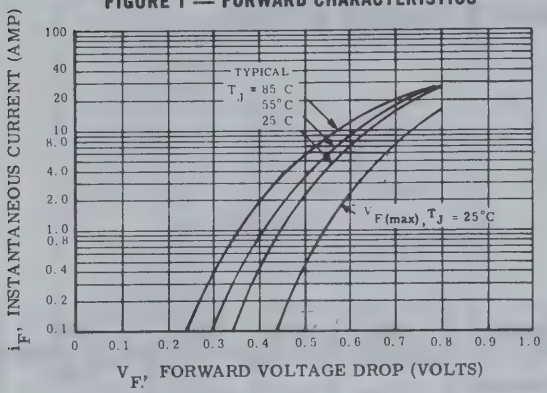


FIGURE 2 — MAXIMUM CURRENT RATINGS

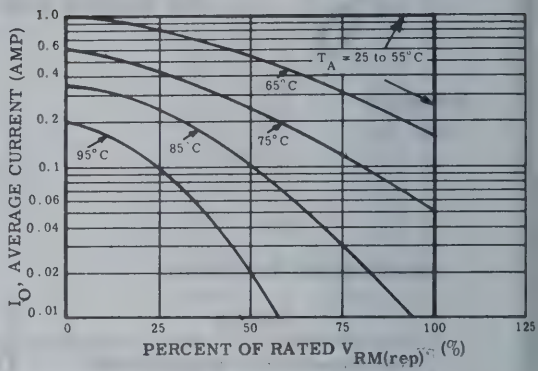


FIGURE 3 — TYPICAL REVERSE CHARACTERISTICS

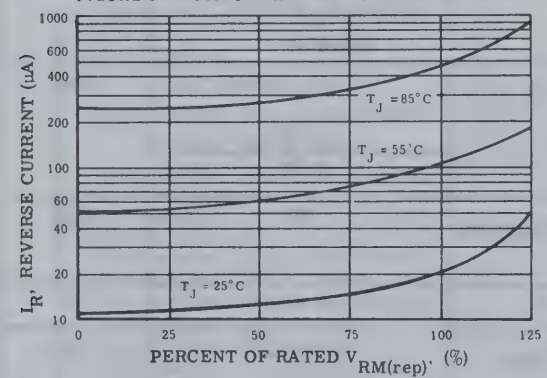
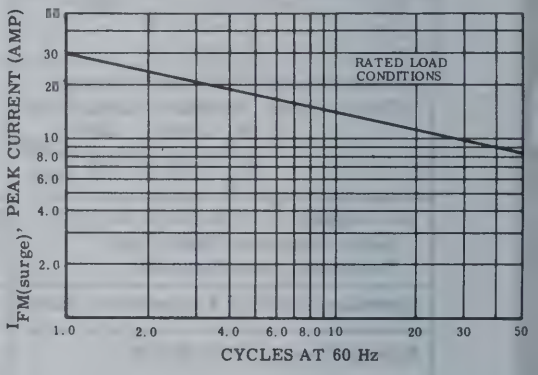


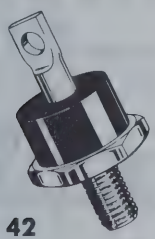
FIGURE 4 — MAXIMUM SURGE CURRENT



1N248B,C thru 1N250B,C

V_R to 600 V
I_O = 20 A

1N1191 thru 1N1198
1N1195A thru 1N1198A
1N3213,1N3214



CASE 42
(DO-5)

Medium current silicon rectifiers. Unique double-case construction consists of hermetically sealed inner metallic case surrounded by molded external case; provides highest degree of ruggedness and reliability. Type numbers shown have cathode connected to case, but reverse-polarity units can be obtained by adding suffix "R" to standard type number, e.g. 1N248BR.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage and DC Blocking Voltage	$V_{RM\ (rep)}$ V_R		Volts
1N248B, 1N1191		50	
1N248C		55	
1N249B, 1N1192		100	
1N249C		110	
1N1193		150	
1N250B, 1N1194		200	
1N250C		220	
1N1195, 1N1195A		300	
1N1196, 1N1196A		400	
1N1197, 1N1197A, 1N3213		500	
1N1198, 1N1198A, 1N3214		600	
RMS Reverse Voltage	V_r		Volts
1N248B, 1N1191		35	
1N248C		38.5	
1N249B, 1N1192		70	
1N249C		77	
1N1193		105	
1N250B, 1N1194		140	
1N250C		154	
1N1195, 1N1195A		210	
1N1196, 1N1196A		280	
1N1197, 1N1197A, 1N3213		350	
1N1198, 1N1198A, 1N3214		420	
Average 1/2-Wave Rectified Forward Current (Resistive Load, 60 Hz, T_C = 150°C)	I_O	20	Amp
Peak Repetitive Forward Current (T_C = 150°C)	$I_{FM\ (rep)}$	90	Amp
Peak Surge Current (T_C = 150°C, superimposed on Rated Current at Rated Voltage, 1/2-Cycle, 1/120 sec)	$I_{FM\ (surge)}$	350	Amp

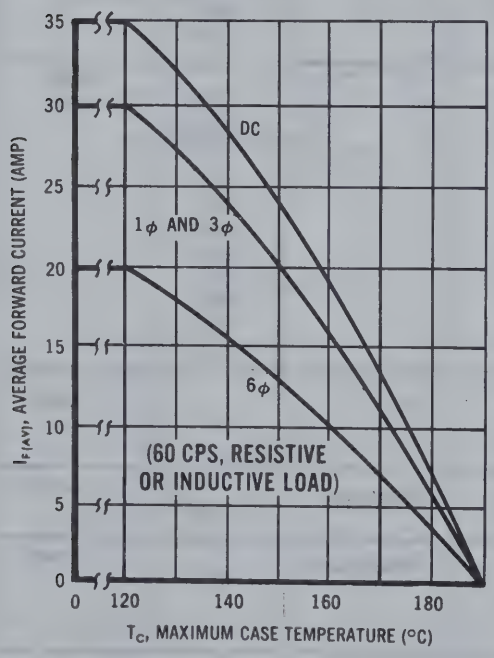
THERMAL CHARACTERISTICS

Maximum Operating and Storage Temperature: −65 to + 190°C
Maximum Thermal Impedance, Junction to Case: θ_{JC} = 1.50°C/W DC

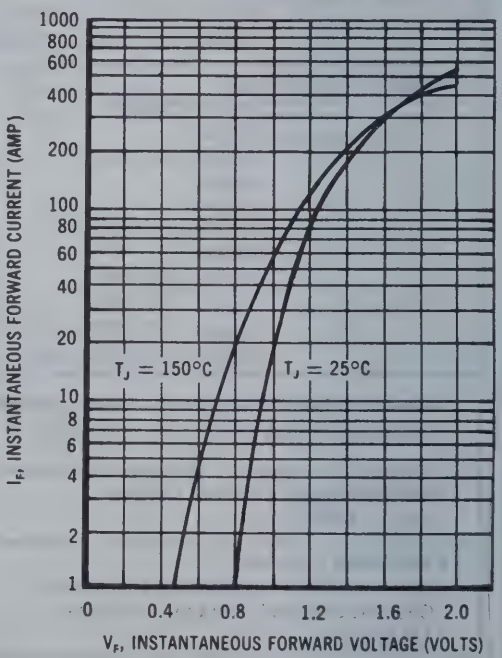
ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop ($I_{O\ (max)}$, rated V_r, 60 cps, T_C = 150°C)	$V_{F(AV)}$	0.6	Volts
Instantaneous Forward Voltage Drop (I_F = 100 Amps, T_J = 25°C)	V_F	1.5	Volts
Full Cycle Average Reverse Current ($I_{O\ (max)}$, rated V_r, 60 cps, T_C = 150°C)	$I_{R(AV)}$		mA
1N248B thru 1N250B, 1N1191 thru 1N1198		5.0	
1N248C		3.8	
1N249C		3.6	
1N250C		3.4	
1N1195A		3.2	
1N1196A		2.5	
1N1197A		2.2	
1N1198A		1.5	
1N3213 and 1N3214		10.0	
DC Reverse Current (Rated V_R, T_C = 25°C)	I_R	1.0	mA

MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM CASE TEMPERATURE

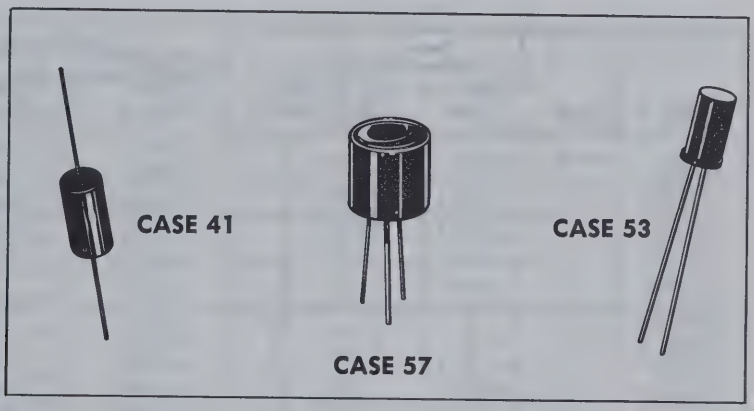


TYPICAL FORWARD CHARACTERISTICS



1N429 (6.2V)
1N1530 series (8.4V)
1N1735 series (6.2V thru 49.6V)
1N4057 series (12.4 thru 200V)

Temperature compensated zener reference diodes designed for reference sources utilizing an oxide-passivated junction for long-term voltage stability, high uniformity and reliable operation.



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Operating Junction Temperature Range	T_J	-55 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C
Power Dissipation*	P_D	See Tables 1 & 2*	W

*The devices are designed for operation at the specified I_{ZT}. Operation above or below this current is not recommended, since the temperature coefficient is no longer valid. See Note 2 and Figure 4.

MECHANICAL CHARACTERISTICS

Case:	Void free, transfer molded plastic package
Polarity:	Indicated by diode symbol except 1N429, 1N1530, 1N1530A where cathode indicated by polarity dot of contrasting color
Weight:	Varies according to device 0.5 grams (min) 12 grams (max)
Finish:	All external surfaces corrosion resistant and leads readily solderable.

TABLE 1 – ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

TYPE	CASE	Zener Voltage ±5% V_Z @ I_{ZT} Volts / mA	Z_{ZT} Ohms (Note 3)	Temperature Coefficient %/°C (Note 2)	ΔV_Z @ I_{ZT} (+25 to +100°C) Volts (Note 2)	ΔV_Z (–55 to + 25°C) Volts (Note 2)	P_D* T_A = 25°C W
1N4057	41-8	12.4 @ 10	25	0.005	0.047	0.050	1.5
1N4057A		12.4	25	0.002	0.019	0.020	
1N4058		14.6	30	0.005	0.055	0.058	
1N4058A		14.6		0.002	0.022	0.023	
1N4059		16.8		0.005	0.063	0.067	
1N4059A		16.8		0.002	0.025	0.027	
1N4060		18.5		0.005	0.069	0.074	
1N4060A		18.5		0.002	0.028	0.030	
1N4061		21	35	0.005	0.079	0.084	
1N4061A		21	35	0.002	0.032	0.034	
1N4062		23	40	0.005	0.086	0.092	
1N4062A		23	40	0.002	0.035	0.037	
1N4063		27	45	0.005	0.101	0.108	
1N4063A		27	45	0.002	0.041	0.043	
1N4064		30	50	0.005	0.113	0.120	
1N4064A		30	50	0.002	0.045	0.048	
1N4065		33	55	0.005	0.124	0.132	
1N4065A		33	55	0.002	0.050	0.053	
1N4066		37 @ 7.5	80	0.005	0.139	0.148	
1N4066A		37	80	0.002	0.056	0.059	
1N4067		43	90	0.005	0.161	0.172	
1N4067A		43	90	0.002	0.065	0.069	
1N4068		47	100	0.005	0.176	0.188	
1N4068A		47	100	0.002	0.071	0.075	
1N4069	41-9	51	110	0.005	0.191	0.204	2.0
1N4069A		51	110	0.002	0.077	0.082	
1N4070		56	120	0.005	0.210	0.224	
1N4070A		56	120	0.002	0.084	0.090	
1N4071		62	135	0.005	0.232	0.248	
1N4071A		62 @ 5.0	135	0.002	0.093	0.099	
1N4072		68	230	0.005	0.255	0.272	
1N4072A		68	230	0.002	0.102	0.109	
1N4073		75	250	0.005	0.281	0.300	
1N4073A		75	250	0.002	0.113	0.120	
1N4074		82	270	0.005	0.307	0.328	
1N4074A		82	270	0.002	0.123	0.131	
1N4075		87	290	0.005	0.326	0.348	
1N4075A		87	290	0.002	0.131	0.139	
1N4076		91	310	0.005	0.341	0.364	
1N4076A		91	310	0.002	0.137	0.146	
1N4077		100	340	0.005	0.375	0.400	
1N4077A		100	340	0.002	0.150	0.160	
1N4078		105 @ 2.5	700	0.005	0.394	0.420	
1N4078A		105	700	0.002	0.158	0.168	
1N4079		110	740	0.005	0.413	0.440	
1N4079A		110	740	0.002	0.165	0.176	
1N4080		120	800	0.005	0.450	0.480	
1N4080A		120	800	0.002	0.180	0.192	
1N4081	41-10	130	840	0.005	0.488	0.520	2.5
1N4081A		130	840	0.002	0.195	0.208	
1N4082		140	960	0.005	0.525	0.560	
1N4082A		140	960	0.002	0.210	0.224	
1N4083		150	1020	0.005	0.563	0.600	
1N4083A		150	1020	0.002	0.225	0.240	
1N4084		175	1150	0.005	0.656	0.700	
1N4084A		175	1150	0.002	0.263	0.280	
1N4085		200	1350	0.005	0.750	0.800	
1N4085A		200	1350	0.002	0.300	0.320	

*Derate linearly from 25°C to 175°C.

TABLE 2 – ELECTRICAL CHARACTERISTICS (I_{ZT} = 7.5 mA, T_A = 25°C unless otherwise noted)

Type Number	Zener Voltage $V_Z \pm 5\%$ (Volts)	Max Voltage Change @ –55, +25, +100°C $\triangle V_Z$ (Volts) (Note 2)	Max Dynamic Impedance (Note 3) Z_{ZT} (Ohms)	Temperature Coefficient (Note 2) (%/°C)	Power* Dissipation P_D (mW)	Case Number	Figure Number
1N429 ①	6.2	0.050	20	0.01	200	53	1
1N1735	6.2	0.050	20	0.01	200	41-6	2
1N1530**	8.4	0.014	15	0.002	250	57	3
1N1530A** ②		0.007		0.001			
1N1736	12.4	0.100	40	0.01	400	41-3	2
1N1736A		0.050		0.005			
1N1737	18.6	0.150	60	0.01	600	41-5	2
1N1737A		0.075		0.005			
1N1738	24.8	0.200	80	0.01	800	41-5	2
1N1738A		0.100		0.005			
1N1739	31.0	0.250	100	0.01	1000	41-4	2
1N1739A		0.125		0.005			
1N1740	37.2	0.300	120	0.01	1200	41-4	2
1N1740A		0.150		0.005			
1N1741	43.4	0.350	140	0.01	1400	41-4	2
1N1741A		0.175		0.005			
1N1742 ③	49.6	0.400	180	0.01	1600	41-4	2
1N1742A		0.200		0.005			

*Derate linearly from 25°C to 175°C

**I_{ZT} = 10 mA

① Available to MIL-S-19500/299 Specifications.
② Available to MIL-S-19500/320 Specifications.
③ Available to MIL-S-19500/298 Specifications.

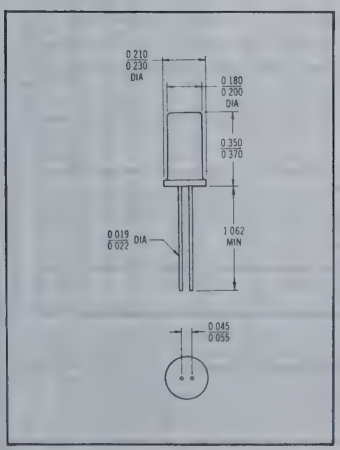
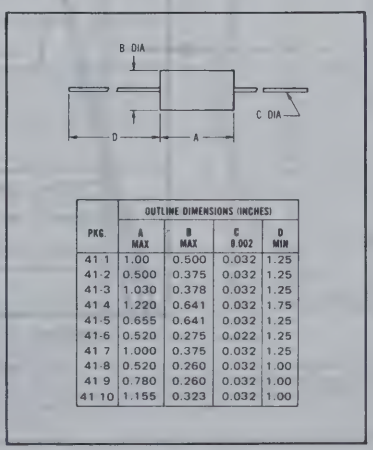


FIGURE 1
CASE 53



PKG.	OUTLINE DIMENSIONS (INCHES)			
	A MAX	B MAX	C 0.002	D MIN
41 1	1.00	0.500	0.032	1.25
41-2	0.500	0.375	0.032	1.25
41-3	1.030	0.378	0.032	1.25
41 4	1.220	0.641	0.032	1.75
41-5	0.655	0.641	0.032	1.25
41-6	0.520	0.275	0.022	1.25
41 7	1.000	0.375	0.032	1.25
41-8	0.520	0.260	0.032	1.00
41 9	0.780	0.260	0.032	1.00
41 10	1.155	0.323	0.032	1.00

FIGURE 2
CASE 41

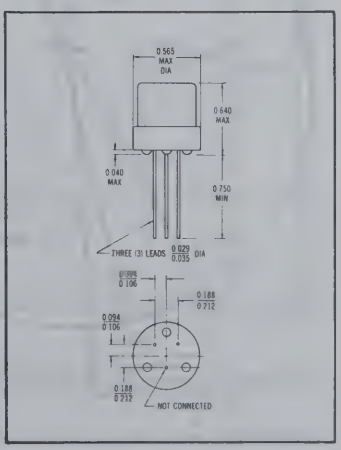


FIGURE 3
CASE 57

TEMPERATURE-COMPENSATED REFERENCE DIODES

Temperature compensated reference diodes are made possible by taking advantage of the differing thermal characteristics of forward and reverse biased silicon PN junctions. A forward biased junction has a negative temperature coefficient of approximately 2.0 millivolts/°C. Reverse biased junctions above 5.0 volts have a positive temperature coefficient and therefore it is possible by judicious selection of combinations of forward and reverse biased junctions to obtain a device which shows a very low temperature coefficient due to cancellation. Because of the differing impedance versus temperature characteristics of the junctions involved, optimum temperature stability is obtained by operating in the zener current range at which the temperature coefficient is a minimum (Figure 4)

Further information, including a method of effective impedance cancellation in a bridge circuit for ultra-stable reference supplies, is contained in the Zener Diode Handbook. The handbook, containing valuable theory, design, and application information, is available from your distributor.

NOTE 1 – Voltage-Current Characteristics

Figure 4 shows the voltage-current characteristics of a typical temperature compensated unit at three different temperatures. The exploded view illustrates the cross-over area (optimum temperature stability point), the non-linearity of the temperature-voltage relationship, and the maximum voltage variation (ΔV_Z) for the three temperatures shown.

Because of device impedance, the reference voltage will vary with changes in zener current. These variations can be minimized by driving the device from a constant current source.

NOTE 2 – Voltage Variation (ΔV_Z) and Temperature Coefficient

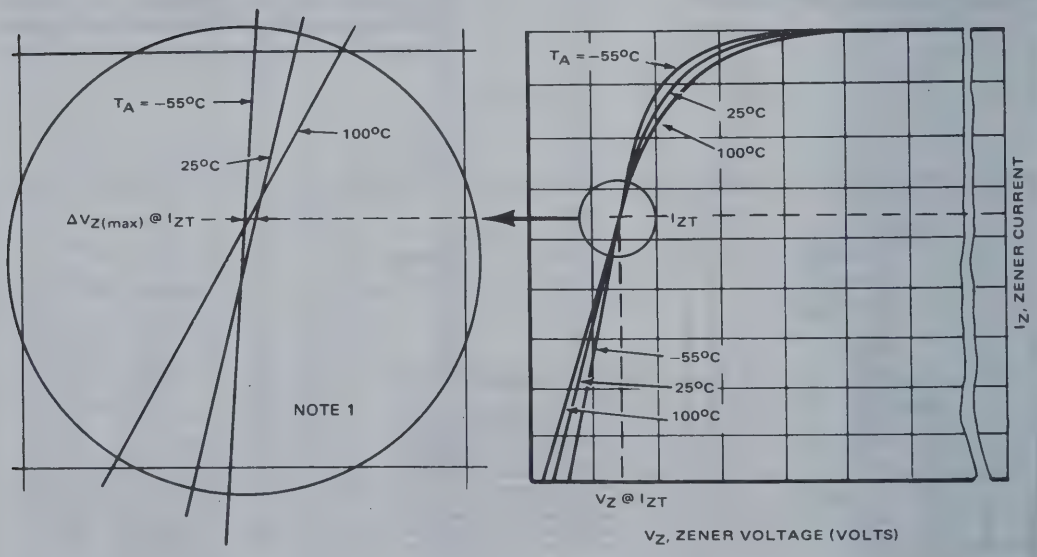
All reference diodes are characterized by the "box" method. This method provides for a guaranteed maximum voltage variation (ΔV_Z in mV) over a specified temperature range at the specified I_{ZT} verified by tests at several points within the range. (Maximum voltage variations over the specified temperature ranges are given in Tables 1 and 2.) The design engineer now has a number (without any calculations) telling him the stability of the voltage over the temperature range of interest thus giving him the maximum flexibility as well as economy in selecting the temperature stability required. The referenced military specifications use this approach to characterize these devices.

Since reference diodes have a non-linear voltage-temperature relationship (illustrated in exploded view, Figure 4) the temperature coefficients in %/°C are tabulated primarily for reference purposes and are guaranteed only at the end points of the temperature range.

NOTE 3 – Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60 Hz ac voltage which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. A cathode-ray tube curve trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

FIGURE 4 – TYPICAL OPERATING CHARACTERISTICS



1N702 thru 1N745

¼ W
2 — 200 V



CASE 51
(DO-7)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N5221 series.

Maximum rating-junction and storage temperature range -65 to +175°C, derated 1.67 mW/°C.

1N746 thru 1N759 1N746A thru 1N759A
1N4370 thru 1N4372 1N4370A thru 1N4372A

400 mW
2.4 — 12 V



CASE 51
(DO-7)

Hermetically sealed, all-glass case with all external surfaces corrosion resistant. Cathode end, indicated by color band, will be positive with respect to anode end when operated in the zener region.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C
D C Power Dissipation: 400 Milliwatts at 50°C Ambient (Derate 3.2 mW/°C Above 50°C Ambient)

TOLERANCE DESIGNATIONS

The type numbers shown have tolerance designations as follows:

1N4370 series: ±10%, suffix A for ±5% units.
1N746 series: ±10%, suffix A for ±5% units.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

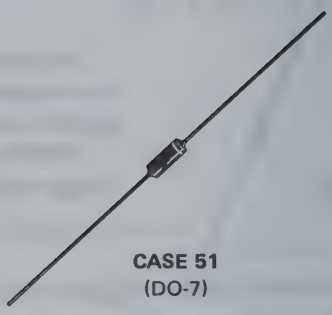
TYPE NUMBER	NOMINAL ZENER VOLTAGE V_Z @ I_{ZT} VOLTS	TEST CURRENT I_{ZT} mA	MAXIMUM ZENER IMPEDANCE Z_{ZT} @ I_{ZT} Ohms	MAXIMUM DC ZENER CURRENT I_{ZM} mA	MAXIMUM REVERSE LEAKAGE CURRENT T_A = 25°C I_R @ V_R = 1 V μA	MAXIMUM REVERSE LEAKAGE CURRENT T_A = 150°C I_R @ V_R = 1 V μA
1N4370	2.4	20	30	150	100	200
1N4371	2.7	20	30	135	75	150
1N4372	3.0	20	29	120	50	100
1N746	3.3	20	28	110	10	30
1N747	3.6	20	24	100	10	30
1N748	3.9	20	23	95	10	30
1N749	4.3	20	22	85	2	30
1N750	4.7	20	19	75	2	30
1N751	5.1	20	17	70	1	20
1N752	5.6	20	11	65	1	20
1N753	6.2	20	7	60	0.1	20
1N754	6.8	20	5	55	0.1	20
1N755	7.5	20	6	50	0.1	20
1N756	8.2	20	8	45	0.1	20
1N757	9.1	20	10	40	0.1	20
1N758	10.0	20	17	35	0.1	20
1N759	12.0	20	30	30	0.1	20

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)
1 — Nominal zener voltages between those shown.
2 — Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.
a Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
b. Two or more units matched to one another with any specified tolerance.
3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

1N761 thru 1N769

Recommended for applications requiring an exact replacement only. For new designs see 1N5221 series.

1N816/.4M.64FR10
.4M1.36FR5
.4M1.36FR2
.4M2.04FR5
.4M2.04FR2



CASE 51
(DO-7)

Constant-voltage reference diodes designed for stable forward reference sources, transistor amplifier biasing and similar applications. Ramrod construction provides a rugged, glass-enclosed, hermetically sealed structure.

	ELECTRICAL CHARACTERISTICS (T_A = 25°C)			
Type	V_F @ I_F Volts min/max	I_F mA	I_R V_R = 4.0 V μA max	R_D @ I_F ohms
.4M.64FR10/1N816	0.58/0.70	1.0	0.1	50
.4M1.36FR5	1.29/1.43	10	↓	20
.4M1.36FR2	1.33/1.39	↓	↓	20
.4M2.04FR5	1.94/2.14	↓	↓	30
.4M2.04FR2	2.00/2.08	↓	↓	30

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all glass

DIMENSIONS: See outline drawing

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band. Cathode negative for forward reference application.

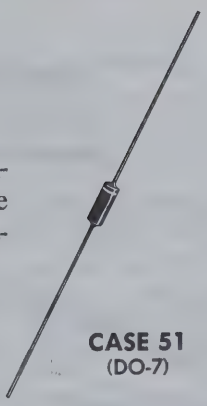
WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

1N821, A, 1N823, A (SILICON)
1N825, A, 1N827, A
1N829, A

6.2 V ± 5.0%

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



CASE 51
(DO-7)

MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 400 mW @ T_A = 50°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Test Temperature °C	Temperature Coefficient %/°C (Note 2)	Maximum Dynamic Impedance Z_{ZT} Ohms (Note 3)
V_Z = 6.2 V ±5.0%* @ I_{ZT} = 7.5 mA				
1N821	0.096	-55, 0, +25, +75, +100	0.01	15
1N823	0.048	↓	0.005	↓
1N825	0.019	↓	0.002	↓
1N827	0.009	↓	0.001	↓
1N829	0.005	↓	0.0005	↓
1N821A	0.096	↓	0.01	10
1N823A	0.048	↓	0.005	↓
1N825A	0.019	↓	0.002	↓
1N827A	0.009	↓	0.001	↓
1N829A	0.005	↓	0.0005	↓

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 30 to 400 pF @ 90% of V_Z

FORWARD BREAKDOWN VOLTAGE (V_f) = 15 to 400 V

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(with I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N821 thru 1N829

FIGURE 1a

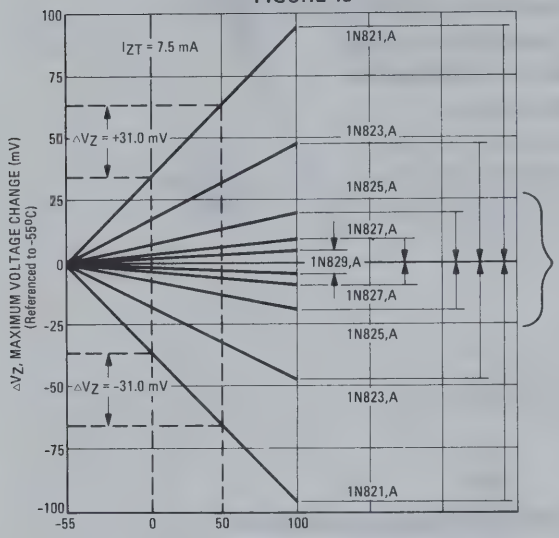
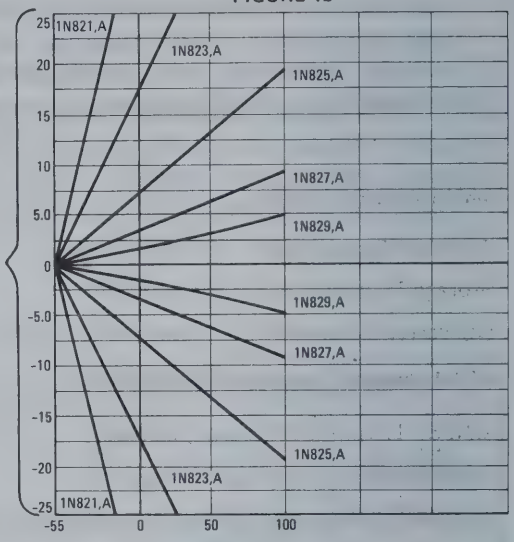


FIGURE 1b



TA, AMBIENT TEMPERATURE (°C)

ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE

(At Specified Temperatures)
(See Note 5)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES.

FIGURE 2 – 1N821 SERIES

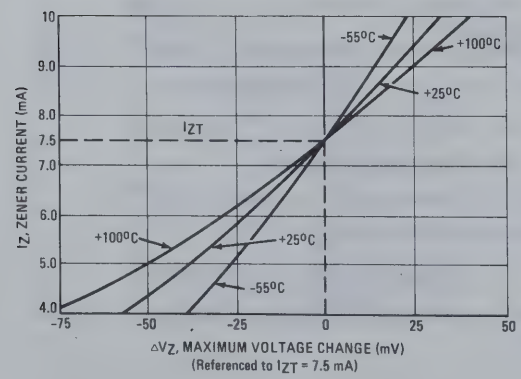
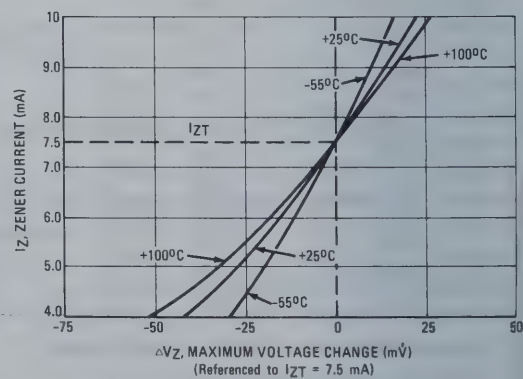


FIGURE 3 – 1N821A SERIES



MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 3)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES.

FIGURE 4 – 1N821 SERIES

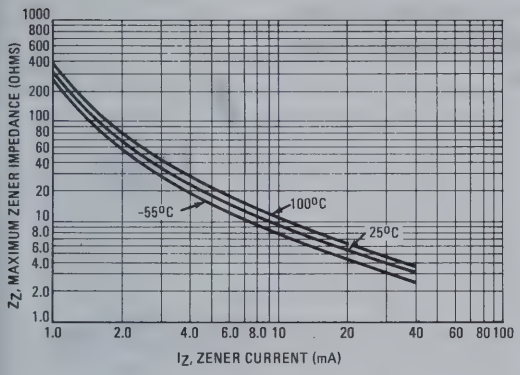


FIGURE 5 – 1N821A SERIES

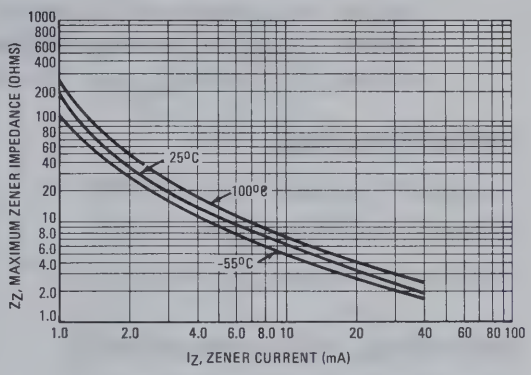
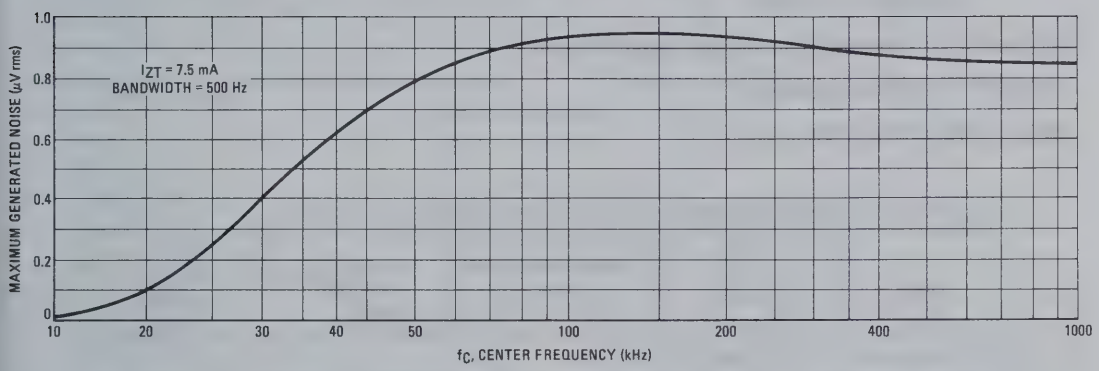


FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N821, 1N823, 1N825, 1N827, and 1N829 are available to MIL-S-19500/159 and MEG-A-LIFE II, Levels 1, 2, & 3, specifications.

NOTE 2:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. V_Z is measured and recorded at each temperature specified. The ΔV_Z between the highest and lowest values must not exceed the maximum ΔV_Z given. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability – by means of temperature coefficient – accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of zener impedance with zener current for each series are given in Figures 4 and 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 4:

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from 0 to +50°C will cause a voltage change no greater than +31 mV or –31 mV for 1N821 or 1N821A, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, an expanded view of the shaded area in Figure 1a is shown in Figure 1b.

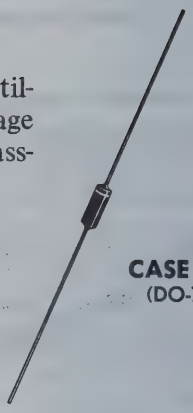
NOTE 5:

The maximum voltage change, ΔV_Z, Figures 2 and 3 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by graphically adding ΔV_Z in Figure 2 or 3 to the ΔV_Z in Figure 1 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 2 or 3 on Figure 1. For a more detailed explanation see AN-437 (Application Note).

1N935, A, B (SILICON) thru 1N939, A, B

9.0 V ± 5.0%

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



CASE 51
(DO-7)

MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 500 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Test Temperature °C	Temperature Coefficient %/°C (Note 2)	Maximum Dynamic Impedance Z_{ZT} (Ohms) (Note 3)
V_Z = 9.0 V ±5.0%* @ I_{ZT} = 7.5 mA				
1N935	0.067	0, +25, +75	0.01	20
1N936	0.033		0.005	
1N937	0.013		0.002	
1N938	0.006		0.001	
1N939	0.003		0.0005	
1N935A	0.139	-55, 0, +25, +75, +100	0.01	20
1N936A	0.069		0.005	
1N937A	0.027		0.002	
1N938A	0.013		0.001	
1N939A	0.007		0.0005	
1N935B	0.184	-55, 0, +25, +75, +100, +150	0.01	20
1N936B	0.092		0.005	
1N937B	0.037		0.002	
1N938B	0.018		0.001	
1N939B	0.009		0.0005	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 20 to 180 pF @ 90% of V_Z

FORWARD BREAKDOWN VOLTAGE (V_f) = 100 to 800 V

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N935 thru 1N939

FIGURE 1a

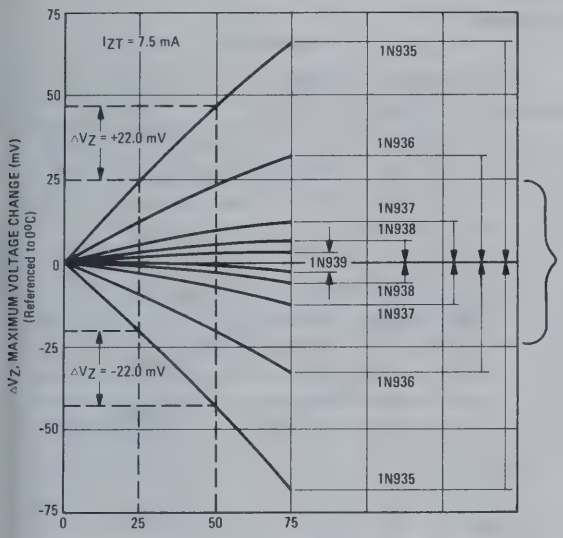
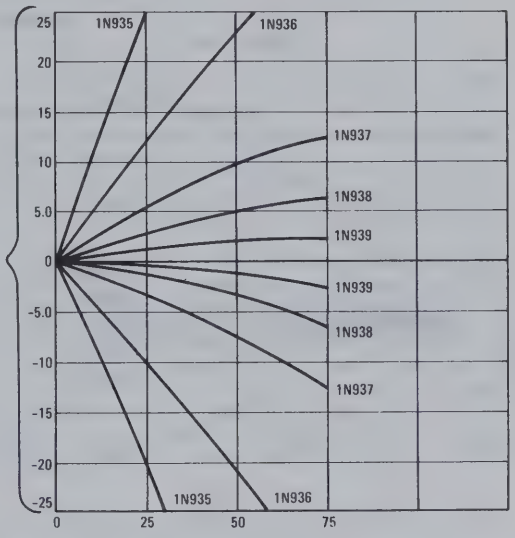


FIGURE 1b



TA, AMBIENT TEMPERATURE (°C)

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N935A thru 1N939A

FIGURE 2a

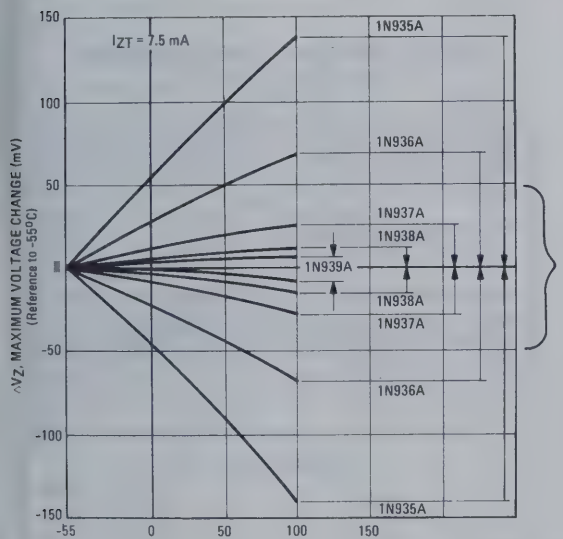
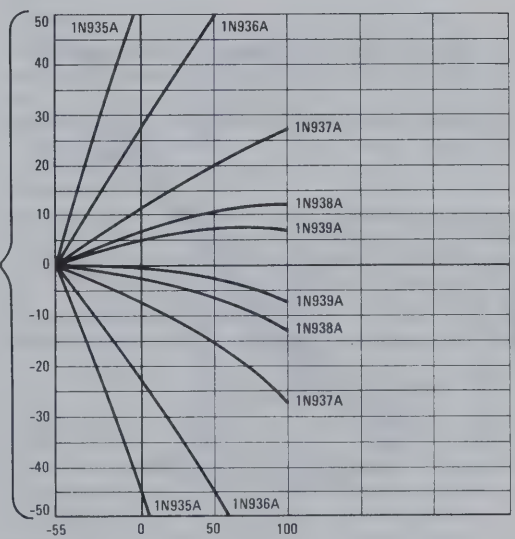


FIGURE 2b



TA, AMBIENT TEMPERATURE (°C)

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N935B thru 1N939B

FIGURE 3a

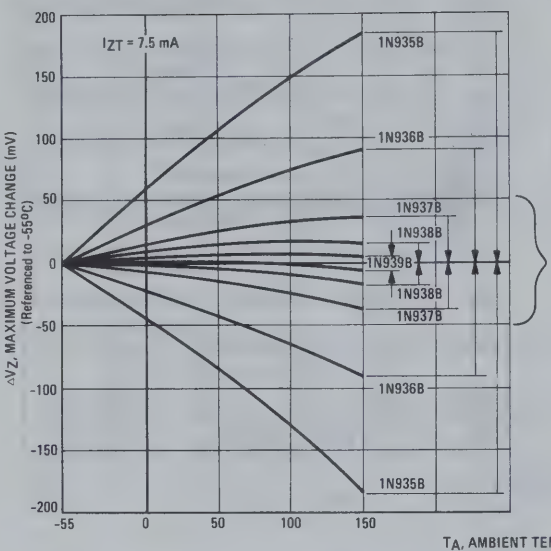


FIGURE 3b

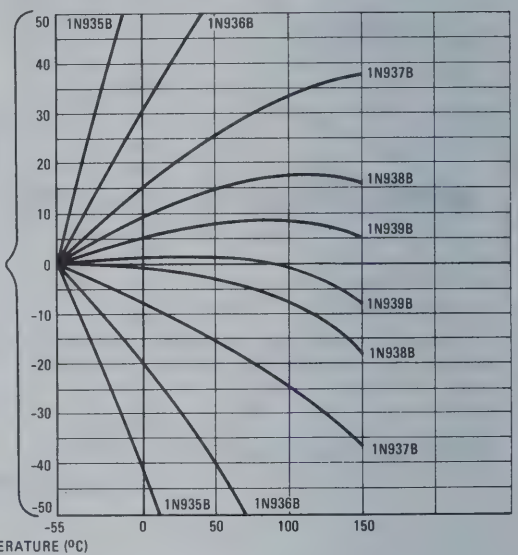


FIGURE 4 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures)
(See Note 5)

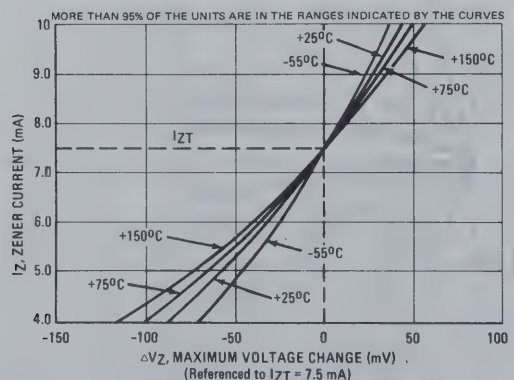


FIGURE 5 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT
(See Note 3)

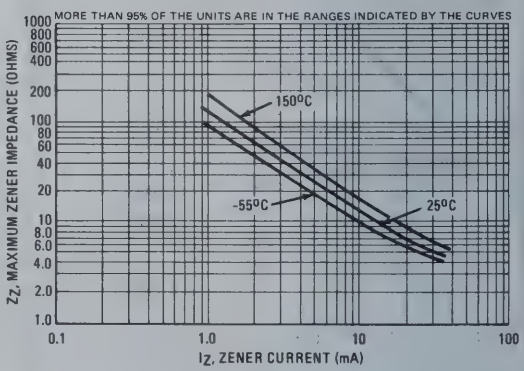
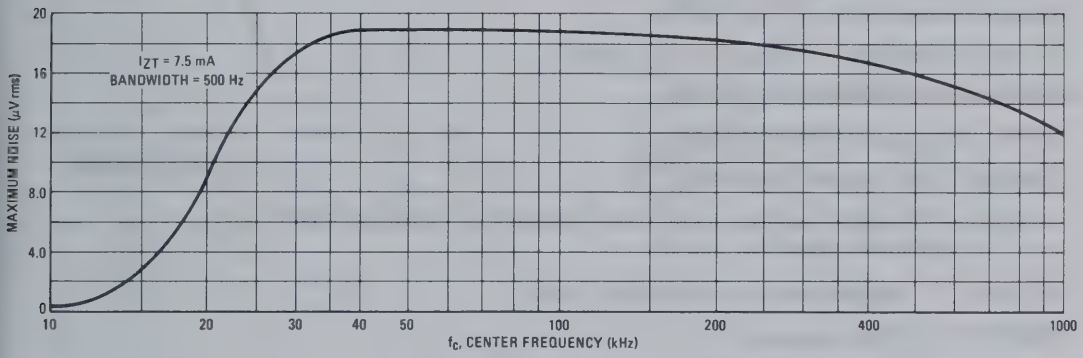


FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N935B, 1N937B, and 1N939B are available to MIL-S-19500/156 and MEG-A-LIFE II, Levels 1, 2, & 3, specifications.

NOTE 2:

Voltage Variation ($\triangle V_Z$) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation ($\triangle V_Z$) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability – by means of temperature coefficient – accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of zener impedance with zener current for each series are given in Figure 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 4:

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from +25 to +50°C will cause a voltage change no greater than +22 mV or -22 mV for 1N935, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, expanded views of the shaded areas in Figures 1a, 2a, and 3a are shown in Figures 1b, 2b, and 3b respectively.

NOTE 5:

The maximum voltage change, $\triangle V_Z$, in Figure 4 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding $\triangle V_Z$ in Figure 4 to the $\triangle V_Z$ in Figure 1, 2, or 3 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 4 on Figure 1, 2, or 3.

1N941, A, B (SILICON)
thru
1N945, A, B

11.7 V ± 5.0%

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



CASE 51
(DO-7)

MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 500 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Test Temperature °C	Temperature Coefficient %/°C (Note 2)	Maximum Impedance Z_{ZT} (Ohms) (Note 3)
V_Z = 11.7 V ±5.0%* @ I_{ZT} = 7.5 mA				
1N941	0.088	0, +25, +75	0.01	30
1N942	0.044		0.005	
1N943	0.018		0.002	
1N944	0.009		0.001	
1N945	0.004		0.0005	
1N941A	0.181	-55, 0, +25, +75, +100	0.01	30
1N942A	0.090		0.005	
1N943A	0.036		0.002	
1N944A	0.018		0.001	
1N945A	0.009		0.0005	
1N941B	0.239	-55, 0, +25, +75, +100, +150	0.01	30
1N942B	0.120		0.005	
1N943B	0.047		0.002	
1N944B	0.024		0.001	
1N945B	0.012		0.0005	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 14 to 35 pF @ 90% of V_Z

FORWARD BREAKDOWN VOLTAGE (V_f) = 150 to 1200 V

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N941 thru 1N945

FIGURE 1a

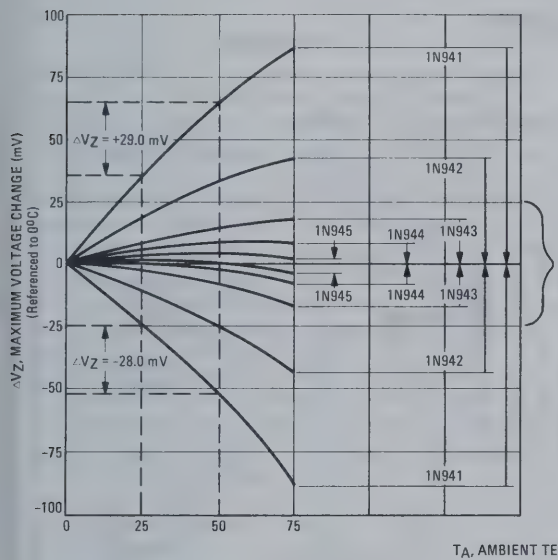
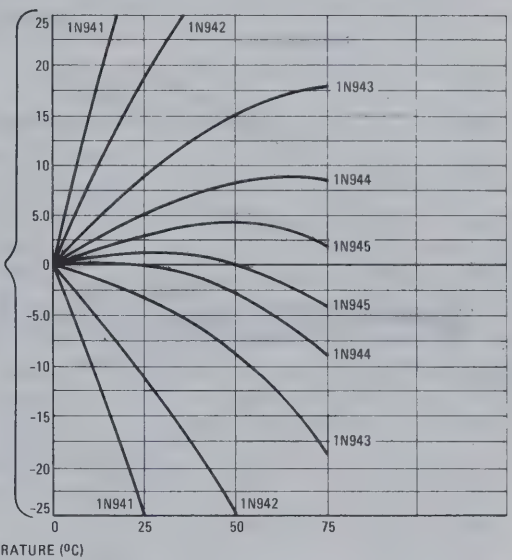


FIGURE 1b



T_A, AMBIENT TEMPERATURE (°C)

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N941A thru 1N945A

FIGURE 2a

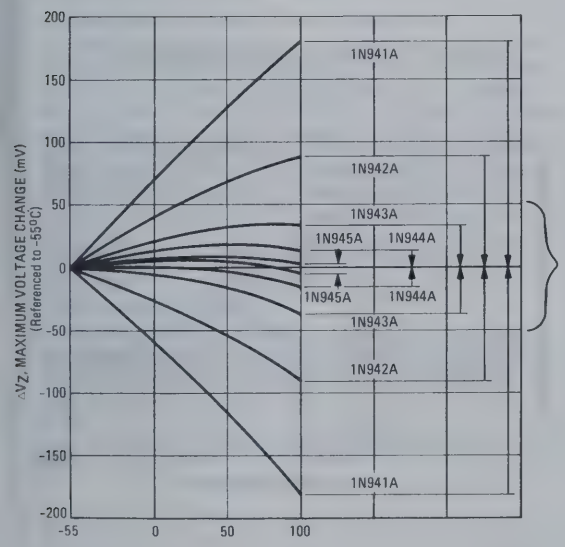
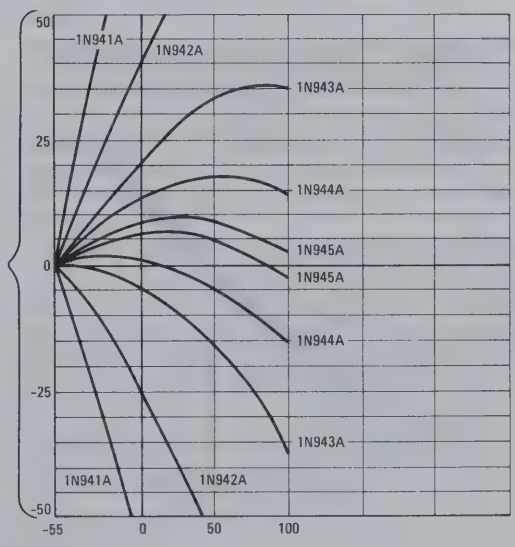


FIGURE 2b



T_A, AMBIENT TEMPERATURE (°C)

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N941B thru 1N945B

FIGURE 3a

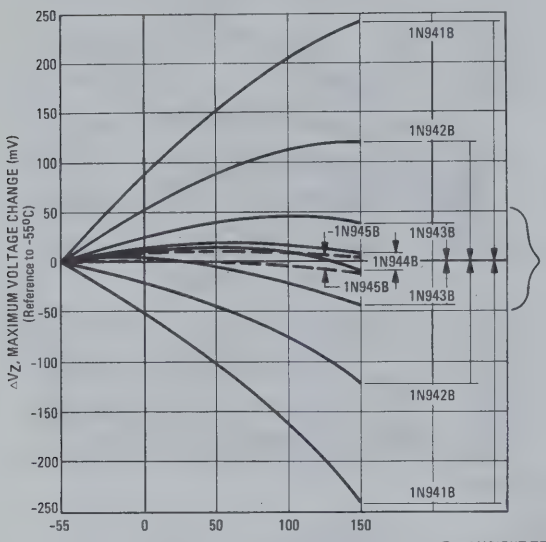
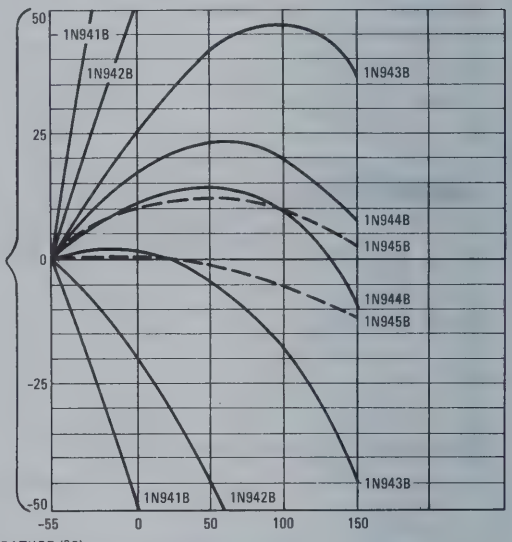


FIGURE 3b



T_A, AMBIENT TEMPERATURE (°C)

FIGURE 4 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (At specified temperatures)

(See Note 5)

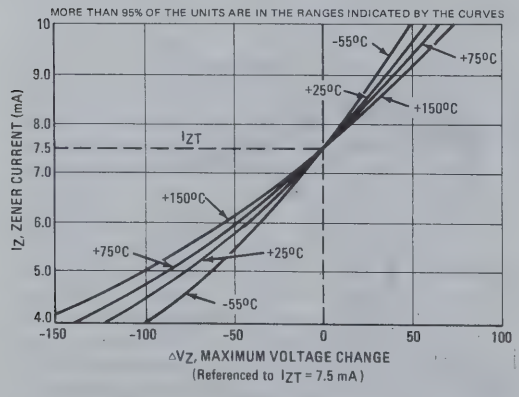


FIGURE 5 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 3)

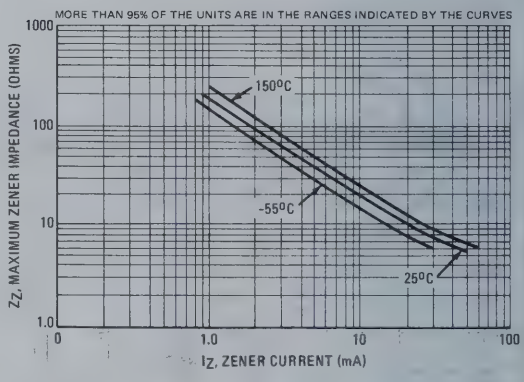
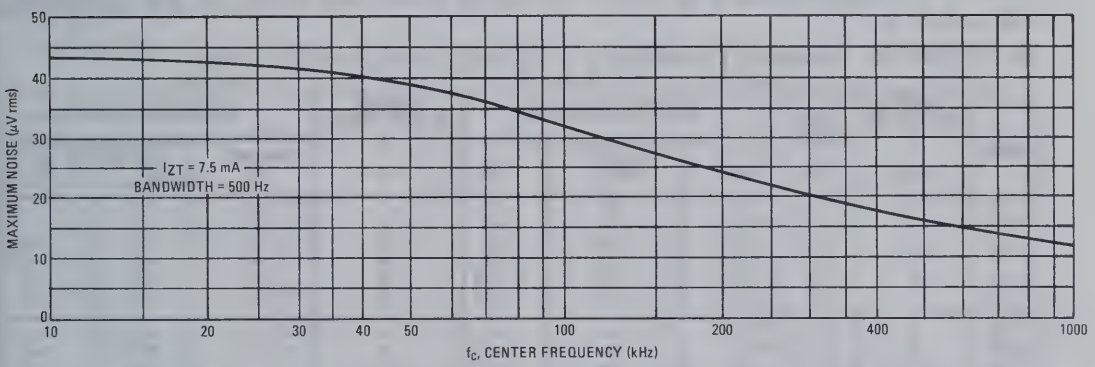


FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N941B, 1N943B, and 1N944B are available to MIL-S-19500/157 and MEG-A-LIFE II, Levels 1, 2, & 3, specifications.

NOTE 2:

Voltage Variation ($\triangle V_Z$) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation ($\triangle V_Z$) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability – by means of temperature coefficient – accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of zener impedance with zener current for each series are given in Figure 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 4:

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from +25 to +50°C will cause a voltage change no greater than +29 mV or -28 mV for 1N941, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, expanded views of the shaded areas in Figures 1a, 2a, and 3a are shown in Figures 1b, 2b, and 3b respectively.

NOTE 5:

The maximum voltage change, $\triangle V_Z$, in Figure 4 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding $\triangle V_Z$ in Figure 4 to the $\triangle V_Z$ in Figure 1, 2, or 3 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 4 on Figure 1, 2, or 3.

1N957 thru 1N992

400 mW
6.8 — 200 V



CASE 51
(DO-7)

Hermetically sealed, all-glass case with all external surfaces corrosion resistant. Cathode end, indicated by color band, will be positive with respect to anode end when operated in the zener region.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C
D C Power Dissipation: 400 Milliwatts at 50°C Ambient (Derate 3.2 mW/°C Above 50°C Ambient)

TOLERANCE DESIGNATIONS

With no suffix, tolerance is ±20%, for ±10% units, add suffix A, for ±5% units, add suffix B.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

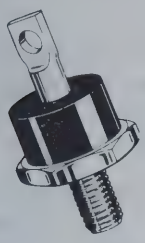
TYPE NUMBER	NOMINAL ZENER VOLTAGE V_Z VOLTS	TEST CURRENT I_{ZT} mA	MAXIMUM ZENER IMPEDANCE Z_{ZT} @ I_{ZT} Ohms	MAXIMUM ZENER IMPEDANCE Z_{ZK} @ I_{ZK} Ohms	MAXIMUM ZENER IMPEDANCE I_{ZK} mA	MAXIMUM DC ZENER CURRENT I_{ZM} mA	REVERSE LEAKAGE CURRENT I_R MAXIMUM (μA)	REVERSE LEAKAGE CURRENT TEST VOLTAGE Vdc * V_{R1}	REVERSE LEAKAGE CURRENT TEST VOLTAGE Vdc * V_{R2}
1N957	6.8	18.5	4.5	700	1.0	47	150	5.2	4.9
1N958	7.5	16.5	5.5	700	0.5	42	75	5.7	5.4
1N959	8.2	15	6.5	700	0.5	38	50	6.2	5.9
1N960	9.1	14	7.5	700	0.5	35	25	6 9	6.6
1N961	10	12.5	8.5	700	0.25	32	10	7.6	7.2
1N962	11	11.5	9.5	700	0.25	28	5	8.4	8.0
1N963	12	10.5	11.5	700	0.25	26	5	9.1	8.6
1N964	13	9.5	13	700	0.25	24	5	9.9	9.4
1N965	15	8.5	16	700	0.25	21	5	11.4	10.8
1N966	16	7.8	17	700	0.25	19	5	12.2	11.5
1N967	18	7.0	21	750	0.25	17	5	13.7	13.0
1N968	20	6.2	25	750	0.25	15	5	15.2	14.4
1N969	22	5.6	29	750	0.25	14	5	16.7	15.8
1N970	24	5.2	33	750	0.25	13	5	18.2	17.3
1N971	27	4.6	41	750	0.25	11	5	20.6	19.4
1N972	30	4.2	49	1000	0.25	10	5	22.8	21.6
1N973	33	3.8	58	1000	0.25	9.2	5	25.1	23.8
1N974	36	3.4	70	1000	0.25	8.5	5	27.4	25.9
1N975	39	3.2	80	1000	0.25	7.8	5	29.7	28.1
1N976	43	3.0	93	1500	0.25	7.0	5	32.7	31.0
1N977	47	2.7	105	1500	0.25	6.4	5	35.8	33.8
1N978	51	2.5	125	1500	0.25	5.9	5	38.8	36.7
1N979	56	2.2	150	2000	0.25	5.4	5	42.6	40.3
1N980	62	2.0	185	2000	0.25	4.9	5	47.1	44.6
1N981	68	1.8	230	2000	0.25	4.5	5	51.7	49.0
1N982	75	1.7	270	2000	0.25	4.0	5	56.0	54.0
1N983	82	1.5	330	3000	0.25	3.7	5	62.2	59.0
1N984	91	1.4	400	3000	0.25	3.3	5	69.2	65.5
1N985	100	1.3	500	3000	0.25	3.0	5	76.0	72.0
1N986	110	1.1	750	4000	0.25	2.7	5	83.6	79.2
1N987	120	1.0	900	4500	0.25	2.5	5	91.2	86.4
1N988	130	0.95	1100	5000	0.25	2.3	5	98.8	93.6
1N989	150	0.85	1500	6000	0.25	2.0	5	114.0	108.0
1N990	160	0.80	1700	6500	0.25	1.9	5	121.6	115.2
1N991	180	0.68	2200	7100	0.25	1.7	5	136.8	129.6
1N992	200	0.65	2500	8000	0.25	1.5	5	152.0	144.0

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)
1 — Nominal zener voltages between those shown.
2 — Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.
a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
b. Two or more units matched to one another with any specified tolerance.
3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

*V_{R1} — Test Voltage for 5% Tolerance Device
V_{R2} — Test Voltage for 10% Tolerance Device
No Leakage Specified as 20% Tolerance Device

1N1183 thru 1N1190

V_R — to 600 V
I_O = 35 A



CASE 42
(DO-5)

Medium current silicon rectifiers. Unique double-case construction consists of hermetically sealed inner metallic case surrounded by molded external case; provides highest degree of ruggedness and reliability. Type numbers shown have cathode connected to case, but reverse-polarity units can be obtained by adding suffix "R" to standard type number, e.g. 1N1183R.

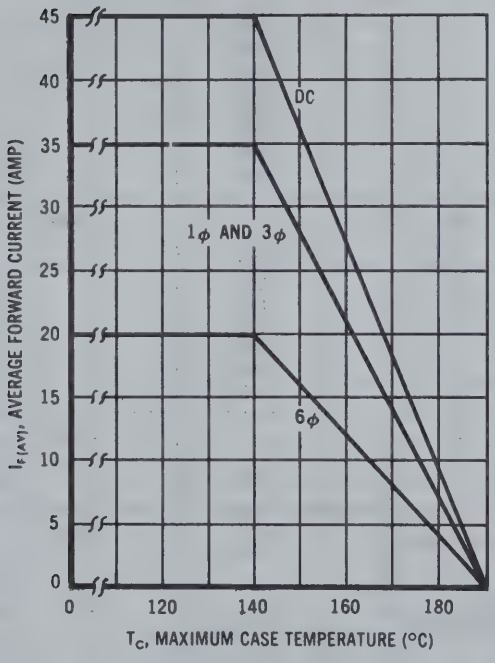
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage and DC Blocking Voltage	$V_{RM\ (rep)}$ V_R		Volts
1N1183		50	
1N1184		100	
1N1185		150	
1N1186		200	
1N1187		300	
1N1188		400	
1N1189		500	
1N1190		600	
RMS Reverse Voltage	V_r		Volts
1N1183		35	
1N1184		70	
1N1185		105	
1N1186		140	
1N1187		210	
1N1188		280	
1N1189		350	
1N1190		420	
Average 1/2-Wave Rectified Forward Current (Resistive Load, 60 Hz, T_C = 140°C)	I_O	35	Amp
Peak Repetitive Forward Current (T_C = 140°C)	$I_{FM\ (rep)}$	150	Amp
Peak Surge Current (T_C = 140°C, superimposed on Rated Current at Rated Voltage)	$I_{FM\ (surge)}$	400	Amp
Operating and Storage Temperature	T_J, T_{stg}	-65 to +190	°C
Thermal Impedance	θ_{JC}	1.0	°C/W, DC steady state

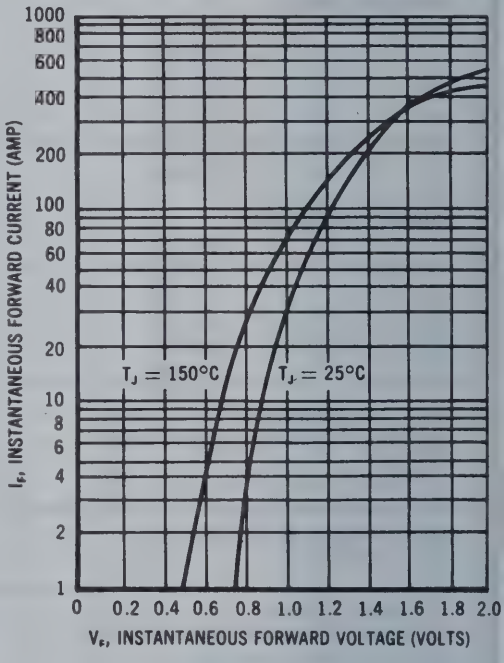
ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Value	Unit
Max Full Cycle Average Forward Voltage Drop ($I_{O\ (max)}$, rated V_r, 60 Hz, T_C = 140°C)	$V_{F(AV)}$	0.6	Volts
Max Instantaneous Forward Voltage Drop (I_F = 100 Amps, T_J = 25°C)	V_F	1.3	Volts
Max Full Cycle Average Reverse Current ($I_{O\ (max)}$, rated V_r, 60 Hz, T_C = 140°C)	$I_{R(AV)}$	10.0	mA
Max DC Reverse Current (Rated V_R, T_C = 25°)	I_R	1.0	mA

MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM CASE TEMPERATURE (60 CPS, RESISTIVE OR INDUCTIVE LOAD)



TYPICAL FORWARD CHARACTERISTICS



1N1191 thru 1N1198

1N1195A thru 1N1198A

For Specifications, See **1N248B** Data.

1N1313 thru 1N1327

150 mW
8.75 — 127.5 V



CASE 53

Very low power zener diodes with standard ±10% tolerances. Available with ±5.0% tolerance by adding suffix "A" to type number.

Standard cathode-to-case polarity.

For new designs and for industry preferred replacement devices, see MZ92-8.8A series.

MAXIMUM RATINGS

Junction and Storage Temperature Range: -65 to +175°C (Derate 1 mW/°C above 25°C).

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Type	Nominal Voltage $V_Z @ I_{ZT} = 200\ \mu A$ volts	Max Reverse Current $T_A = 25°C$ $I_R @ V_R$ μA	Max Reverse Current $T_A = 100°C$ $I_A @ V_R$ μA	Test Voltage V_R volts
1N1313	8.75	0.5	5	6.8
1N1314	10.50	0.5	5	8.2
1N1315	12.75	0.5	5	10
1N1316	15.75	0.5	5	12
1N1317	19.00	0.5	5	15

Type	Nominal Voltage $V_Z @ I_{ZT} = 200\ \mu A$ volts	Max Reverse Current $T_A = 25°C$ $I_R @ V_R$ μA	Max Reverse Current $T_A = 100°C$ $I_A @ V_R$ μA	Test Voltage V_R volts
1N1318	23.50	0.1	10	18
1N1319	28.50	0.1	10	22
1N1320	34.50	0.1	10	27
1N1321	41.00	0.1	10	33
1N1322	48.50	0.1	10	39

Type	Nominal Voltage $V_Z @ I_{ZT} = 200\ \mu A$ volts	Max Reverse Current $T_A = 25°C$ $I_R @ V_R$ μA	Max Reverse Current $T_A = 100°C$ $I_A @ V_R$ μA	Test Voltage V_R volts
1N1323	58.00	0.1	10	47
1N1324	71.00	1.0	50	56
1N1325	87.50	1.0	50	68
1N1326	105.0	1.0	50	82
1N1327	127.5	1.0	50	100

1N1351 thru 1N1375

10 W
10 — 100 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

1N1507 thru 1N1517

¾ W
3.9 — 27 V



CASE 52
(DO-13)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1.0-watt, 1N4728 series.

1N1518 thru 1N1528

1 W
3.9 — 27 V



CASE 52
(DO-13)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N4728 series.

1N1530, A

For Specifications, See 1N429 Data.

1N1588 thru 1N1598

3.5 W
3.9 — 27 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series.

1N1599 thru 1N1609

10 W
3.9 — 27 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series.

HIGH VOLTAGE SILICON RECTIFIERS MOLDED ASSEMBLIES

1N1730 thru 1N1734
1N2382 thru 1N2385

I_O — to 0.2 A
$V_{RM(rep)}$ — to 10,000 V



CASE 41

Standard single-phase, half-wave, high-voltage silicon rectifier assemblies.

MAXIMUM RATINGS (covering all devices in the table below)

Max. DC Reverse Current @ Rated Peak Reverse Voltage 25°C	10 μA
100°C	100 μA
Max. Surge Current (8 ms)	2.5A
Operating Temperature	-55°C to +150°C

ELECTRICAL CHARACTERISTICS

Rectifier Types	V_{RM} (rep)	Avg. Rectified Fwd. Current – mA @25°C	@100°C	Max. RMS Input Voltage	Max. DC Fwd. Voltage @ 100mA @ 25°C	Case Dimensions L	Dia.	Lead Dimensions L	Dia.
1N1730	1000	200	100	700	5	.5	.375	1.250	.030
1N1731	1500	200	100	1050	5	.5	.375	1.250	.030
1N1732	2000	200	100	1400	9	1.0	.375	1.250	.030
1N1733	3000	150	75	2100	12	1.0	.375	1.250	.030
1N1734	5000	100	50	3500	18	1.0	.5	1.250	.030
1N2382	4000	150	75	2800	18	1.5	.5	1.250	.030
1N2383	6000	100	50	4200	27	1.5	.5	1.250	.030
1N2384	8000	70	35	5600	27	1.5	.5	1.250	.030
1N2385	10000	70	35	7000	39	2.0	.5	1.250	.030

1N1735 thru 1N1742
1N1736A thru 1N1742A

For Specifications, See 1N429 Data.

1N1765 thru 1N1802

1 W
5.6 — 200 V



CASE 52
(DO-13)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N4728 series.

1N1803 thru 1N1836

10 W
5.6 — 200 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series, and 1N2970 series.

1N1816 thru 1N1836 are available as clipper devices. To order, add suffix "C" for ±10%, suffix "CA" for ±5%.

1N2008 thru 1N2012

10 W
100 — 150 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

1N2032 thru 1N2040

¾ W
4.3 — 12 V



CASE 52
(DO-13)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N4728 series.

1N2041 thru 1N2049

10 W
4.3 — 27 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series.

1N2163 thru 1N2171

9.4 V ± 0.4 V

1N2163A thru 1N2171A

9.4 ± 0.2 V

1N3580, A, B thru 1N3583, A, B

11.7 ± 5.0%

TEMPERATURE-COMPENSATED ZENER REFERENCE DIODES

Highly reliable reference sources utilizing an oxide-passivated junction for long-term voltage stability. Construction consists of welded hermetically sealed metal and glass case.

- Low Dynamic Impedance
- Choice of Three Temperature Ranges
- "Box Method" Specifications Guarantee Maximum Voltage Deviation.

Temperature compensated reference diodes are made by taking advantage of the differing thermal characteristics of forward and reverse biased silicon PN junctions. A forward biased junction has a negative temperature coefficient of approximately 2.0 millivolts/°C. Reverse biased junctions above 5.0 volts have a positive temperature coefficient and therefore it is possible by judicious selection of combinations of forward and reverse biased junctions to obtain a device that shows a very low temperature coefficient due to cancellation. Because of the differing impedance versus temperature characteristics of the junctions involved, optimum temperature stability is obtained by operating in the zener current range at which the temperature coefficient is a minimum.

MAXIMUM RATINGS

Junction Temperature: -55 to +200°C

Storage Temperature: -65 to +200°C

DC Power Dissipation: 750 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, welded metal glass

DIMENSIONS: See outline drawing.

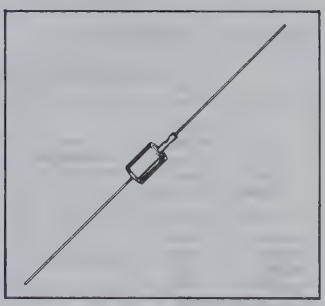
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

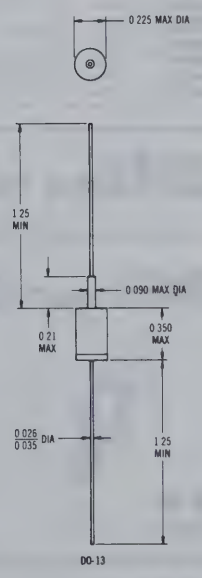
POLARITY: Cathode to case

WEIGHT: 1.5 Grams (approx)

MOUNTING POSITION: Any

TEMPERATURE-COMPENSATED SILICON ZENER REFERENCE DIODES





CASE 52
(DO-13)

1N2163 thru 1N2171, 1N2163A thru 1N2171A, 1N3580, A, B thru 1N3583, A, B (continued)

ELECTRICAL CHARACTERISTICS

V_Z = 9.4 Volts ± 0.4 V (± 0.2 V Suffix "A") @ (I_{ZT} = 10 mA)				
Type Number	Max Voltage Change (Note 1) ΔV_Z (Volts)	Test Temperatures °C	Temperature Coefficient (Note 1) %/°C	Max Dynamic Impedance (Note 2) Z_{ZT} (Ohms)
1N2163,A	0.033	0, +25, +70	0.005	15
1N2164,A	0.086	-55, 0, +25, +75, +125	0.005	
1N2165,A	0.115	-55, 0, +25, +75, +125, +185	0.005	
1N2166,A	0.007	0, +25, +70	0.001	15
1N2167,A	0.017	-55, 0, +25, +75, +125	0.001	
1N2168,A	0.023	-55, 0, +25, +75, +125, +185	0.001	
1N2169,A	0.004	0, +25, +70	0.0005	15
1N2170,A	0.009	-55, 0, +25, +75, +125	0.0005	
1N2171,A	0.012	-55, 0, +25, +75, +125, +185	0.0006	

NOTE 1:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. V_Z is measured and recorded at each temperature specified. The ΔV_Z between the highest and lowest values must not exceed the maximum ΔV_Z given.

This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

ELECTRICAL CHARACTERISTICS

V_Z = 11.7 Volts ± 5.0% (I_{ZT} = 7.5 mA)				
Type Number	Max Voltage Change (Note 1) ΔV_Z (Volts)	Test Temperatures °C	Temperature Coefficient (Note 1) %/°C	Max Dynamic Impedance (Note 2) Z_{ZT} (Ohms)
1N3580	0.088	0, +25, +75	0.01	25
1N3581	0.044		0.005	
1N3582	0.018		0.002	
1N3583	0.009		0.001	
1N3580A	0.181	-55, 0, +25, +75, +100	0.01	25
1N3581A	0.090		0.005	
1N3582A	0.036		0.002	
1N3583A	0.018		0.001	
1N3580B	0.239	-55, 0, +25 +75, +100, +150	0.01	25
1N3581B	0.120		0.005	
1N3582B	0.048		0.002	
1N3583B	0.024		0.001	

NOTE 2:

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. A cathode-ray tube curve-trace test on a sample basis is used to ensure that the zener has a sharp and stable knee region.

1N2382 thru 1N2385

For Specifications, See 1N1730 Data.

1N2498 thru 1N2500

10 W
10 — 12 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

1N2609 thru 1N2617

Obsolete, discontinued types, replace with devices from the 1N4001 series.

1N2620, A, B (SILICON) thru 1N2624, A, B

9.3 V ± 5.0%

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. Construction consists of welded hermetically sealed metal and glass case.



CASE 52
(DO-13)

MAXIMUM RATINGS

Junction Temperature: −55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 750 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, welded metal and glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily soldered and weldable.

POLARITY: Cathode to case

WEIGHT: 1.5 Grams (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

JEDEC Type No.	Maximum Voltage Change ΔV_Z (Volts) (Note 1)	Test Temperature °C	Temperature Coefficient %/°C (Note 1)	Maximum Dynamic Impedance Z_{ZT} (Ohms) (Note 2)
V_Z = 9.3 V ±5.0%* @ I_{ZT} = 10 mA				
1N2620	0.070	0, +25, +75	0.01	15
1N2621	0.035		0.005	
1N2622	0.014		0.002	
1N2623	0.007		0.001	
1N2624	0.003		0.0005	
1N2620A	0.144	-55, 0, +25, +75, +100	0.01	15
1N2621A	0.072		0.005	
1N2622A	0.029		0.002	
1N2623A	0.014		0.001	
1N2624A	0.007		0.0005	
1N2620B	0.191	-55, 0, +25, +75, +100, +150	0.01	15
1N2621B	0.095		0.005	
1N2622B	0.038		0.002	
1N2623B	0.019		0.001	
1N2624B	0.010		0.0005	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 75 to 200 pF @ 90% of V_Z

FORWARD BREAKDOWN VOLTAGE (V_f) = 100 to 800 V

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 10 mA ±0.01 mA) (See Note 3)

1N2620 thru 1N2624

FIGURE 1a

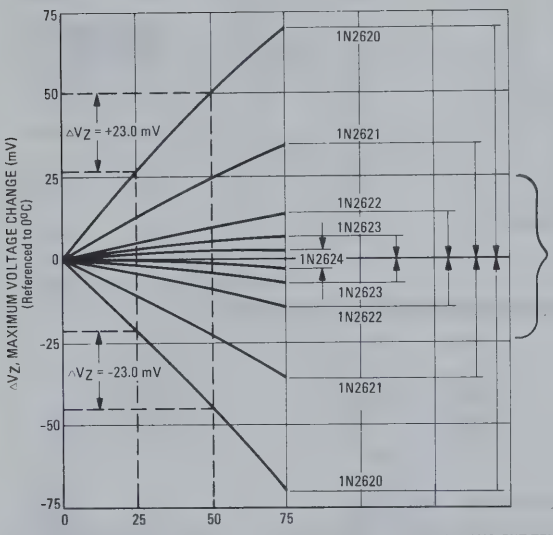
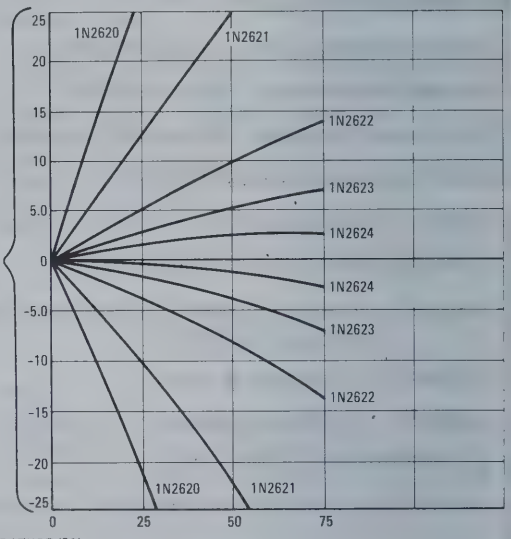


FIGURE 1b



T_A, AMBIENT TEMPERATURE (°C)

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 10 mA ±0.01 mA) (See Note 3)

1N2620A thru 1N2624A

FIGURE 2a

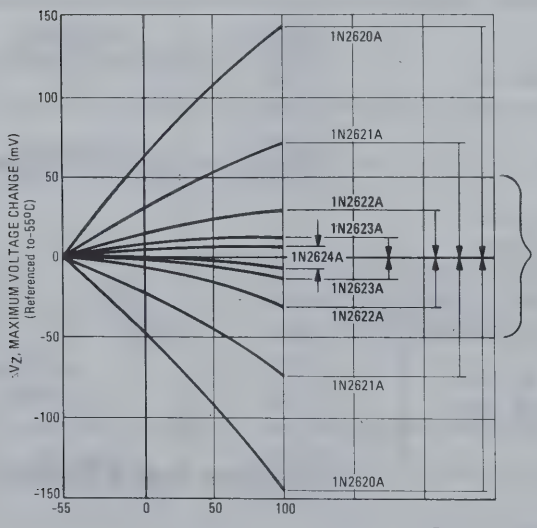
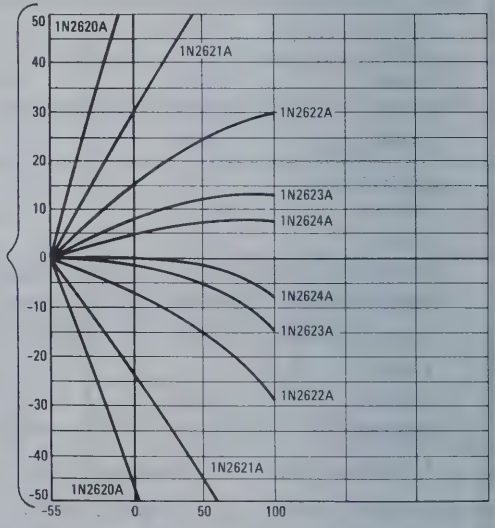


FIGURE 2b



T_A, AMBIENT TEMPERATURE (°C)

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with I_{ZT} = 10 mA ±0.01 mA) (See Note 4)

1N2620B thru 1N2624B

FIGURE 3a

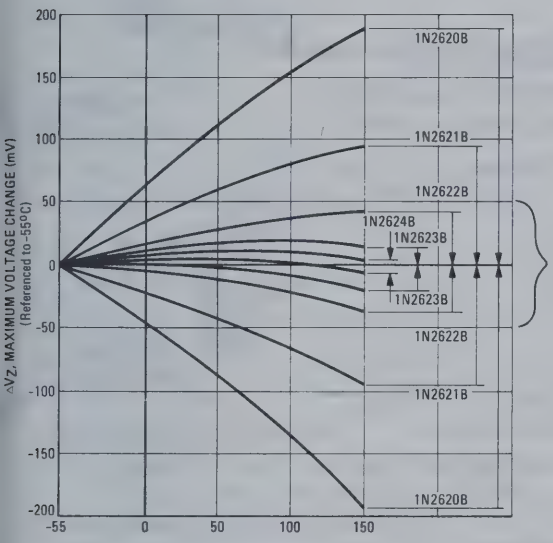
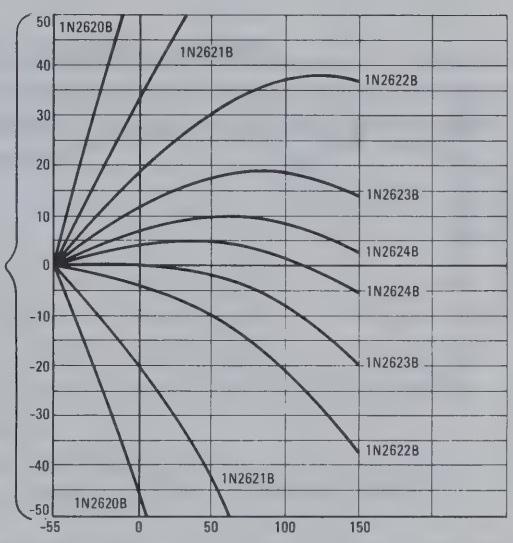


FIGURE 3b



TA, AMBIENT TEMPERATURE (°C)

FIGURE 4 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures)
(See Note 4)

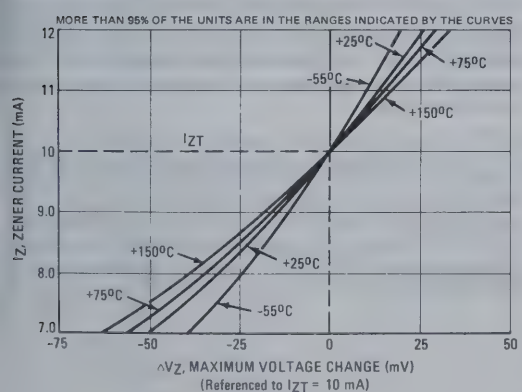


FIGURE 5 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT
(See Note 2)

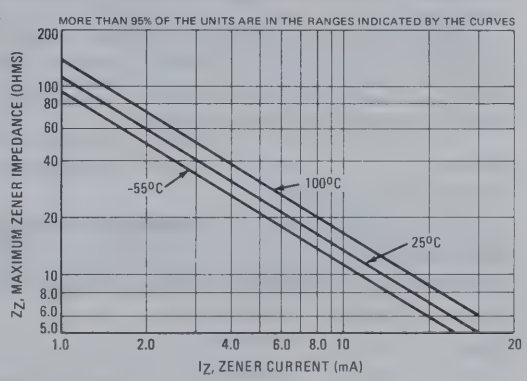
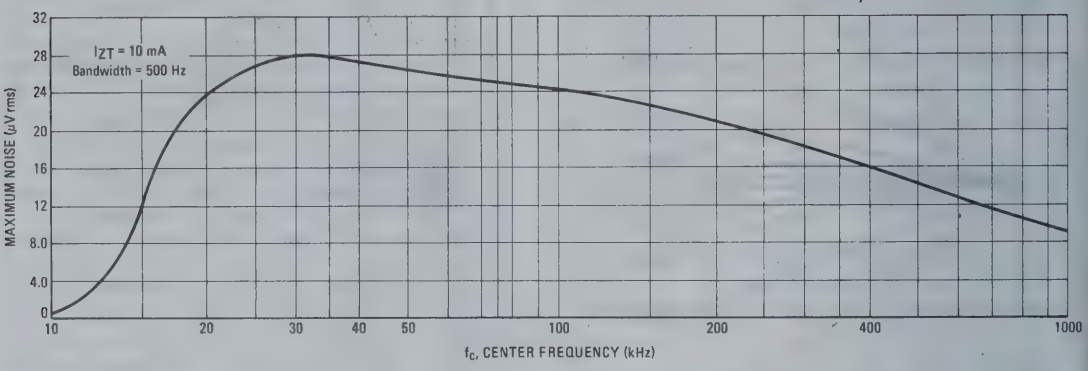


FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Voltage Variation ($\triangle V_Z$) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation ($\triangle V_Z$) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability – by means of temperature coefficient – accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 2:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of zener impedance with zener current for each series are given in Figure 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 3:

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from +25 to +50°C will cause a voltage change no greater than +23 mV or -23 mV for 1N2620, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, expanded views of the shaded areas in Figures 1a, 2a, and 3a are shown in Figures 1b, 2b, and 3b respectively.

NOTE 4:

The maximum voltage change, $\triangle V_Z$, in Figure 4 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding $\triangle V_Z$ in Figure 4 to the $\triangle V_Z$ in Figure 1, 2, or 3 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 4 on Figure 1, 2, or 3.

1N2804 thru 1N2846 (Case 54)
6.8V thru 200V

1N4557 thru 1N4564 (Case 54)
3.9V thru 7.5V

1N3305 thru 1N3350 (Case 58)
6.8V thru 200V

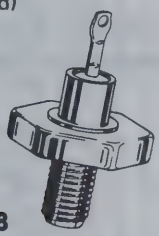
1N4549 thru 1N4556 (Case 58)
3.9V thru 7.5V

50 W
3.9 — 200 V



CASE 54
(TO-3 Modified)

Units are available with anode-to-case and cathode-to-case connections (standard and reverse polarity). For reverse polarity, add suffix "R" to type number.



CASE 58
(stud package)

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D C Power Dissipation: 50 Watts. (Derate 0.5 W/°C above 75°C).

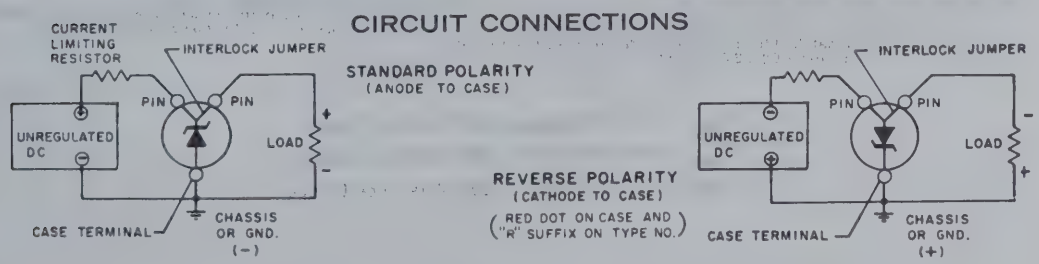
TOLERANCE DESIGNATION

The type numbers shown have a standard tolerance of ±20% on the nominal zener voltage. Add suffix "A" for ±10% units or "B" for ±5% units. (2% and 1% tolerance also available. *(See Selector Guide for details)*

CASE 54 APPLICATIONS INFORMATION

If these units are used with a socket, the unregulated line should be connected to one pin through a suitable current limiting resistor and the load should be connected to the other pin. The load will now be disconnected from the line if the unit is removed from the socket.

Typical circuit connections for anode-to-case and cathode-to-case polarities (standard and reverse polarities, respectively) are shown below



1N2804 thru 1N2846 (continued)

ELECTRICAL CHARACTERISTICS

(Tc = 30°C unless otherwise specified) V_F = 1.5 V max @ 10 A on all types.

50 Watt CASE 54	50 Watt CASE 58	Nominal Zener Voltage @ I_{ZT} (V_Z) Volts	Test Current (I_{ZT}) mA	Max Zener Impedance		Max DC Zener Current 75°C Case Temp (I_{ZM}) mA	REVERSE * LEAKAGE CURRENT			Typical Zener Voltage Temp. Coeff. %/°C
				Z_{ZT} @ I_{ZT} ohms	Z_{ZK} @ I_{ZK} = 5mA ohms		I_R MAX (μA)	V_{R1}	V_{R2}	
1N4557	1N4549	3.9	3200	0.16	400	11900	150	0.5	0.5	-.025
1N4558	1N4550	4.3	2900	0.16	500	10650	150	0.5	0.5	-.025
1N4559	1N4551	4.7	2650	0.12	600	9700	100	1.0	1.0	.010
1N4560	1N4552	5.1	2450	0.12	650	8900	20	1.0	1.0	.015
1N4561	1N4553	5.6	2250	0.12	900	8100	20	1.0	1.0	.030
1N4562	1N4554	6.2	2000	0.14	1000	7300	20	2.0	2.0	.040
1N2804	1N3305	6.8	1850	0.2	70	6600	150	4.5	4.3	.040
1N4563	1N4555	6.8	1850	0.16	200	6650	10	2.0	2.0	.045
1N2805	1N3306	7.5	1700	0.3	70	5900	75	5.0	4.7	.045
1N4564	1N4556	7.5	1650	0.24	100	6050	10	3.0	3.0	.053
1N2806	1N3307	8.2	1500	0.4	70	5200	50	5.4	5.2	.048
1N2807	1N3308	9.1	1370	0.5	70	4800	25	6.1	5.7	.051
1N2808	1N3309	10	1200	0.6	80	4300	10	6.7	6.3	.055
1N2809	1N3310	11	1100	0.8	80	3900	5	8.4	8.0	.060
1N2810	1N3311	12	1000	1.0	80	3600	5	9.1	8.6	.065
1N2811	1N3312	13	960	1.1	80	3300	5	9.9	9.4	.065
1N2812	1N3313	14	890	1.2	80	3000	5	10.6	10.1	.070
1N2813	1N3314	15	830	1.4	80	2800	5	11.4	10.8	.070
1N2814	1N3315	16	780	1.6	80	2650	5	12.2	11.5	.070
1N2815	1N3316	17	740	1.8	80	2500	5	13.0	12.2	.075
1N2816	1N3317	18	700	2.0	80	2300	5	13.7	13.0	.075
1N2817	1N3318	19	660	2.2	80	2200	5	14.4	13.7	.075
1N2818	1N3319	20	630	2.4	80	2100	5	15.2	14.4	.075
1N2819	1N3320	22	570	2.5	80	1900	5	16.7	15.8	.080
1N2820	1N3321	24	520	2.6	80	1750	5	18.2	17.3	.080
1N2821	1N3322	25	500	2.7	90	1550	5	19.0	18.0	.080
1N2822	1N3323	27	460	2.8	90	1500	5	20.6	19.4	.085
1N2823	1N3324	30	420	3.0	90	1400	5	22.8	21.6	.085
1N2824	1N3325	33	380	3.2	90	1300	5	25.1	23.8	.085
1N2825	1N3326	36	350	3.5	90	1150	5	27.4	25.9	.085
1N2826	1N3327	39	320	4.0	90	1050	5	29.7	28.1	.090
1N2827	1N3328	43	290	4.5	90	975	5	32.7	31.0	.090
1N2828	1N3329	45	280	4.5	100	930	5	34.2	32.4	.090
1N2829	1N3330	47	270	5.0	100	880	5	35.8	33.8	.090
1N2830	1N3331	50	250	5.0	100	830	5	38.0	36.0	.090
1N2831	1N3332	51	245	5.2	100	810	5	38.8	36.7	.090
-	1N3333	52	240	5.5	100	790	5	39.5	37.4	.090
1N2832	1N3334	56	220	6	110	740	5	42.6	40.3	.090
1N2833	1N3335	62	200	7	120	680	5	47.1	44.6	.090
1N2834	1N3336	68	180	8	140	600	5	51.7	49.0	.090
1N2835	1N3337	75	170	9	150	540	5	56.0	54.0	.090
1N2836	1N3338	82	150	11	160	490	5	62.2	59.0	.090
1N2837	1N3339	91	140	15	180	420	5	69.2	65.5	.090
1N2838	1N3340	100	120	20	200	400	5	76.0	72.0	.090
1N2839	1N3341	105	120	25	210	380	5	79.8	75.6	.095
1N2840	1N3342	110	110	30	220	365	5	83.6	79.2	.095
1N2841	1N3343	120	100	40	240	335	5	91.2	86.4	.095
1N2842	1N3344	130	95	50	275	310	5	98.8	93.6	.095
-	1N3345	140	90	60	325	290	5	106.4	100.8	.095
1N2843	1N3346	150	85	75	400	270	5	114.0	108.0	.095
1N2844	1N3347	160	80	80	450	250	5	121.6	115.2	.095
-	1N3348	175	70	85	500	230	5	133.0	126.0	.095
1N2845	1N3349	180	68	90	525	220	5	136.8	129.6	.095
1N2846	1N3350	200	65	100	600	200	5	152.0	144.0	.100

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

1 — Nominal zener voltages between those shown.
2 — Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.
   a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
   b. Two or more units matched to one another with any specified tolerance.
3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

*V_{R1} — Test Voltage for 5% Tolerance Device

V_{R2} — Test Voltage for 10% Tolerance Device

No Leakage Specified as 20% Tolerance Device

FIGURE 1 — TEMPERATURE CHARACTERISTICS

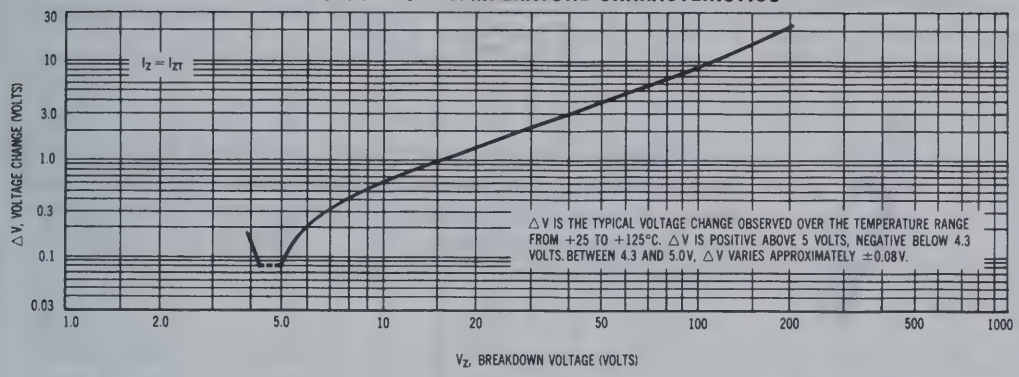


FIGURE 2 — POWER-TEMPERATURE DERATING CURVE



FIGURE 3 — LEAKAGE CURRENT

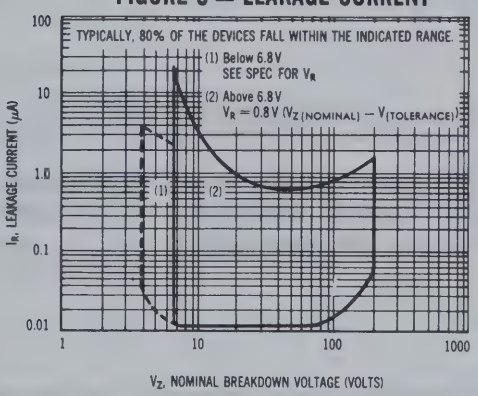
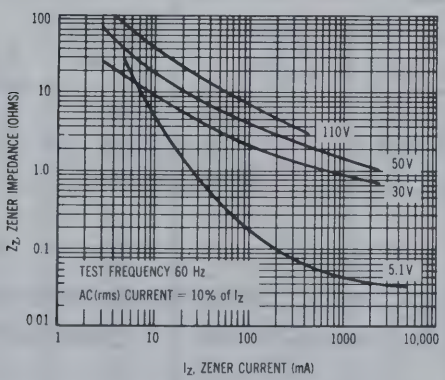
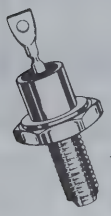


FIGURE 4 — ZENER IMPEDANCE versus ZENER CURRENT



1N2970 thru 1N3015

10W
6.8 — 200 V



CASE 56
(DO-4)

Diffused-junction zener diodes for both military and high-reliability industrial applications. Available with anode-to-case and cathode-to-case connections (standard and reverse polarity), i.e., 1N2970 and 1N2970R. Supplied with mounting hardware.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D C Power Dissipation: 10 Watts. (Derate 83.3 mW/°C above 55°C).

The type numbers shown have a standard tolerance of ±20% on the nominal zener voltage. Add suffix "A" for ±10% units or "B" for ±5% units. (2% and 1% tolerance also available.)

ELECTRICAL CHARACTERISTICS

(T_C = 30°C unless otherwise noted) V_F = 1.5 V max @ I_F = 2 amp on all types.

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance			Max DC Zener Current I_{ZM} mA	Max. Reverse Current *		
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA		I_R Max (μA)	V_{R1}	V_{R2}
1N2970	6.8	370	1.2	500	1.0	1,320	150	5.2	4.9
1N2971	7.5	335	1.3	250	1.0	1,180	75	5.7	5.4
1N2972	8.2	305	1.5	250	1.0	1,040	50	6.2	5.9
1N2973	9.1	275	2.0	250	1.0	960	25	6.9	6.6
1N2974	10	250	3	250	1.0	860	10	7.6	7.2
1N2975	11	230	3	250	1.0	780	5	8.4	8.0
1N2976	12	210	3	250	1.0	720	5	9.1	8.6
1N2977	13	190	3	250	1.0	660	5	9.9	9.4
1N2978	14	180	3	250	1.0	600	5	10.6	10.1
1N2979	15	170	3	250	1.0	560	5	11.4	10.8
1N2980	16	155	4	250	1.0	530	5	12.2	11.5
1N2982	18	140	4	250	1.0	460	5	13.7	13.0
1N2983	19	130	4	250	1.0	440	5	14.4	13.7
1N2984	20	125	4	250	1.0	420	5	15.2	14.4
1N2985	22	115	5	250	1.0	380	5	16.7	15.8
1N2986	24	105	5	250	1.0	350	5	18.2	17.3
1N2988	27	95	7	250	1.0	300	5	20.6	19.4
1N2989	30	85	8	300	1.0	280	5	22.8	21.6
1N2990	33	75	9	300	1.0	260	5	25.1	23.8
1N2991	36	70	10	300	1.0	230	5	27.4	25.9

*V_{R1} — Test Voltage for 5% Tolerance Device. V_{R2} — Test Voltage for 10% Tolerance Device. No Leakage Specified as 20% Tolerance Device.

1N2970 thru 1N3015 (continued)

ELECTRICAL CHARACTERISTICS

(T_C = 30°C unless otherwise noted) V_F = 1.5 V max @ I_F = 2 amp on all types.

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance			Max DC Zener Current I_{ZM} mA	Max. Reverse Current *		
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA		I_R Max (μA)	V_{R1}	V_{R2}
1N2992	39	65	11	300	1.0	210	5	29.7	28.1
1N2993	43	60	12	400	1.0	195	5	32.7	31.0
1N2995	47	55	14	400	1.0	175	5	35.8	33.8
1N2996	50	50	15	500	1.0	165	5	38.0	36.0
1N2997	51	50	15	500	1.0	163	5	38.8	36.7
1N2998	52	50	15	500	1.0	160	5	39.5	37.4
1N2999	56	45	16	500	1.0	150	5	42.6	40.3
1N3000	62	40	17	600	1.0	130	5	47.1	44.6
1N3001	68	37	18	600	1.0	120	5	51.7	49.0
1N3002	75	33	22	600	1.0	110	5	56.0	54.0
1N3003	82	30	25	700	1.0	100	5	62.2	59.0
1N3004	91	28	35	800	1.0	85	5	69.2	65.5
1N3005	100	25	40	900	1.0	80	5	76.0	72.0
1N3006	105	25	45	1,000	1.0	75	5	79.8	75.6
1N3007	110	23	55	1,100	1.0	72	5	83.6	79.2
1N3008	120	20	75	1,200	1.0	67	5	91.2	86.4
1N3009	130	19	100	1,300	1.0	62	5	98.8	93.6
1N3010	140	18	125	1,400	1.0	58	5	106.4	100.8
1N3011	150	17	175	1,500	1.0	54	5	114.0	108.0
1N3012	160	16	200	1,600	1.0	50	5	121.6	115.2
1N3014	180	14	260	1,850	1.0	45	5	136.8	129.6
1N3015	200	12	300	2,000	1.0	40	5	152.0	144.0

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)
1 — Nominal zener voltages between those shown.
2 — Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.
a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
b. Two or more units matched to one another with any specified tolerance.
3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

*V_{R1} — Test Voltage for 5% Tolerance Device. V_{R2} — Test Voltage for 10% Tolerance Device. No Leakage Specified as 20% Tolerance Device.

1N3016 thru 1N3051

1 W
6.8 — 200 V

CASE 52
(DO-13)



Hermetically sealed package, with 36 standard voltage ratings and 5%, 10% and 20% standard tolerances. Cathode connected to case.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D C Power Dissipation: 1 Watt. (Derate 6.67 mW/°C above 25°C).

The type numbers shown have a standard tolerance of ±20% on the nominal zener voltage. Add suffix "A" for ±10% units or "B" for ±5% units. (2% and 1% tolerance also available. *(See Selector Guide for details)*

ELECTRICAL CHARACTERISTICS (T_C = 30°C unless otherwise noted)

V_F = 1.5 V max @ 200 mA on all types.

Type No.	Nominal Zener Voltage V_z @ I_{zt} Volts	Test Current I_{zt} mA	Max Zener Impedance			Reverse Leakage Current*			Max DC Zener Current I_{zm} mA	Typical Zener Voltage Temp. Coeff. %/ C
			Z_{zt} @ I_{zt} Ohms	Z_{zk} @ I_{zk} Ohms	I_{zk} mA	I_R Max (μA)	V_{R1}	V_{R2}		
1N3016	6.8	37	3.5	700	1.0	150	5.2	4.9	130	.040
1N3017	7.5	34	4.0	700	0.5	75	5.7	5.4	120	.045
1N3018	8.2	31	4.5	700	0.5	50	6.2	5.9	105	.048
1N3019	9.1	28	5.0	700	0.5	25	6.9	6.6	95	.051
1N3020	10	25	7	700	0.25	10	7.6	7.2	85	.055
1N3021	11	23	8	700	0.25	5	8.4	8.0	75	.060
1N3022	12	21	9	700	0.25	5	9.1	8.6	70	.065
1N3023	13	19	10	700	0.25	5	9.9	9.4	65	.065
1N3024	15	17	14	700	0.25	5	11.4	10.8	56	.070
1N3025	16	15.5	16	700	0.25	5	12.2	11.5	53	.070
1N3026	18	14	20	750	0.25	5	13.7	13.0	46	.075
1N3027	20	12.5	22	750	0.25	5	15.2	14.4	42	.075
1N3028	22	11.5	23	750	0.25	5	16.7	15.8	38	.080
1N3029	24	10.5	25	750	0.25	5	18.2	17.3	35	.080
1N3030	27	9.5	35	750	0.25	5	20.6	19.4	30	085
1N3031	30	8.5	40	1,000	0.25	5	22.8	21.6	28	.085
1N3032	33	7.5	45	1,000	0.25	5	25.1	23.8	26	.085
1N3033	36	7.0	50	1,000	0.25	5	27.4	25.9	24	.085
1N3034	39	6.5	60	1,000	0.25	5	29.7	28.1	20	.090
1N3035	43	6.0	70	1,500	0.25	5	32.7	31.0	19	.090
1N3036	47	5.5	80	1,500	0.25	5	35.8	33.8	17	.090
1N3037	51	5.0	95	1,500	0.25	5	38.8	36.7	16	.090
1N3038	56	4.5	110	2,000	0.25	5	42.6	40.3	15	.090
1N3039	62	4.0	125	2,000	0.25	5	47.1	44.6	13	.090
1N3040	68	3.7	150	2,000	0.25	5	51.7	49.0	12	.090
1N3041	75	3.3	175	2,000	0.25	5	56.0	54.0	11	.090
1N3042	82	3.0	200	3,000	0.25	5	62.2	59.0	10	.090
1N3043	91	2.8	250	3,000	0.25	5	69.2	65.5	9	.090
1N3044	100	2.5	350	3,000	0.25	5	76.0	72.0	8	.090
1N3045	110	2.3	450	4,000	0.25	5	83.6	79.2	7.2	.095
1N3046	120	2.0	550	4,500	0.25	5	91.2	86.4	7.0	.095
1N3047	130	1.9	700	5,000	0.25	5	98.8	93.6	6.0	.095
1N3048	150	1.7	1,000	6,000	0.25	5	114.0	108.0	5.5	.095
1N3049	160	1.6	1,100	6,500	0.25	5	121.6	115.2	5.2	.095
1N3050	180	1.4	1,200	7,000	0.25	5	136.8	129.6	4.6	.095
1N3051	200	1.2	1,500	8,000	0.25	5	152.0	144.0	4.0	.100

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

1 – Nominal zener voltages between those shown.

2 – Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.

a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.

b. Two or more units matched to one another with any specified tolerance.

3 – Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

*V_{R1} – Test Voltage for 5% Tolerance Device

V_{R2} – Test Voltage for 10% Tolerance Device

No Leakage Specified as 20% Tolerance Device

1N3154, A (SILICON)
thru
1N3157, A

8.4 V ± 5.0%

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



CASE 51
(DO-7)

MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 500 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Test Temperature °C	Temperature Coefficient %/°C (Note 2)	Maximum Dynamic Impedance Z_{ZT} (Ohms) (Note 3)
V_Z = 8.4 V ±5.0%* @ I_{ZT} = 10 mA				
1N3154	0.130	-55, 0, +25, +75, +100	0.01	15
1N3155	0.065		0.005	
1N3156	0.026		0.002	
1N3157	0.013		0.001	
1N3154A	0.172	-55, 0, +25, +75, +100, +150	0.01	15
1N3155A	0.086		0.005	
1N3156A	0.034		0.002	
1N3157A	0.017		0.001	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 20 to 180 pF @ 90% of V_Z

FORWARD BREAKDOWN VOLTAGE (V_f) = 100 to 800 V

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(with I_{ZT} = 10 mA ±0.01 mA) (See Note 4)

1N3154 thru 1N3157

FIGURE 1a

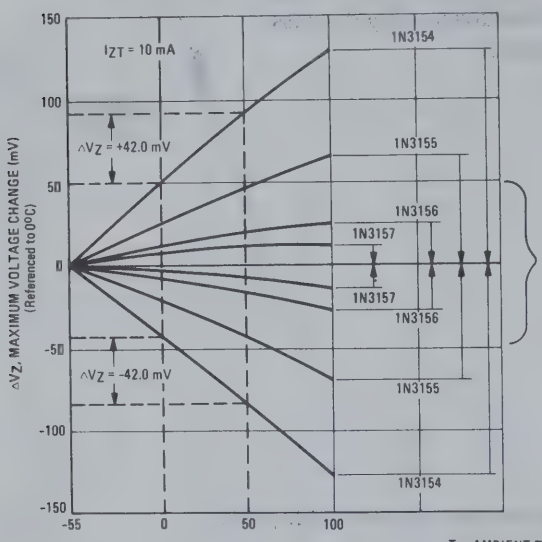
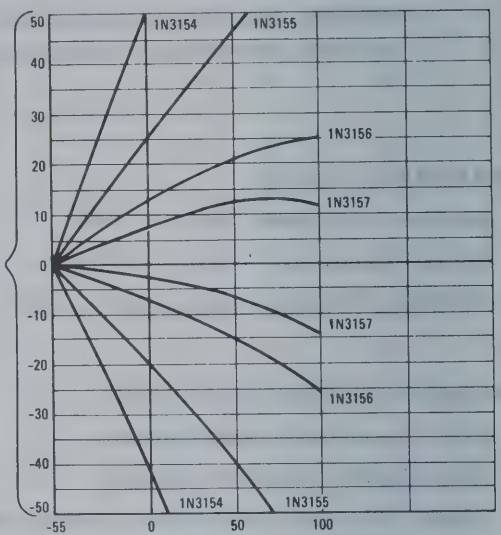


FIGURE 1b



T_A, AMBIENT TEMPERATURE (°C)

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(with I_{ZT} = 10 mA ±0.01 mA) (See Note 4)

1N3154A thru 1N3157A

FIGURE 2a

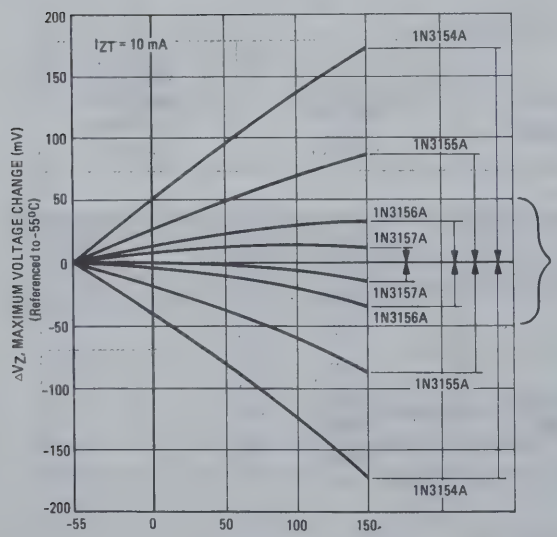
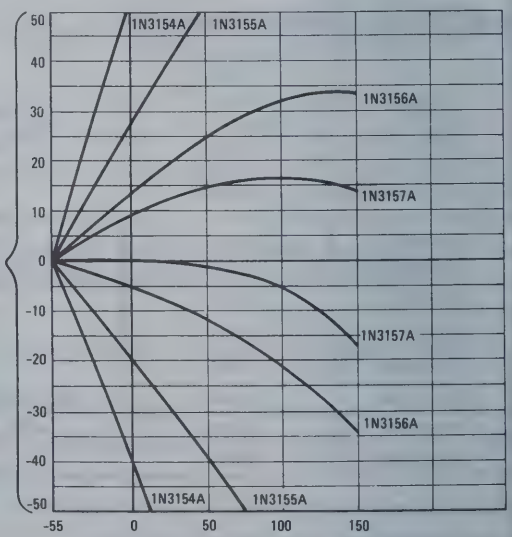


FIGURE 2b



T_A, AMBIENT TEMPERATURE (°C)

FIGURE 3 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures)
(See Note 5)

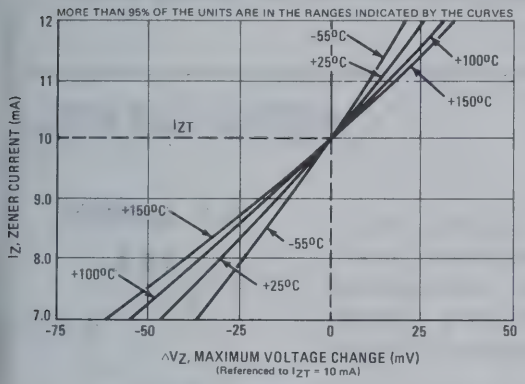


FIGURE 4 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT
(See Note 3)

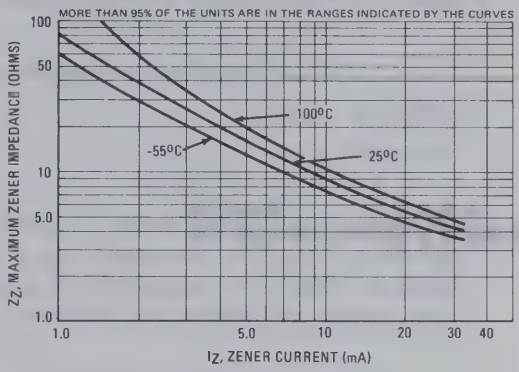
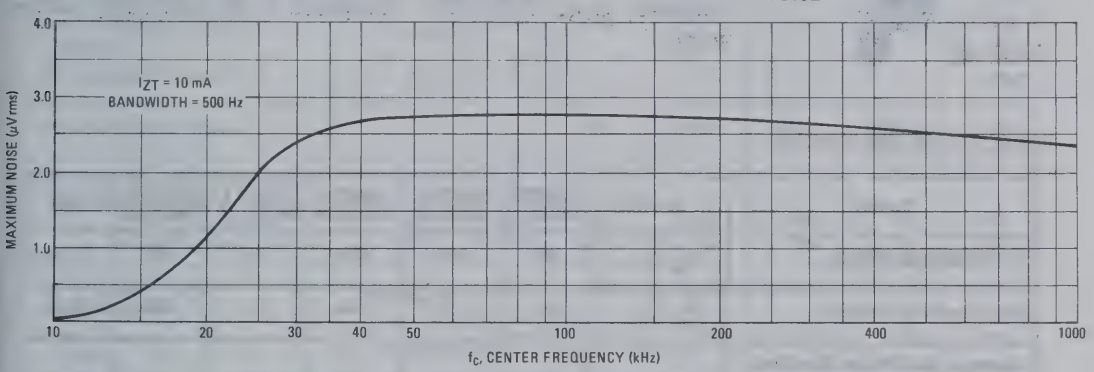


FIGURE 5 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N3154 thru 1N3157 are available to MIL-S-19500/158 and MEG-A-LIFE II, Levels 1, 2, & 3, specifications.

NOTE 2:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability – by means of temperature coefficient – accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of zener impedance with zener current for each series are given in Figure 4. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 4:

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from 0 to +50°C will cause a voltage change no greater than +42 mV or –42 mV for 1N3154, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, expanded views of the shaded areas in Figures 1a and 2a are shown in Figures 1b and 2b respectively.

NOTE 5:

The maximum voltage change, ΔV_Z, in Figure 3 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 3 to the ΔV_Z in Figure 1 or 2 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 3 on Figure 1 or 2.

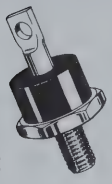
1N3189 thru 1N3191

Obsolete, discontinued types, replace with devices from the 1N4001 series.

1N3208 thru 1N3212

V_R — to 400 V

I_O = 15 A



CASE 42
(DO-5)

Medium-current silicon rectifiers. Cathode connected to case, but reverse polarity (anode-to-case connection) also available by adding suffix "R" to type number, e.g. 1N3208R. Supplied with mounting hardware.

MAXIMUM RATINGS

Rating	Symbol	1N3208 1N3208R	1N3209 1N3209R	1N3210 1N3210R	1N3211 1N3211R	1N3212 1N3212R	Unit
D C Blocking Voltage	V_R	50	100	200	300	400	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	Volts
Average Half-Wave Rectified Forward Current With Resistive Load	I_O*	15	15	15	15	15	Amp
Peak One Cycle Surge Current (60 cps & 25°C Case Temp)	$I_{FM(surge)}$	250	250	250	250	250	Amp
Operating Junction Temperature	T_J	-65 to + 175					°C
Storage Temperature	T_{stg}	-65 to + 175					°C

*T_C = 150°C

ELECTRICAL CHARACTERISTICS (All Types) at 25°C Case Temp.

Characteristic	Symbol	Value	Unit
Maximum Forward Voltage at 40 Amp D-C Forward Current	V_F	1.5	Volts
Maximum Reverse Current at Rated D-C Reverse Voltage	I_R	1.0	mAdc
Typical Thermal Resistance, Junction To Case	θ_{JC}	1.7	C/W

1N3213, 1N3214

For Specifications, See **1N248B** Data.

1N3282 thru 1N3286

V_R — to 3000 V
I_O = 100 mA



CASE 51
(DO-7)

Low-current silicon rectifiers for applications requiring extremely high reverse-voltage capability. Hermetically sealed, subminiature glass package, offering excellent stability and reliability under environmental extremes.

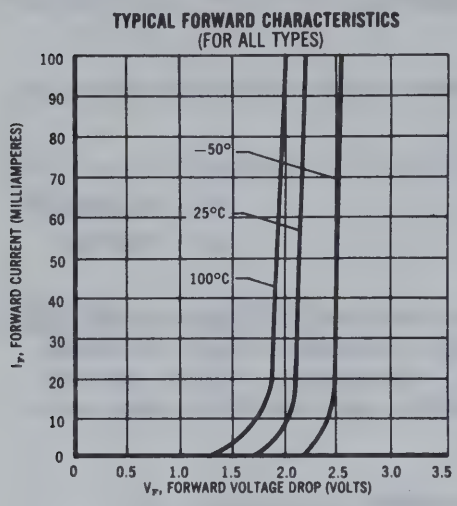
MAXIMUM RATINGS (At 60 cps Sinusoidal Input, Resistive or Inductive Load)

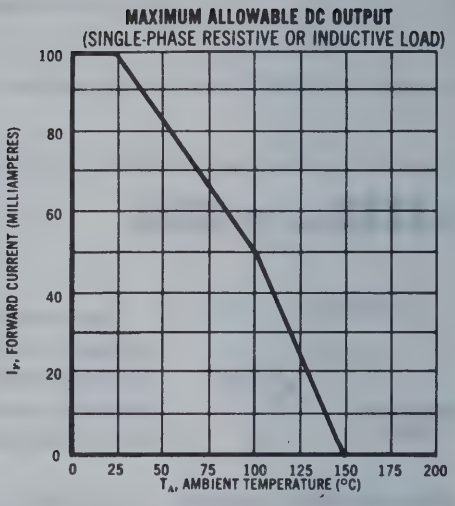
Rating	Symbol	1N3282	1N3283	1N3284	1N3285	1N3286	Unit
Peak Repetitive Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ V_R	1000	1500	2000	2500	3000	Volts
RMS Reverse Voltage	V_r	700	1050	1400	1750	2100	Volts
Average Half-Wave Rectified Forward Current (25°C Ambient) (100°C Ambient)	I_O	 100 50	 100 50	 100 50	 100 50	 100 50	 mA mA
Peak Surge Current (1/2-cycle, 60 Hz)	$I_{FM(surge)}$	2.5	2.5	2.5	2.5	2.5	Amp
Peak Repetitive Forward Current	$I_{FM(rep)}$	0.50	0.50	0.50	0.50	0.50	Amp
Operating and Storage Temperature Range	T_J, T_{stg}	-65 to + 150					°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Maximum Forward Voltage Drop @ 100 mA, Continuous DC (25°C)	V_F	2.5	Volts
Maximum Full-Cycle Average Forward Voltage Drop @ Rated Current (100°C)	$V_{F(AV)}$	1.2	Volts
Maximum Reverse Current @ Rated DC Voltage (25°C) (100°C)	I_R	 1.0 10.0	 μA
Maximum Full-Cycle Average Reverse Current @ Max Rated PIV and Current (as Half-Wave Rectifier, Resistive Load, 100°C)	$I_{R(AV)}$	10.0	μA
Typical Thermal Resistance, Junction to Ambient	θ_{JA}	400	°C/W

1N3282 thru 1N3286 (continued)





1N3305 thru 1N3350

For Specifications, see 1N2804 Data.

1N3491 thru 1N3495 (SILICON)
(MR322 thru MR328) MR330, MR331

V_R — to 1000 V
I_O = 25 A



CASE 43
(DO-21)

Medium-current silicon rectifiers – compact, highly efficient silicon rectifiers for medium-current applications.

MAXIMUM RATINGS

Rating	Symbol	1N3491 MR322	1N3492 MR323	1N3493 MR324	1N3494 MR325	1N3495 MR326	MR327	MR328	MR330	MR331	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	500	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	300	400	500	600	720	1000	1200	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	350	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) T_C = 130°C	I_O	25									Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 5)	$I_{FM(surge)}$	300 (for 1/2 cycle)									Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	375									$A_{(rms)}^2$ sec
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175									°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.2	°C/Watt

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

FINISH: All external surfaces corrosion-resistant and the terminal lead is readily solderable.

POLARITY: CATHODE TO CASE (reverse polarity units are available upon request and are designated by an "R" suffix i.e. MR327R or 1N3491R).

MOUNTING POSITIONS: Any.

ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$V_{F(AV)}$	0.6	Volts
Instantaneous Forward Voltage Drop (i_F = 100 Amps, T_J = 25°C)	V_F	1.5	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$I_{R(AV)}$		mA
1N3491/MR322		10	
1N3492/MR323		10	
1N3493/MR324		8	
1N3494/MR325		6	
1N3495/MR326		4	
MR327		3	
MR328		2.5	
MR330		2	
MR331		1.5	
DC Reverse Current (Rated V_R, T_C = 25°C)	I_R	1.0	mA

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

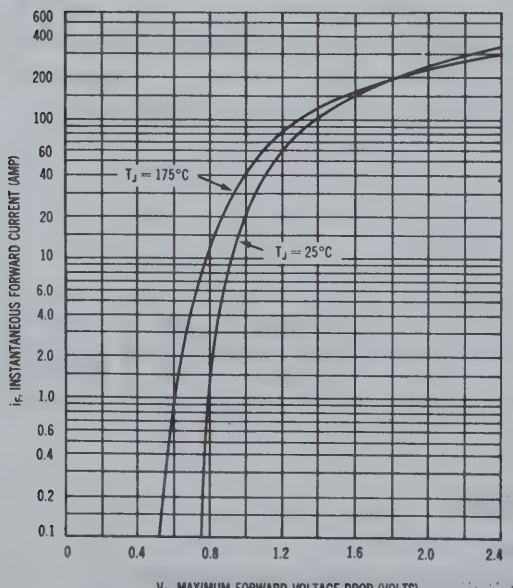


FIGURE 2 — MAXIMUM FORWARD POWER DISSIPATION

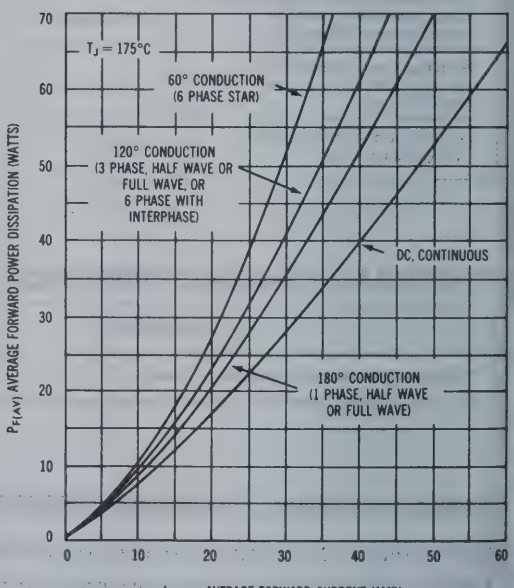


FIGURE 3 — MAXIMUM CURRENT RATINGS

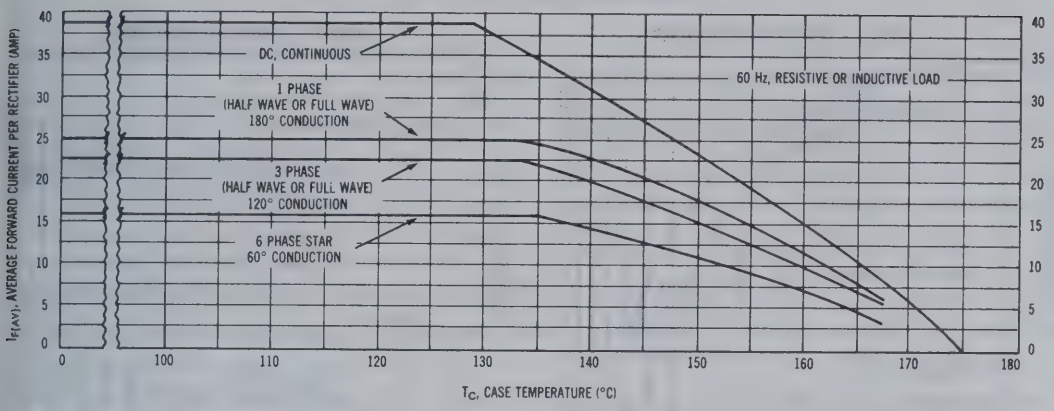


FIGURE 4 — MAXIMUM EFFECTIVE TRANSIENT THERMAL IMPEDANCE

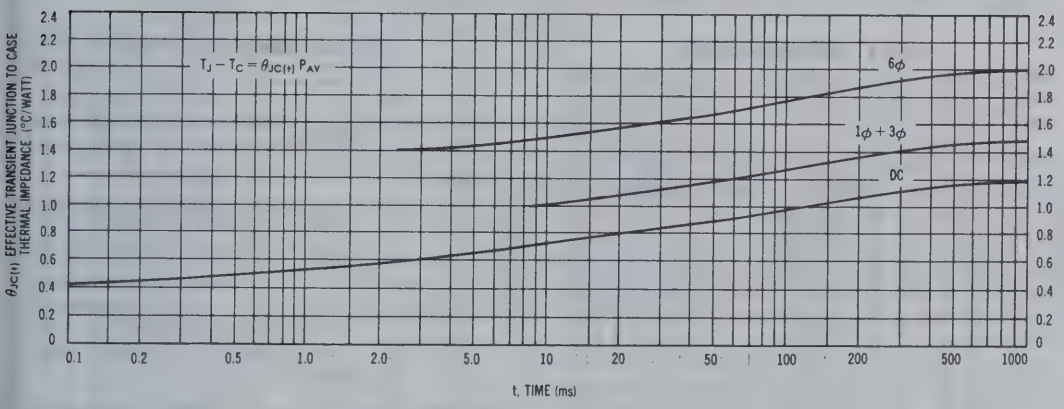
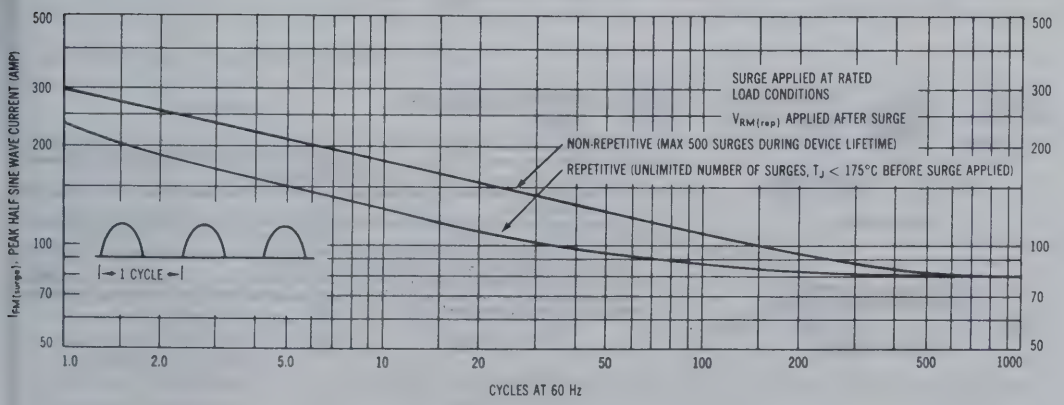


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 — RECTIFICATION EFFICIENCY

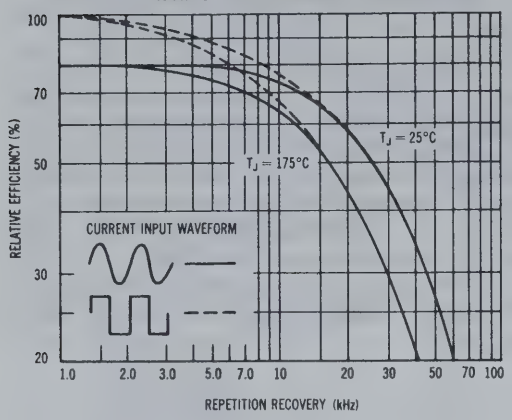


FIGURE 7 — REVERSE RECOVERY TIME

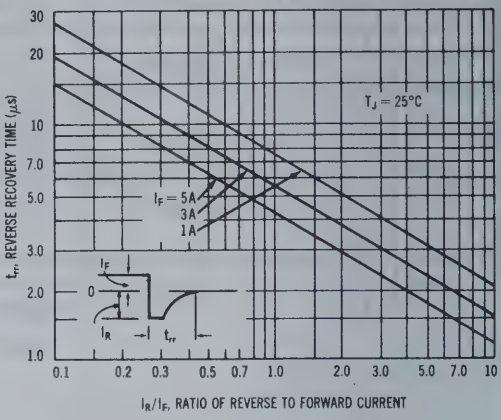


FIGURE 8 — JUNCTION CAPACITANCE

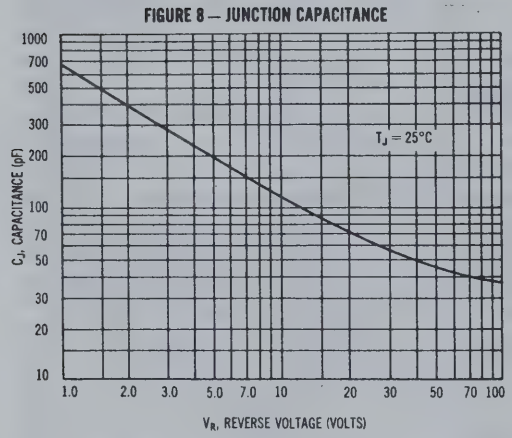
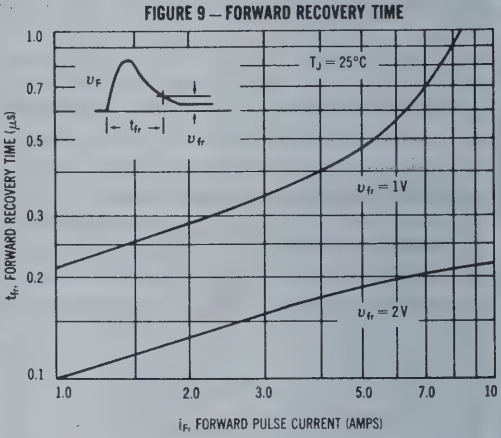
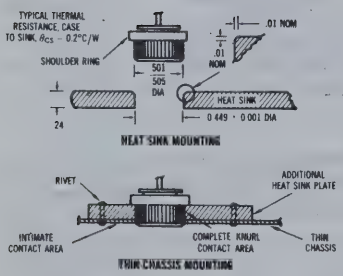


FIGURE 9 — FORWARD RECOVERY TIME





MOUNTING PROCEDURES

MR322-MR331 and 1N3491-1N3495 rectifiers are designed to be press-fitted in a heat sink in order to attain full device ratings. Recommended procedures for this type of mounting are as follows:

1. Drill a hole in the heat sink 0.499 ± .001 inch in diameter.
2. Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.
3. The depth and width of the break should be 0.010 inch maximum to retain maximum heat sink surface contact.
4. To prevent damage to the rectifier during press-in, the pressing force should be applied only on the shoulder ring of the rectifier case as shown in the figure.
5. The pressing force should be applied evenly about the shoulder ring to avoid tilting or canting of the rectifier case in the hole during the press-in operation. Also, the use of a light industrial lubricant will be of considerable aid.

1N3580, A, B thru 1N3583, A, B

For Specifications, See 1N2163 Data.

1N3649, 1N3650

Obsolete, discontinued types, replace with devices from the MR1120 series.

1N3659 thru 1N3663

V_R — 400 V
I_O = 30 A



CASE 43
(DO-21)

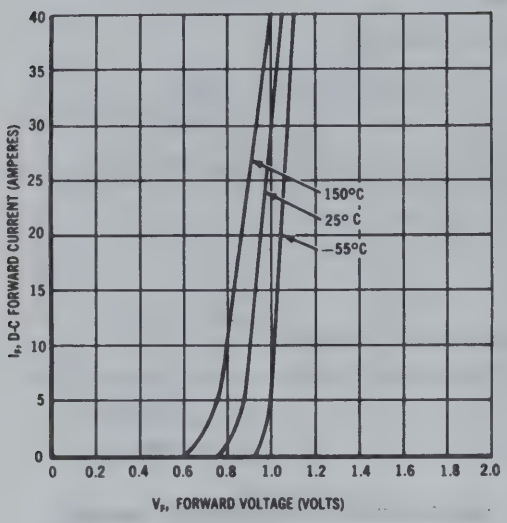
Low-cost silicon rectifiers in hermetically sealed, press-fit case, designed for operation under severe environmental conditions. Cathode connected to case, but available with reverse polarity by adding suffix "R" to type number.

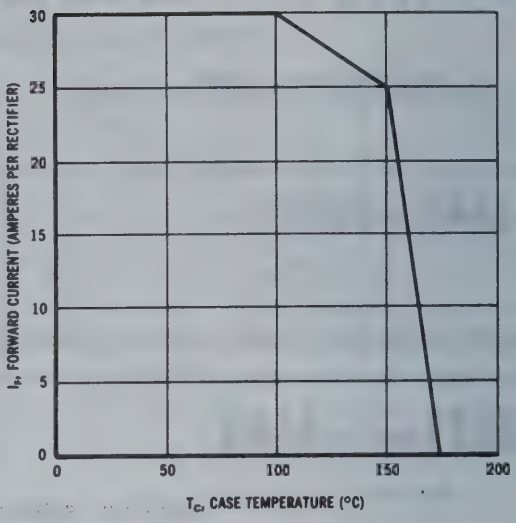
MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	1N3659 1N3659R	1N3660 1N3660R	1N3661 1N3661R	1N3662 1N3662R	1N3663 1N3663R	Units
Peak Repetitive Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ V_R	50	100	200	300	400	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	Volts
Average Half-Wave Rectified Forward Current with Resistive Load @ 100°C case @ 150°C case	I_O			30 25			 Amp Amp
Peak One Cycle Surge Current (150°C case temp, 60 Hz)	$I_{FM(surge)}$			400			Amp
Operating Junction Temperature	T_J			−65 to +175			°C
Storage Temperature	T_{stg}			−65 to +200			°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	1N3659 1N3659R	1N3660 1N3660R	1N3661 1N3661R	1N3662 1N3662R	1N3663 1N3663R	Unit
Maximum Forward Voltage at 25 Amp DC Forward Current	V_F	1.2	1.2	1.2	1.2	1.2	Volts
Maximum Full Cycle Average Forward Voltage Drop @ Rated PIV and Current	$V_{F(AV)}$	0.7	0.7	0.7	0.7	0.7	Volts
Maximum Full Cycle Average Reverse Current @ Rated PIV and Current (as half-wave rectifier, resistive load, 150°C)	$I_{R(AV)}$	5.0	4.5	4.0	3.5	3.0	mA
Thermal Resistance	θ_{JC}			1.0			°C/W



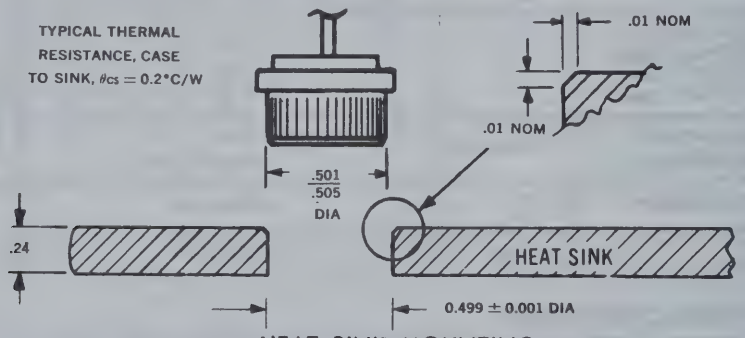


1N3659-1N3663 rectifiers are designed for press-fitted mounting in a heat sink. Recommended procedures for this type of mounting are as follows:

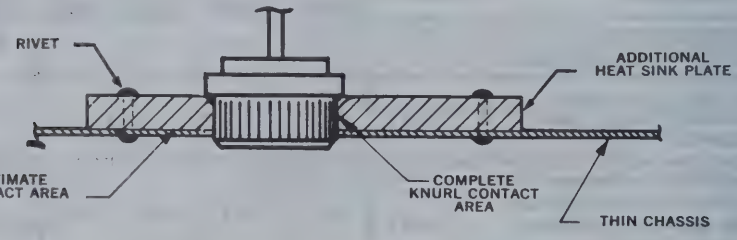
1. Drill a hole in the heat sink 0.499 ± .001 inch in diameter.
2. Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.
3. The depth of the break should be 0.010 inch maximum to retain maximum heat sink surface contact with the knurled rectifier surface.
4. Width of the break should be 0.010 inch as shown.

These procedures will allow proper entry of the rectifier knurled surface, provide good rectifier- heat sink surface contact, and assure reliable rectifier operation. If the break is made too deep, thereby reducing contact area for heat transfer, reliability of operation will be impaired.

These devices can be mounted in a thin chassis by inserting the rectifier through an additional heat sink plate which is mounted in intimate contact with the upper side of the chassis. This provides additional contact area for the rectifier knurled edge, as well as additional heat sink capacity.



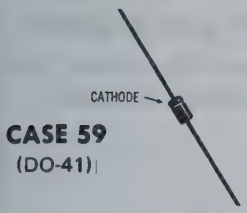
HEAT SINK MOUNTING



THIN-CHASSIS MOUNTING

1N3675 thru 1N3703

¾ W
6.8 — 100 V



CASE 59
(DO-41)

Oxide passivated silicon zener diodes in void-free, transfer-molded, thermosetting plastic case. Offer 3/4-watt performance in a package no larger in volume than a conventional 400 mW glass package.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D C Power Dissipation: 750 Milliwatts at 50°C Ambient.
(Derate 6 mW/°C)
Lead Temperature, 1/16 ± 1/32 inch from case: +235°C for 12 seconds.
(Method 2031, MIL-STD-750).

The type numbers shown have a standard tolerance of ±20% on the nominal zener voltage. Add suffix "A" for ±10% units or "B" for ±5% units.

ELECTRICAL CHARACTERISTICS 25°C Ambient

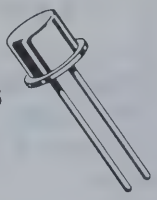
$V_F = 1.5$ V @ $I_F = 200$ mA for all units)

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance Z_{ZT} @ I_{ZT} Ohms	Max Zener Impedance Z_{ZK} @ I_{ZK} Ohms	Max DC Zener Current I_{ZM} mA	$I_R = 5\ \mu A$ Max @ Reverse Voltage
1N3675	6.8	18.5	4.5	700	100	5.2
1N3676	7.5	16.5	5.5	700	90	5.7
1N3677	8.2	15.0	6.5	700	80	6.2
1N3678	9.1	14.0	7.5	700	70	6.9
1N3679	10	12.5	8.5	700	65	7.6
1N3680	11	11.5	9.5	700	55	8.4
1N3681	12	10.5	11.5	700	53	9.1
1N3682	13	9.5	13.0	700	50	9.9
	14	9.0	14.5	700	45	10.6
1N3683	15	8.5	16.0	700	42	11.4
1N3684	16	7.8	17.0	700	40	12.2
	17	7.2	19.0	700	38	13.0
1N3685	18	7.0	21.0	750	35	13.7
	19	6.5	23.0	750	33	14.4
1N3686	20	6.2	25.0	750	32	15.2
1N3687	22	5.6	29.0	750	29	16.7
1N3688	24	5.2	33.0	750	26	18.2
	25	5.0	36.0	750	24	19.0
1N3689	27	4.6	41.0	750	23	20.6
1N3690	30	4.2	49.0	1000	21	22.8
1N3691	33	3.8	58.0	1000	20	25.1
1N3692	36	3.4	70.0	1000	18	27.4
1N3693	39	3.2	80.0	1000	15	29.7
1N3694	43	3.0	93.0	1500	14	32.7
	45	2.8	99.0	1500	13.5	34.2
1N3695	47	2.7	105.0	1500	13	35.8
1N3696	51	2.5	125.0	1500	12.2	38.8
1N3697	56	2.2	150.0	2000	11	42.6
1N3698	62	2.0	185.0	2000	10	47.1
1N3699	68	1.8	230.0	2000	9.0	51.7
1N3700	75	1.7	270.0	2000	8.5	56.0
1N3701	82	1.5	330.0	3000	7.5	62.2
1N3702	91	1.4	400.0	3000	7.0	69.2
1N3703	100	1.3	500.0	3000	6.0	76.0

1N3785 thru 1N3820

1.5 W
6.8 — 200 V

CASE 55



Low silhouette single-ended package for printed circuit or socket mounting. Cathode connected to case.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D C Power Dissipation: 1.5 Watts at 25°C Ambient. (Derate 10 mW/°C).

The type numbers shown have a standard tolerance of ±20% on the zener voltage. Standard tolerances of ±10% and ±5% on individual units are also available and are indicated by suffixing "A" for ±10% and "B" for ±5% units to the standard type number.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

V_F = 1.5 V max @ 300 mA

Type No.	Nominal Zener Voltage @ I_{ZT} (V_Z) Volts	Test Current (I_{ZT}) mA	Max Zener Impedance			Max DC Zener Current (I_{ZM}) mA	Reverse Leakage Current*			Typical Zener Voltage Temp. Coeff. %/°C
			Z_{ZT} @ I_{ZT} ohms	Z_{ZK} @ I_{ZK} ohms	I_{ZK} mA		I_R Max (μA)	V_{R1}	V_{R2}	
1N3785	6.8	55	2.7	700	1.0	195	150	5.2	4.9	.040
1N3786	7.5	50	3.0	700	0.5	175	75	5.7	5.4	.045
1N3787	8.2	46	3.5	700	0.5	155	50	6.2	5.9	.048
1N3788	9.1	41	4.0	700	0.5	140	25	6.9	6.6	.051
1N3789	10	37	5	700	0.25	125	10	7.6	7.2	.055
1N3790	11	34	6	700	0.25	115	5	8.4	8.0	.060
1N3791	12	31	7	700	0.25	105	5	9.1	8.6	.065
1N3792	13	29	8	700	0.25	98	5	9.9	9.4	.065
1N3793	15	25	10	700	0.25	85	5	11.4	10.8	.070
1N3794	16	23	11	700	0.25	80	5	12.2	11.5	.070
1N3795	18	21	13	750	0.25	70	5	13.7	13.0	.075
1N3796	20	19	15	750	0.25	62	5	15.2	14.4	.075
1N3797	22	17	16	750	0.25	56	5	16.7	15.8	.080
1N3798	24	16	17	750	0.25	51	5	18.2	17.3	.080
1N3799	27	14	20	750	0.25	46	5	20.6	19.4	.085
1N3800	30	12	25	1,000	0.25	41	5	22.8	21.6	.085
1N3801	33	11	30	1,000	0.25	38	5	25.1	23.8	.085
1N3802	36	10	35	1,000	0.25	35	5	27.4	25.9	.085
1N3803	39	10	40	1,000	0.25	31	5	29.7	28.1	.090
1N3804	43	9.0	45	1,500	0.25	28	5	32.7	31.0	.090
1N3805	47	8.0	55	1,500	0.25	26	5	35.8	33.8	.090
1N3806	51	7.4	65	2,000	0.25	24	5	38.8	36.6	.090
1N3807	56	6.7	75	2,000	0.25	22	5	42.6	40.3	.090
1N3808	62	6.0	85	2,000	0.25	20	5	47.1	44.6	.090
1N3809	68	5.5	95	2,000	0.25	18	5	51.7	49.0	.090
1N3810	75	5.0	110	2,000	0.25	16	5	56.0	54.0	.090
1N3811	82	4.5	130	3,000	0.25	14	5	62.0	59.0	.090
1N3812	91	4.1	150	3,000	0.25	13	5	69.2	65.5	.090
1N3813	100	3.7	200	3,000	0.25	12.0	5	76.0	72.0	.090
1N3814	110	3.4	300	4,000	0.25	11.0	5	83.6	79.2	.095
1N3815	120	3.1	350	4,500	0.25	10.5	5	91.2	86.4	.095
1N3816	130	2.9	400	5,000	0.25	9.0	5	98.8	93.6	.095
1N3817	150	2.5	700	6,000	0.25	8.0	5	114.0	108.0	.095
1N3818	160	2.3	750	6,500	0.25	8.0	5	121.8	115.0	.095
1N3819	180	2.1	800	7,000	0.25	7.0	5	137.0	130.0	.095
1N3820	200	1.9	1,000	8,000	0.25	6.0	5	152.0	144.0	.100

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

1 — Nominal zener voltages between those shown.
2 — Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.
  a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
  b. Two or more units matched to one another with any specified tolerance.
3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

*V_{R1} — Test Voltage for 5% Tolerance Device. V_{R2} — Test Voltage for 10% Tolerance Device. No Leakage Specified as 20% Tolerance Device.

1N3821 thru 1N3830

1 W
3.3 – 7.5 V

1N3821A thru 1N3830A



CASE 52
(DO-13)

Low-voltage, alloy-junction zener diodes in hermetically sealed package with cathode connected-to-case. Available as standard industrial types as well as for military and high-reliability applications.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D C Power Dissipation: 1 Watt. (Derate 6.67 mW/°C above 25°C).

The type numbers shown have a standard tolerance on the nominal zener voltage of ±10%. A standard tolerance of ±5% on individual units is also available and is indicated by suffixing "A" to the standard type number.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$; $V_F = 1.5$ V @ $I_F = 200$ mA for all units)

JEDEC Type No. (Note 1)	Motorola Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mA	Max Zener Impedance (Note 3) Z_{ZT} @ I_{ZT} Ohms	Max Zener Impedance (Note 3) Z_{ZK} @ $I_{ZK} = 1.0$ mA Ohms	Max DC Zener Current I_{ZM} mA (Note 4)	I_R µA Max	@ V_R Volts
1N3821	1M3.3AZ10	3.3	76	10	400	276	100	1
1N3822	1M3.6AZ10	3.6	69	10	400	252	100	1
1N3823	1M3.9AZ10	3.9	64	9	400	238	50	1
1N3824	1M4.3AZ10	4.3	58	9	400	213	10	1
1N3825	1M4.7AZ10	4.7	53	8	500	194	10	1
1N3826	1M5.1AZ10	5.1	49	7	550	178	10	1
1N3827	1M5.6AZ10	5.6	45	5	600	162	10	2
1N3828	1M6.2AZ10	6.2	41	2	700	146	10	3
1N3829	1M6.8AZ10	6.8	37	1.5	500	133	10	3
1N3830	1M7.5AZ10	7.5	34	1.5	250	121	10	3

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)
1 – Nominal zener voltages between those shown.
2 – Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.
a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
b. Two or more units matched to one another with any specified tolerance.
3 – Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

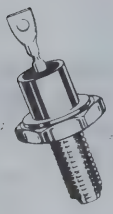
1N3879 thru 1N3883, 1N3889 thru 1N3893 (SILICON)
1N3899 thru 1N3903, 1N3909 thru 1N3913

For Specifications, See 1N4933 Data.

1N3993 thru 1N4000

10 W
3.9 – 7.5 V

CASE 56
(DO-4)



Low-voltage, alloy-junction zener diodes in hermetically sealed package with cathode connected to case. Supplied with mounting hardware.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D C Power Dissipation: 10 Watts. (Derate 83.3 mW/°C above 55°C).

The type numbers shown in the table have a standard tolerance on the nominal zener voltage of ±10%. A standard tolerance of ±5% on individual units is also available and is indicated by suffixing "A" to the standard type number.

ELECTRICAL CHARACTERISTICS

(T_B = 30°C ± 3, V_F = 1.5 max @ I_F = 2 amp for all units)

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance		Max DC Zener Current I_{ZM} mA	Reverse Leakage Current	
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} = 1.0 mA Ohms		I_R μA	V_R Volts
1N3993	3.9	640	2	400	2380	100	0.5
1N3994	4.3	580	1.5	400	2130	100	0.5
1N3995	4.7	530	1.2	500	1940	50	1
1N3996	5.1	490	1.1	550	1780	10	1
1N3997	5.6	445	1.0	600	1620	10	1
1N3998	6.2	405	1.1	750	1460	10	2
1N3999	6.8	370	1.2	500	1330	10	2
1N4000	7.5	335	1.3	250	1210	10	3

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)
1 – Nominal zener voltages between those shown.
2 – Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.
a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
b. Two or more units matched to one another with any specified tolerance.
3 – Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

1N4001 thru 1N4007

V_R = 50-1000 V
I_O = 1.0 A



CASE 59
(DO-41)

Surmetic rectifiers, subminiature size, axial lead mounted rectifiers for general purpose low-power applications.

MAXIMUM RATINGS

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz peak)	$V_{RM(non-rep)}$	75	150	300	600	900	1200	1500	Volts
RMS Reverse Voltage	V_r	35	70	140	280	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 6, T_A = 75°C)	I_O	1.0							Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 2)	$I_{FM(surge)}$	30 (for 1 cycle)							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175							°C

ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage Drop (i_F = 1.0 Amp, T_J = 25°C) Figure 1	V_F	1.1	Volts
Maximum Full-Cycle Average Forward Voltage Drop (I_O = 1.0 Amp, T_L = 75°C, 1 inch leads)	$V_{F(AV)}$	0.8	Volts
Maximum Reverse Current (rated dc voltage) T_J = 25°C T_J = 100°C	I_R	0.01 0.05	mA
Maximum Full-Cycle Average Reverse Current (I_O = 1.0 Amp, T_L = 75°C, 1 inch leads)	$I_{R(AV)}$	0.03	mA

MECHANICAL CHARACTERISTICS

CASE: Void free, Transfer Molded
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C, ⅜" from case for 10 seconds at 5 lbs. tension
FINISH: All external surfaces are corrosion-resistant, leads are readily solderable
POLARITY: Cathode indicated by color band
WEIGHT: 0.40 Grams (approximately)

FIGURE 1 — FORWARD VOLTAGE

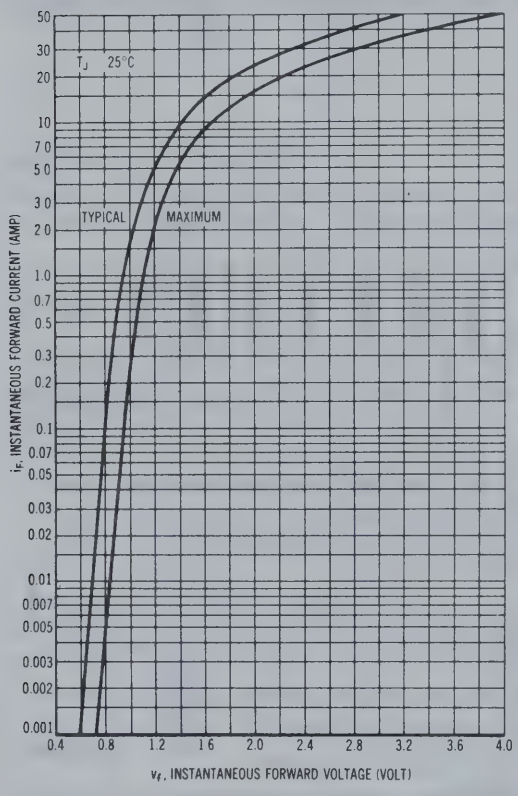


FIGURE 2 — MAXIMUM SURGE CAPABILITY

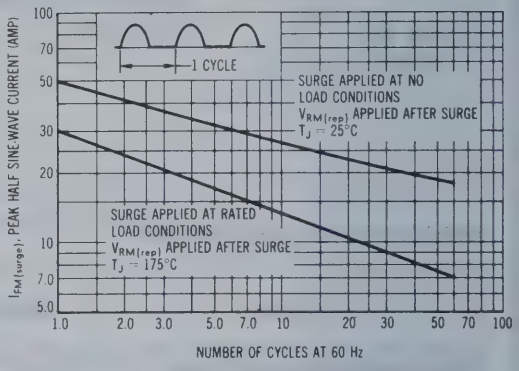


FIGURE 3 — FORWARD VOLTAGE TEMPERATURE COEFFICIENT

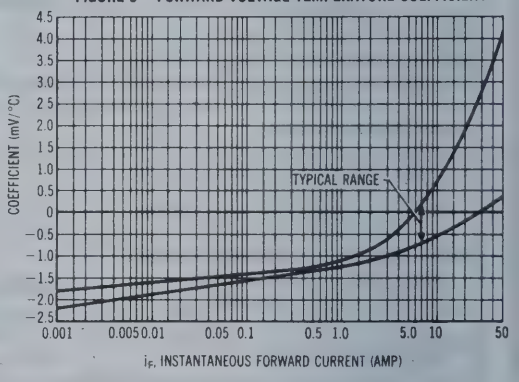
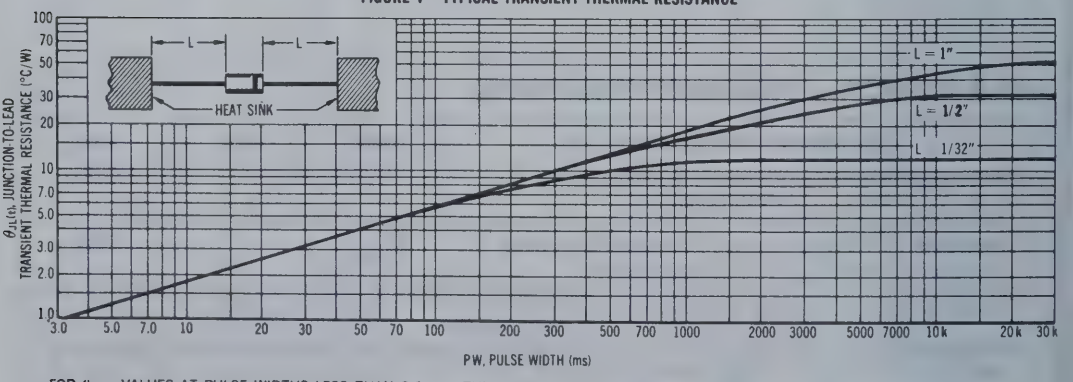


FIGURE 4 — TYPICAL TRANSIENT THERMAL RESISTANCE



FOR $\theta_{JL(t)}$ VALUES AT PULSE WIDTHS LESS THAN 3.0 ms, THE ABOVE CURVE CAN BE EXTRAPOLATED DOWN TO 10 μs AT A CONTINUING SLOPE OF 1/2

CURRENT DERATING DATA

FIGURE 5 — LEAD TEMPERATURE DERATING (DC ONLY)

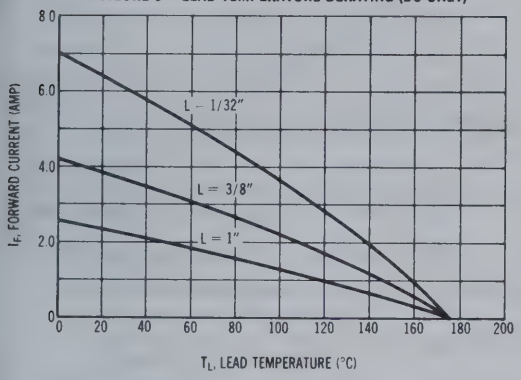


FIGURE 6 — RESISTIVE, INDUCTIVE LOADS

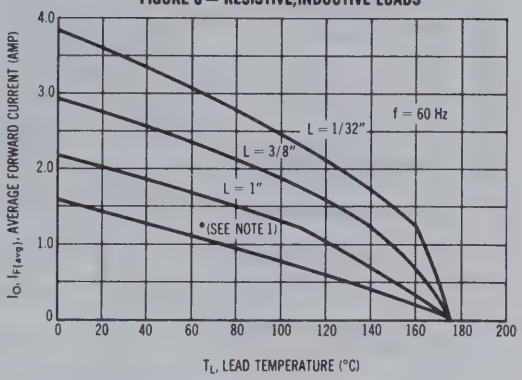


FIGURE 7 — CAPACITIVE LOADS

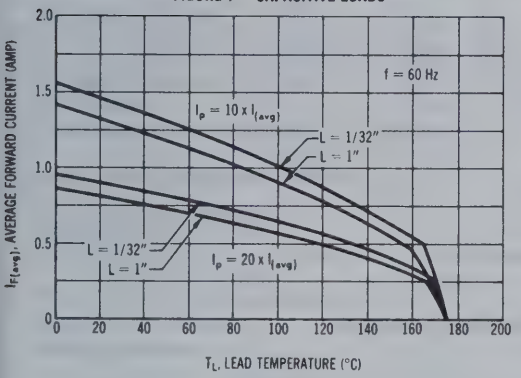
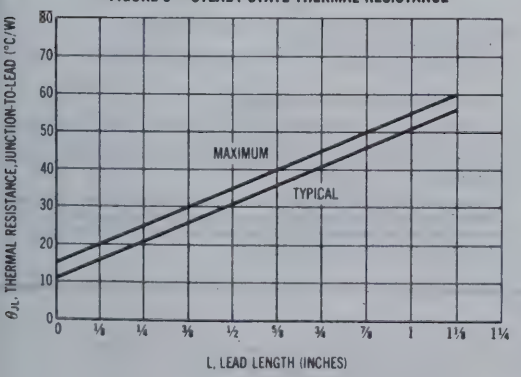


FIGURE 8 — STEADY-STATE THERMAL RESISTANCE

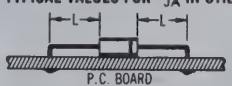


NOTES

NOTE 1

Data shown for thermal resistance junction-to-ambient (θ_{JA}) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

TYPICAL VALUES FOR θ_{JA} IN STILL AIR



MOUNTING METHOD 1

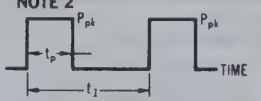


MOUNTING METHOD 2

MOUNTING METHOD	LEAD LENGTH, L (IN.)			θ_{JA}
	1/32	3/8	1	
1	—	75	85	°C/W
2	55	72	85	°C/W

***Using Mounting Method 1 or 2 with L = 1" the curve marked * in Figure 6 can be used for 60 Hz half-wave resistive/inductive load (Rating vs. Ambient Temperature). The abscissa of Figure 6 then indicates T_A in °C.**

NOTE 2



DUTY CYCLE, $D = t_p/t_1$

PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the lead should be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L, the junction temperature may be determined by:

$$T_J = T_L + \Delta T_{JL},$$

where ΔT_{JL} is the increase in junction temperature above the lead temperature. It may be determined by:

$$\Delta T_{JL} = P_{pk}\left[\theta_{JL(\infty)} \cdot D + (1 - D) \cdot \theta_{JL(t_1 + t_p)} + \theta_{JL(t_p)} - \theta_{JL(t_1)}\right]$$

where $\theta_{JL(t)}$ = value of transient thermal resistance at time t, i.e.:

$\theta_{JL(t_1+t_p)}$ = value of $\theta_{JL(t)}$ at time t_1+t_p

$\theta_{JL(t_p)}$ = value of $\theta_{JL(t)}$ at end of pulse width t_p

$\theta_{JL(t_1)}$ = value of $\theta_{JL(t)}$ at time t_1

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 9 — FORWARD RECOVERY TIME

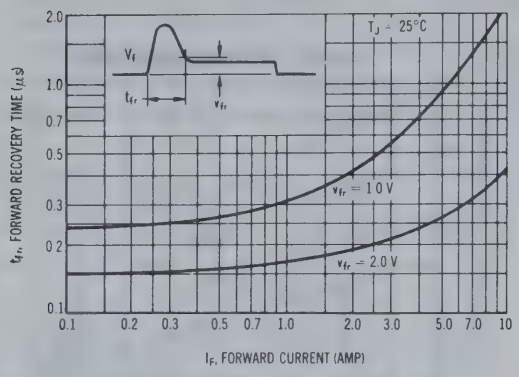


FIGURE 10 — REVERSE RECOVERY TIME

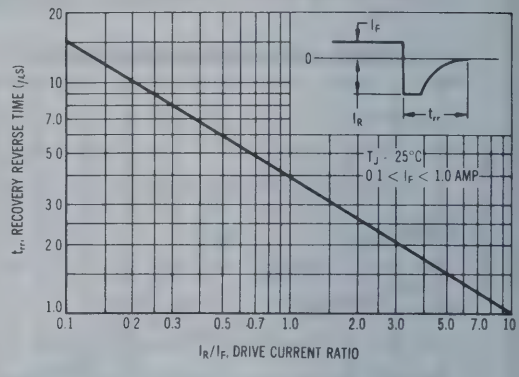


FIGURE 11 — RECTIFICATION WAVEFORM EFFICIENCY

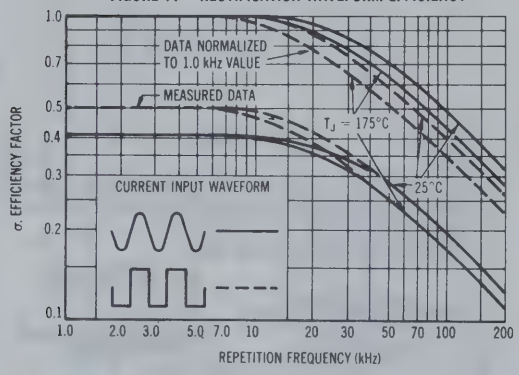
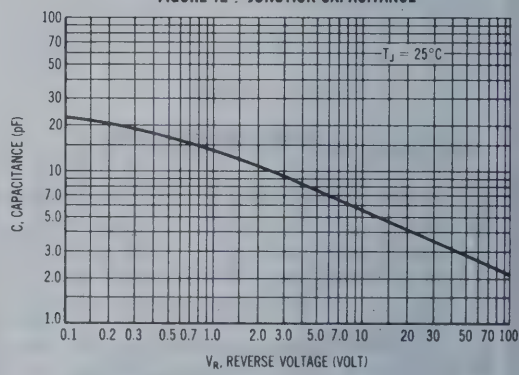
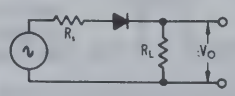


FIGURE 12 — JUNCTION CAPACITANCE



RECTIFIER EFFICIENCY NOTE

FIGURE 13 — SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 11 was calculated using the formula:

$$\sigma = \frac{P_{dc}}{P_{rms}} = \frac{\frac{V^2_{O(dc)}}{R_L}}{\frac{V^2_{O(rms)}}{R_L}} \cdot 100\% = \frac{V^2_{O(dc)}}{V^2_{O(ac)} + V^2_{O(dc)}} \cdot 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma(\text{sine}) = \frac{\frac{V^2_m}{\pi^2 R_L}}{\frac{V^2_m}{4R_L}} \cdot 100\% = \frac{4}{\pi^2} \cdot 100\% \doteq 40.6\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma(\text{square}) = \frac{\frac{V^2_m}{2R_L}}{\frac{V^2_m}{R_L}} \cdot 100\% = 50\% \quad (3)$$

(A full wave circuit has twice these efficiencies)

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 10) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current, thereby reducing the value of the efficiency factor σ, as shown on Figure 11.

It should be emphasized that **Figure 11 shows waveform efficiency only; it does not provide a measure of diode losses.** Data was obtained by measuring the ac component of V_O with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 11.

1N4057,A thru 1N4085, A

For Specifications, See 1N429 Data.

1N4099 thru 1N4135
(MZ4614 thru MZ4627)

LOW-LEVEL SILICON PASSIVATED ZENER DIODES

. . . designed for 250 mW applications requiring low leakage, low impedance, and low noise.

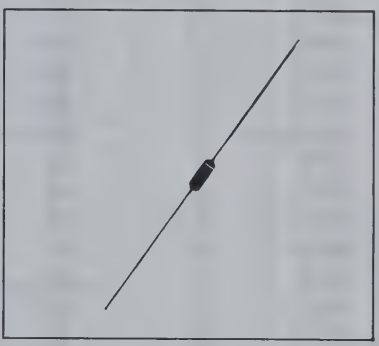
- Voltage Range from 1.8 to 100 Volts
- First Zener Diode Series to Specify Noise—50% Lower than Conventional Diffused Zeners
- Zener Impedance and Zener Voltage Specified for Low-Level Operation at I_{ZT} = 250 μA
- Low Leakage Current — I_R from 0.01 to 10 μA over Voltage Range
- Expanded Temperature Range — T_J = −65 to +200°C

SILICON ZENER DIODES

(±5.0% TOLERANCE)

250 MILLIWATTS
1.8–100 VOLTS

SILICON OXIDE PASSIVATED JUNCTION



MAXIMUM RATINGS

Rating	Value	Unit
DC Power Dissipation, 25°C Ambient	250	mW
Derating Factor	1.43	mW/°C
Junction and Storage Temperature	−65 to +200	°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass.

DIMENSIONS: See outline drawing.

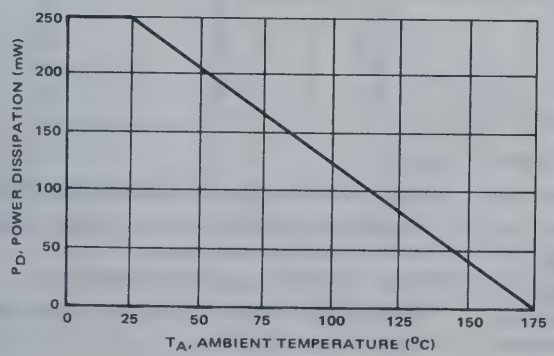
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

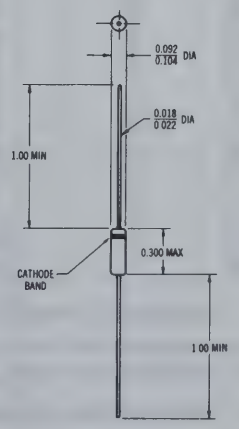
POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 gram (approx)

MOUNTING POSITION: Any

POWER TEMPERATURE DERATING CURVE





CASE 51
(DO-7)

ELECTRICAL CHARACTERISTICS

(At 25°C Ambient temperature unless otherwise specified) I_{ZT} = 250 μA and V_F = 1.0 V max @ I_F = 200 mA on all Types

Type Number (Note 1)	Nominal Zener Voltage V_Z (Note 1) (Volts)	Max Zener Impedance Z_{ZT} (Note 2) (Ohms)	Max Reverse Current I_R (μA)	@ (Note 4)	Test Voltage V_R (Volts)	Max Noise Density At I_{ZT} = 250 μA N_D (Fig 1) (micro-volts per Square Root Cycle)	Max Zener Current I_{ZM} (Note 3) (mA)
MZ4614	1.8	1200	7.5		1.0	1.0	120
MZ4615	2.0	1250	5.0		1.0	1.0	110
MZ4616	2.2	1300	4.0		1.0	1.0	100
MZ4617	2.4	1400	2.0		1.0	1.0	95
MZ4618	2.7	1500	1.0		1.0	1.0	90
MZ4619	3.0	1600	0.8		1.0	1.0	85
MZ4620	3.3	1650	7.5		1.5	1.0	80
MZ4621	3.6	1700	7.5		2.0	1.0	75
MZ4622	3.9	1650	5.0		2.0	1.0	70
MZ4623	4.3	1600	4.0		2.0	1.0	65
MZ4624	4.7	1550	10		3.0	1.0	60
MZ4625	5.1	1500	10		3.0	2.0	55
MZ4626	5.6	1400	10		4.0	4.0	50
MZ4627	6.2	1200	10		5.0	5.0	45
1N4099	6.8	200	10		5.2	40	35
1N4100	7.5	200	10		5.7	40	31.8
1N4101	8.2	200	1.0		6.3	40	29.0
1N4102	8.7	200	1.0		6.7	40	27.4
1N4103	9.1	200	1.0		7.0	40	26.2
1N4104	10	200	1.0		7.6	40	24.8
1N4105	11	200	0.05		8.5	40	21.6
1N4106	12	200	0.05		9.2	40	20.4
1N4107	13	200	0.05		9.9	40	19.0
1N4108	14	200	0.05		10.7	40	17.5
1N4109	15	100	0.05		11.4	40	16.3
1N4110	16	100	0.05		12.2	40	15.4
1N4111	17	100	0.05		13.0	40	14.5
1N4112	18	100	0.05		13.7	40	13.2
1N4113	19	150	0.05		14.5	40	12.5
1N4114	20	150	0.01		15.2	40	11.9
1N4115	22	150	0.01		16.8	40	10.8
1N4116	24	150	0.01		18.3	40	9.9
1N4117	25	150	0.01		19.0	40	9.5
1N4118	27	150	0.01		20.5	40	8.8
1N4119	28	200	0.01		21.3	40	8.5
1N4120	30	200	0.01		22.8	40	7.9
1N4121	33	200	0.01		25.1	40	7.2
1N4122	36	200	0.01		27.4	40	6.6
1N4123	39	200	0.01		29.7	40	6.1
1N4124	43	250	0.01		32.7	40	5.5
1N4125	47	250	0.01		35.8	40	5.1
1N4126	51	300	0.01		38.8	40	4.6
1N4127	56	300	0.01		42.6	40	4.2
1N4128	60	400	0.01		45.6	40	4.0
1N4129	62	500	0.01		47.1	40	3.8
1N4130	68	700	0.01		51.7	40	3.5
1N4131	75	700	0.01		57.0	40	3.1
1N4132	82	800	0.01		62.4	40	2.9
1N4133	87	1000	0.01		66.2	40	2.7
1N4134	91	1200	0.01		69.2	40	2.6
1N4135	100	1500	0.01		76.0	40	2.3

NOTE 1: TOLERANCE AND VOLTAGE DESIGNATION

The type numbers shown have a standard tolerance of ±5.0% on the nominal zener voltage.

NOTE 2: ZENER IMPEDANCE (Z_{ZT}) DERIVATION

The zener impedance is derived from the 60 cycle ac voltage, which results when an ac current having an rms value equal to 10% of the dc zener current (I_{ZT}) is superimposed on I_{ZT}.

NOTE 3: MAXIMUM ZENER CURRENT RATINGS (I_{ZM})

Maximum zener current ratings are based on maximum zener voltage of the individual units.

NOTE 4: REVERSE LEAKAGE CURRENT I_R

Reverse leakage currents are guaranteed and are measured at V_R as shown on the table.

ZENER NOISE DENSITY

A zener diode generates noise when it is biased in the zener direction. A small part of this noise is due to the internal resistance associated with the device. A larger part of zener noise is a result of the zener breakdown phenomenon and is called microplasma noise. This microplasma noise is generally considered "white" noise with equal amplitude for all frequencies from about zero cycles to approximately 200,000 cycles. To eliminate the higher frequency components of noise a small shunting capacitor can be used. The lower frequency noise generally must be tolerated since a capacitor required to eliminate the lower frequencies would degrade the regulation properties of the zener in many applications.

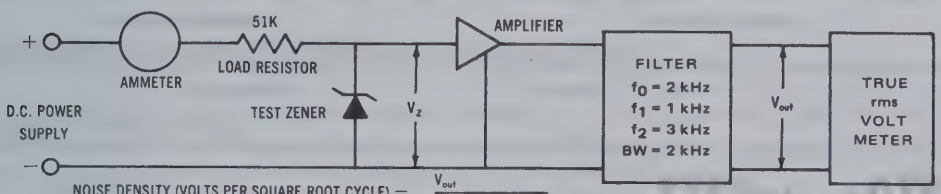
Motorola is rating this series with a maximum noise density at 250 microamperes. The rating of microvolts RMS per square root cycle enables calculation of the maximum RMS noise for any bandwidth.

Noise density decreases as zener current increases. This can be seen by the graph in Figure 2 where a typical noise density is plotted as a function of zener current.

The junction temperature will also change the zener noise levels. Thus the noise rating must indicate bandwidth, current level and temperature.

The block diagram given in Figure 1 shows the method used to measure noise density. The input voltage and load resistance is high so that the zener is driven from a constant current source. The amplifier must be low noise so that the amplifier noise is negligible compared to the test zener. The filter bandpass is known so that the noise density in volts RMS per square root cycle can be calculated.

FIGURE 1 – NOISE DENSITY MEASUREMENT METHOD



$$\text{NOISE DENSITY (VOLTS PER SQUARE ROOT CYCLE)} = \frac{V_{out}}{\text{OVERALL GAIN } \sqrt{BW}}$$

WHERE: BW = FILTER BANDWIDTH (CYCLES)

V_{out} = OUTPUT NOISE (VOLTS RMS)

FIGURE 2 – TYPICAL NOISE DENSITY versus ZENER CURRENT

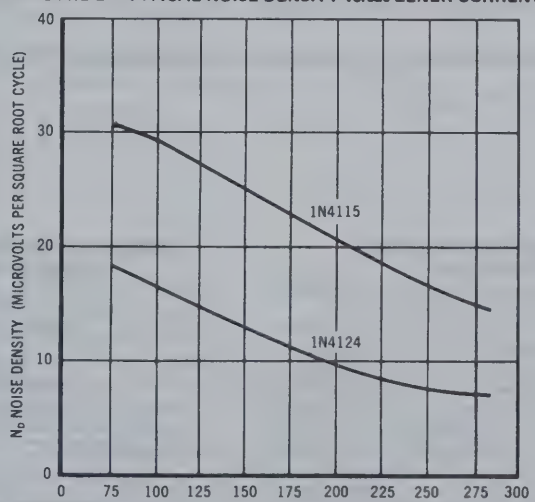


FIGURE 3 – TYPICAL CAPACITANCE

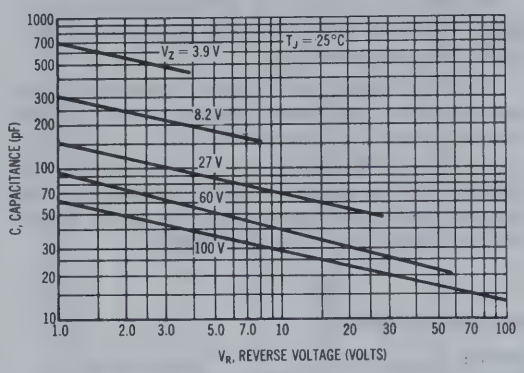
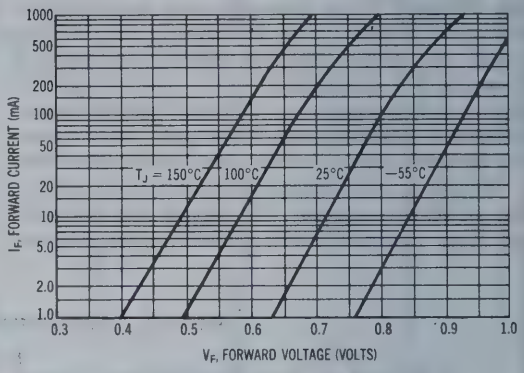


FIGURE 4 – TYPICAL FORWARD CHARACTERISTICS



1N4370 thru 1N4372
1N4370A thru 1N4372A

For Specifications, see 1N746 thru 1N759 Data.

1N4387
(MV1804)



CASE 44
(DO-4)

Silicon varactor diode for high-power frequency multiplication applications.

cathode connected to stud

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	150	Vdc
RF Power Input	P_{in}	40	Watts
Total Device Dissipation @ T_C = 75°C Derate above 75° C	P_D	20 200	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

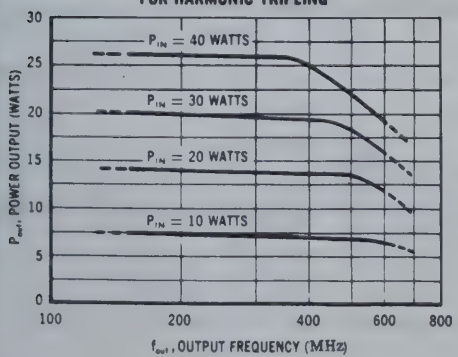
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	150	200	-	Vdc
Series Resistance (V_R = 6.0 Vdc, f = 50 MHz)	R_S	-	1.0	1.5	Ohms
Junction Capacitance (V_R = 6.0 Vdc, f = 1.0 MHz)	C_J	-	25	35	pF
Figure of Merit (V_R = 6.0 Vdc, f = 50 MHz)	Q	150	200	-	-

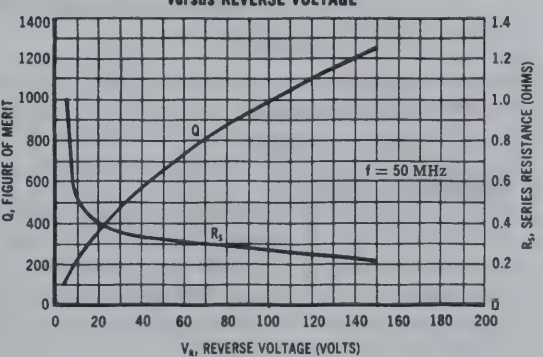
FUNCTIONAL TESTS

Power Output	Tripler Circuit P_{in} = 30 W, f_{in} = 150 MHz, f_{out} = 450 MHz	P_{out}	15	18	-	Watts
Efficiency		η	50	60	-	%

POWER OUTPUT versus OUTPUT FREQUENCY FOR HARMONIC TRIPLING



SERIES RESISTANCE AND FIGURE OF MERIT versus REVERSE VOLTAGE



1N4388
(MV1806)



Silicon varactor diode for high-frequency harmonic generation applications.

CASE 44
(DO-4)

cathode connected to stud

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Forward Current	I_F	1.0	Amp
RF Power Input	P_{in}	25	Watts
Total Device Dissipation @ $T_C = 75°C$ Derate above 75°C	P_D	10 0.10	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

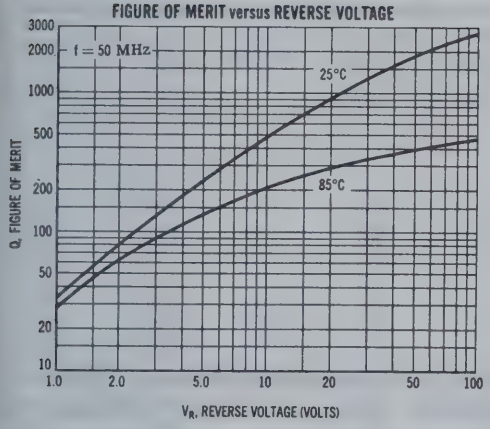
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

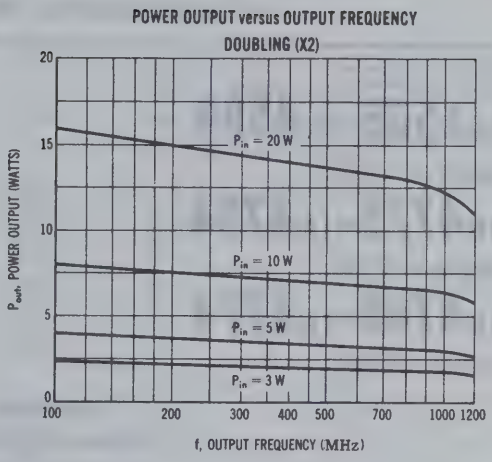
Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	100	150	-	Vdc
Reverse Current (V_R = 75 Vdc) (V_R = 75 Vdc, T_A = 150°C)	I_R	- -	0.5 -	2.0 100	μAdc
Diode Capacitance (V_R = 6.0 Vdc, f = 1.0 MHz) (V_R = 90 Vdc, f = 1.0 MHz)	C_T*	- -	10 5.0	20 10	pF
Series Resistance (V_R = 6.0 Vdc, f = 50 MHz)	R_S	-	1.2	2.0	Ohms
Figure of Merit (V_R = 6.0 Vdc, f = 50 MHz) (V_R = 90 Vdc, f = 50 MHz)	Q	200 1000	300 -	- -	-

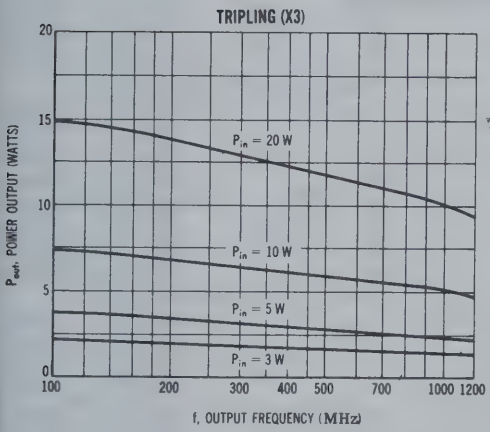
FUNCTIONAL TESTS

Power Output	Doubler Circuit (Figure 1) P_{in} = 20 W, f_{in} = 500 MHz, f_{out} = 1000 MHz	P_{out}	11.0	12.0	-	Watts
Efficiency		η	55	60	-	%

*$C_T = C_J + C_C$







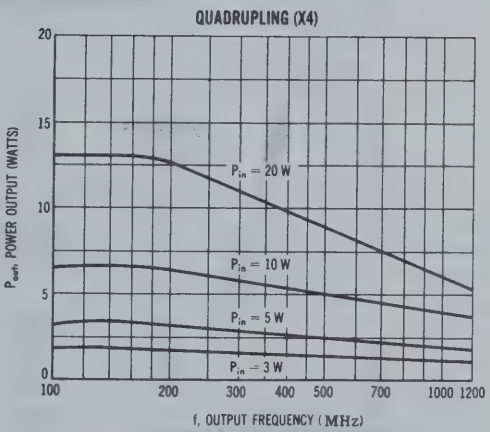
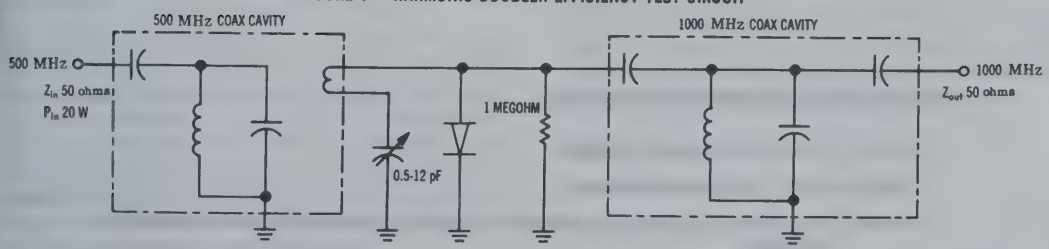


FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT



1N4549 thru 1N4556
1N4557 thru 1N4564

For Specifications, See 1N2804 Data

1N4565-1N4584
6.4 V ± 5.0%
1N4775-1N4784
8.5 V ± 5.0%
1N4765-1N4774
9.1 V ± 5.0%

Low level temperature-compensated zener reference diodes—highly reliable reference sources utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



CASE 51
(DO-7)

MAXIMUM RATINGS

Junction and Storage Temperature: −65°C to +175°C

DC Power Dissipation: 400 Milliwatts at 50°C Ambient
(Derate 3.2 mW/°C Above 50°C)

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

TYPE	△Vz @ Test Temperature (Note 1) Volts Max	°C	Temperature Coefficient for Reference %/°C (Note 1)	Dynamic Imped. Ohms Max (Note 2)
Vz = 6.4 Volts ±5% (IZT = 0.5 mA)				
1N4565	0.048		0.01	
1N4566	0.024		0.005	
1N4567	0.010	0, +25,	0.002	200
1N4568	0.005	+75	0.001	
1N4569	0.002		0.0005	
1N4565A	0.099		0.01	
1N4566A	0.050	−55, 0,	0.005	
1N4567A	0.020	+25, +75,	0.002	200
1N4568A	0.010	+100	0.001	
1N4569A	0.005		0.0005	
Vz = 6.4 Volts ±5% (IZT = 1.0 mA)				
1N4570	0.048		0.01	
1N4571	0.024		0.005	
1N4572	0.010	0, +25,	0.002	100
1N4573	0.005	+75	0.001	
1N4574	0.002		0.0005	
1N4570A	0.099		0.01	
1N4571A	0.050	−55, 0,	0.005	
1N4572A	0.020	+25, +75,	0.002	100
1N4573A	0.010	+100	0.001	
1N4574A	0.005		0.0005	
Vz = 6.4 Volts ±5% (IZT = 2.0 mA)				
1N4575	0.048		0.01	
1N4576	0.024		0.005	
1N4577	0.010	0, +25,	0.002	50
1N4578	0.005	+75	0.001	
1N4579	0.002		0.0005	
1N4575A	0.099		0.01	
1N4576A	0.050	−55, 0,	0.005	
1N4577A	0.020	+25, +75,	0.002	50
1N4578A	0.010	+100	0.001	
1N4579A	0.005		0.0005	
Vz = 6.4 Volts ±5% (IZT = 4.0 mA)				
1N4580	0.048		0.01	
1N4581	0.024		0.005	
1N4582	0.010	0, +25,	0.002	25
1N4583	0.005	+75	0.001	
1N4584	0.002		0.0005	
1N4580A	0.099		0.01	
1N4581A	0.050	−55, 0,	0.005	
1N4582A	0.020	+25, +75,	0.002	25
1N4583A	0.010	+100	0.001	
1N4584A	0.005		0.0005	

TYPE	△Vz @ Test Temperature (Note 1) Volts Max	°C	Temperature Coefficient for Reference %/°C (Note 1)	Dynamic Imped. Ohms Max (Note 2)
Vz = 8.5 Volts ±5% (IZT = 0.5 mA)				
1N4775	0.064		0.01	
1N4776	0.032		0.005	
1N4777	0.013	0, +25,	0.002	200
1N4778	0.006	+75	0.001	
1N4779	0.003		0.0005	
1N4775A	0.132		0.01	
1N4776A	0.066	−55, 0,	0.005	
1N4777A	0.026	+25, +75,	0.002	200
1N4778A	0.013	+100	0.001	
1N4779A	0.007		0.0005	
Vz = 8.5 Volts ±5% (IZT = 1.0 mA)				
1N4780	0.064		0.01	
1N4781	0.032		0.005	
1N4782	0.013	0, +25,	0.002	100
1N4783	0.006	+75	0.001	
1N4784	0.003		0.0005	
1N4780A	0.132		0.01	
1N4781A	0.066	−55, 0,	0.005	
1N4782A	0.026	+25, +75,	0.002	100
1N4783A	0.013	+100	0.001	
1N4784A	0.007		0.0005	
Vz = 9.1 Volts ±5% (IZT = 0.5 mA)				
1N4765	0.068		0.01	
1N4766	0.034		0.005	
1N4767	0.014	0, +25,	0.002	350
1N4768	0.007	+75	0.001	
1N4769	0.003		0.0005	
1N4765A	0.141		0.01	
1N4766A	0.070	−55, 0,	0.005	
1N4767A	0.028	+25, +75,	0.002	350
1N4768A	0.014	+100	0.001	
1N4769A	0.007		0.0005	
Vz = 9.1 Volts ±5% (IZT = 1.0 mA)				
1N4770	0.068		0.01	
1N4771	0.034		0.005	
1N4772	0.014	0, +25,	0.002	200
1N4773	0.007	+75	0.001	
1N4774	0.003		0.0005	
1N4770A	0.141		0.01	
1N4771A	0.070	−55, 0,	0.005	
1N4772A	0.028	+25, +75,	0.002	200
1N4773A	0.014	+100	0.001	
1N4774A	0.007		0.0005	

NOTE 1:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability – by means of temperature coefficient – accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 2:

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. A cathode-ray tube curve-trace test on a sample basis is used to ensure that the zener has a sharp and stable knee region.

1N4719 thru 1N4725
1N4997 thru 1N5003
MR1030 thru MR1036, MR1038, MR1040

V_R — to 1000 V

I_O = 3.0 A





CASE 60
1N4719 THRU 1N4725
MR1030A THRU MR1040A

CASE 70
1N4997 thru 1N5003
MR1030B THRU MR1040B

Silicon high-conductance rectifiers available in either axial-lead or single-ended packages. Type numbers shown have cathode connected to case. For anode-to-case connection, add suffix "R" to type number, i. e. 1N4719R

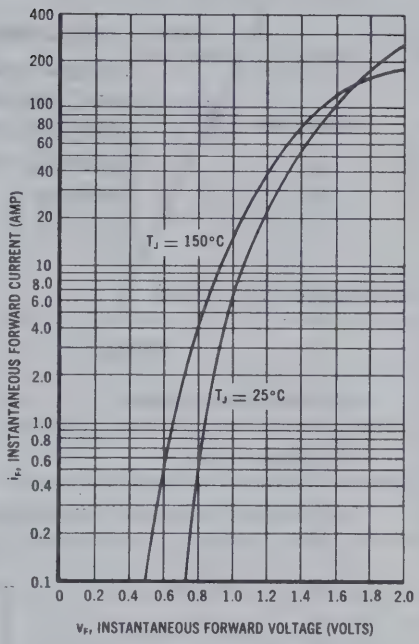
MAXIMUM RATINGS (Both Package Types) T_A = 25°C unless otherwise noted

Rating	Symbol	1N 4719 MR 1030	1N 4720 MR 1031	1N 4721 MR 1032	MR 1033	1N 4722 MR 1034	MR 1035	1N 4723 MR 1036	1N 4724 MR 1038	1N 4725 MR 1040	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RM} (rep) V_{RM} (wkg) V_R	50	100	200	300	400	500	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	V_{RM} (non-rep)	100	200	300	400	500	600	720	1000	1200	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	350	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, T_A = 75°C) see figure 4	I_O	3.0									Amp
Peak Repetitive Forward Current (T_A = 75°C)	I_{FM} (rep)	25									Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 75°C) see figure 1	I_{FM} (surge)	300 (for 1/2 cycle)									Amp
I^2t Rating (non-repetitive, 1 msec <t <8.3 msec)	I^2t	185									$A_{(rms)}{}^2s$
Operating and Case Temperature	T_J, T_{stg}	-65 to + 175									°C
Thermal Resistance	θ_{JA}	30									°C/Watt

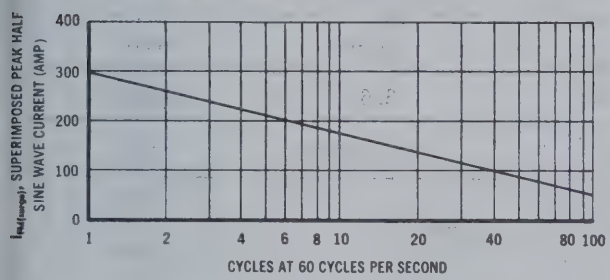
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max Limit	Unit
Full Cycle Average Forward Voltage Drop (I_O = 3.0 Amps and Rated V_R, T_A = 75°C, Half Wave Rectifier)	$V_{F(AV)}$	0.45	Volts
DC Forward Voltage Drop (I_F = 3.0 Adc, T_A = 25°C)	V_F	0.9	Volts
Full Cycle Average Reverse Current (I_O = 3.0 Amps and Rated V_R, T_A = 75°C, Half Wave Rectifier)	$I_{R(AV)}$	1.5	mA
DC Reverse Current (Rated V_R, T_A = 25°C)	I_R	0.5	mA

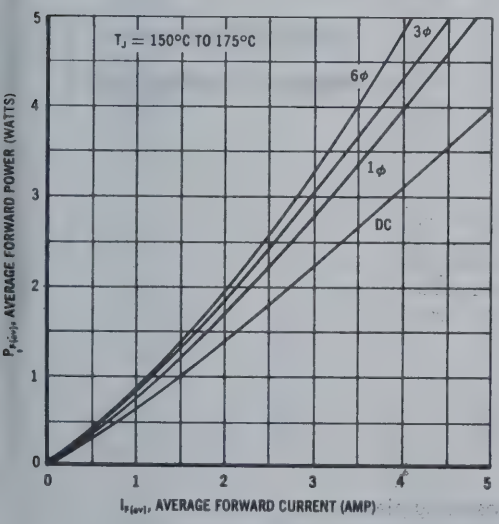
FORWARD VOLTAGE CHARACTERISTICS



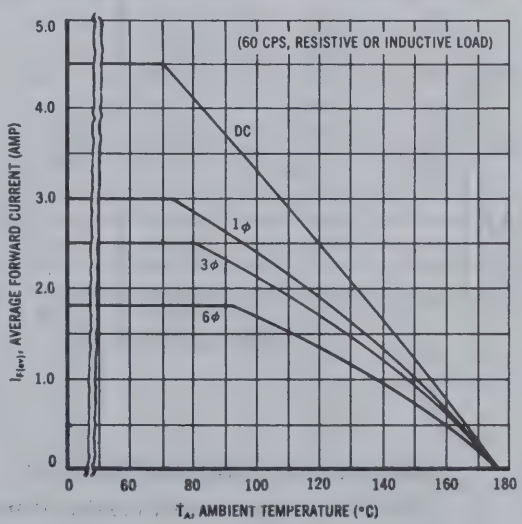
MAXIMUM SURGE CURRENT (T_A = 75°C)



MAXIMUM FORWARD POWER DISSIPATION versus AVERAGE FORWARD CURRENT

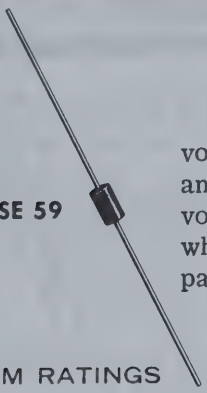


MAXIMUM FORWARD CURRENT versus AMBIENT TEMPERATURE



1N4728 thru 1N4764
1M110ZS thru 1M200ZS

1 W
3.3 — 200 V

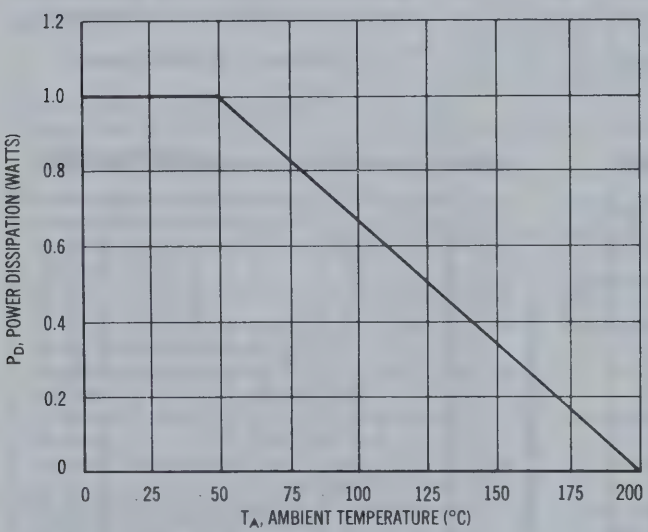


CASE 59

One-watt silicon zener diodes designed for constant voltage reference from 3.3 thru 100 volts, with 10% and 5.0% tolerances. These diodes are packaged in a void-free, transfer-molded thermosetting plastic case which is no larger than the conventional 400 mW glass package.

MAXIMUM RATINGS

Rating	Value	Unit
DC Power Dissipation	1.0	Watt
Derating Factor	6.67	mW/°C
Junction and Storage Temperature	-65 to +200	°C



POWER RATING versus AMBIENT TEMPERATURE

MECHANICAL CHARACTERISTICS

CASE: Void free, transfer molded, thermosetting plastic.

FINISH: All external surfaces are corrosion resistant. Leads are readily solderable.

POLARITY: Cathode, indicated by color band. When operated in zener mode cathode will be positive with respect to anode.

MOUNTING POSITION: Any

WEIGHT: 0.42 gram (approximately)

1N4728 thru 1N4764 (continued)

IN--- type numbers have a standard tolerance of ±10% on the nominal zener voltage; "A" for ±5.0% units. For 1M--- type numbers, suffix 10 indicates 10% tolerance, suffix 5 indicates 5.0% tolerance.

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise specified)

$V_F = 1.5\,V$ max @ $I_F = 200\,mA$ on all types.

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance (Note 3)			REVERSE LEAKAGE CURRENT		Surge Current @ $T_A = 25°C$ I_R	Max DC Zener Current I_{ZM} mA
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA	I_R μA Max	@ V_R Volts		
1N4728	3.3	76	10	400	1.0	100	1	1380	276
1N4729	3.6	69	10	400	1.0	100	1	1260	252
1N4730	3.9	64	9	400	1.0	50	1	1190	234
1N4731	4.3	58	9	400	1.0	10	1	1070	217
1N4732	4.7	53	8	500	1.0	10	1	970	193
1N4733	5.1	49	7	550	1.0	10	1	890	178
1N4734	5.6	45	5	600	1.0	10	2	810	162
1N4735	6.2	41	2	700	1.0	10	3	730	146
1N4736	6.8	37	3.5	700	1.0	10	4	660	133
1N4737	7.5	34	4.0	700	0.5	10	5	605	121
1N4738	8.2	31	4.5	700	0.5	10	6	550	110
1N4739	9.1	28	5.0	700	0.5	10	7	500	100
1N4740	10	25	7	700	0.25	10	7.6	454	91
1N4741	11	23	8	700	0.25	5	8.4	414	83
1N4742	12	21	9	700	0.25	5	9.1	380	76
1N4743	13	19	10	700	0.25	5	9.9	344	69
1N4744	15	17	14	700	0.25	5	11.4	304	61
1N4745	16	15.5	16	700	0.25	5	12.2	285	57
1N4746	18	14	20	750	0.25	5	13.7	250	50
1N4747	20	12.5	22	750	0.25	5	15.2	225	45
1N4748	22	11.5	23	750	0.25	5	16.7	205	41
1N4749	24	10.5	25	750	0.25	5	18.2	190	38
1N4750	27	9.5	35	750	0.25	5	20.6	170	34
1N4751	30	8.5	40	1,000	0.25	5	22.8	150	30
1N4752	33	7.5	45	1,000	0.25	5	25.1	135	27
1N4753	36	7.0	50	1,000	0.25	5	27.4	125	25
1N4754	39	6.5	60	1,000	0.25	5	29.7	115	23
1N4755	43	6.0	70	1,500	0.25	5	32.7	110	22
1N4756	47	5.5	80	1,500	0.25	5	35.8	95	19
1N4757	51	5.0	95	1,500	0.25	5	38.8	90	18
1N4758	56	4.5	110	2,000	0.25	5	42.6	80	16
1N4759	62	4.0	125	2,000	0.25	5	47.1	70	14
1N4760	68	3.7	150	2,000	0.25	5	51.7	65	13
1N4761	75	3.3	175	2,000	0.25	5	56.0	60	12
1N4762	82	3.0	200	3,000	0.25	5	62.2	55	11
1N4763	91	2.8	250	3,000	0.25	5	69.2	50	10
1N4764	100	2.5	350	3,000	0.25	5	76.0	45	9
1M110ZS10	110	2.3	450	4,000	0.25	5.0	83.6	—	7.2
1M110ZS5	110	2.3	450	4,000	0.25	5.0	83.6	—	7.2
1M120ZS10	120	2.0	550	4,500	0.25	5.0	91.2	—	7.0
1M120ZS5	120	2.0	550	4,500	0.25	5.0	91.2	—	7.0
1M130ZS10	130	1.9	700	5,000	0.25	5.0	98.8	—	6.0
1M130ZS5	130	1.9	700	5,000	0.25	5.0	98.8	—	6.0
1M150ZS10	150	1.7	1,000	6,000	0.25	5.0	114	—	5.5
1M150ZS5	150	1.7	1,000	6,000	0.25	5.0	114	—	5.5
1M160ZS10	160	1.6	1,100	6,500	0.25	5.0	121.6	—	5.2
1M160ZS5	160	1.6	1,100	6,500	0.25	5.0	121.6	—	5.2
1M180ZS10	180	1.4	1,200	7,000	0.25	5.0	136.8	—	4.6
1M180ZS5	180	1.4	1,200	7,000	0.25	5.0	136.8	—	4.6
1M200ZS10	200	1.2	1,500	8,000	0.25	5.0	152	—	4.0
1M200ZS5	200	1.2	1,500	8,000	0.25	5.0	152	—	4.0

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

1 — Nominal zener voltages between those shown.

2 — Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.
   a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
   b. Two or more units matched to one another with any specified tolerance.

3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

1N4765 thru 1N4774
1N4775 thru 1N4784

For Specifications, See 1N4565 Data.

1N4896,A thru 1N4915,A

12.8 V ± 5.0%

1N4916,A thru 1N4932,A

19.2 V ± 5.0%

LOW NOISE TEMPERATURE-COMPENSATED ZENER REFERENCE DIODES

Highly reliable reference sources utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.

- Low Noise Density Specified for Critical Applications
- Low Power Drain
  Devices Specified @ 0.5 mA, 1.0 mA, 2.0 mA, 4.0 mA, and 7.5 mA
- Maximum Voltage Change Specified over Test Temperature Range
- Temperature Compensation Guaranteed over Two Standard Operating Temperature Ranges:
  +25 to +100°C
  -55 to +100°C

MAXIMUM RATINGS

Junction and Storage Temperature: −65°C to +175°C

DC Power Dissipation: 400 Milliwatts at 50°C Ambient
(Derate 3.2 mW/°C Above 50°C)

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

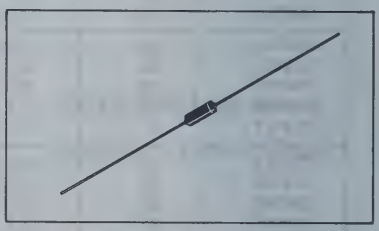
DIMENSIONS: See outline drawing.

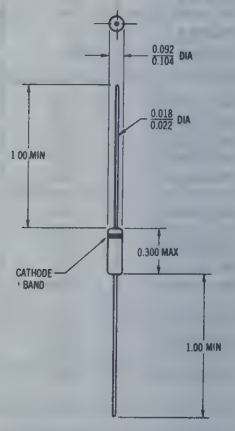
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any





CASE 51
DO-7

V_Z = 12.8 V

TEMPERATURE RANGE:

STANDARD DEVICES
+25, +75, +100°C

"A" SUFFIX
-55, 0 + 25, +75, +100°C

Type Number	ΔV_Z Volts (Note 1)	Temp. Coeff. for Ref. %/°C (Note 1)	Dynamic Imped. Ohms Max (Note 2)
I_{ZT} = 0.5 mA $^*N_D = 0.8 \frac{\mu V}{\sqrt{Hz}}$			
1N4896	0.096	0.01	400
1N4896A	0.198	0.01	
1N4897	0.048	0.005	
1N4897A	0.099	0.005	
1N4898	0.019	0.002	
1N4898A	0.040	0.002	
1N4899	0.010	0.001	
1N4899A	0.020	0.001	
I_{ZT} = 1.0 mA $^*N_D = 0.4 \frac{\mu V}{\sqrt{Hz}}$			
1N4900	0.096	0.01	200
1N4900A	0.198	0.01	
1N4901	0.048	0.005	
1N4901A	0.099	0.005	
1N4902	0.019	0.002	
1N4902A	0.040	0.002	
1N4900	0.010	0.001	
1N4903A	0.020	0.001	
I_{ZT} = 2.0 mA $^*N_D = 0.25 \frac{\mu V}{\sqrt{Hz}}$			
1N4904	0.096	0.01	100
1N4904A	0.198	0.01	
1N4905	0.048	0.005	
1N4905A	0.099	0.005	
1N4906	0.019	0.002	
1N4906A	0.040	0.002	
1N4907	0.010	0.001	
1N4907A	0.020	0.001	
I_{ZT} = 4.0 mA $^*N_D = 0.22 \frac{\mu V}{\sqrt{Hz}}$			
1N4908	0.096	0.01	50
1N4908A	0.198	0.01	
1N4909	0.048	0.005	
1N4909A	0.099	0.005	
1N4910	0.019	0.002	
1N4910A	0.040	0.002	
1N4911	0.010	0.001	
1N4911A	0.020	0.001	
I_{ZT} = 7.5 mA $^*N_D = 0.20 \frac{\mu V}{\sqrt{Hz}}$			
1N4912	0.096	0.01	25
1N4912A	0.198	0.01	
1N4913	0.048	0.005	
1N4913A	0.099	0.005	
1N4914	0.019	0.002	
1N4914A	0.040	0.002	
1N4915	0.010	0.001	
1N4915A	0.020	0.001	

V_Z = 19.2 V

TEMPERATURE RANGE:

STANDARD DEVICES
+25, +75, +100°C

"A" SUFFIX
-55, 0, +25, +75, +100°C

Type Number	ΔV_Z Volts (Note 1)	Temp. Coeff. for Ref. %/°C (Note 1)	Dynamic Imped. Ohms Max (Note 2)
I_{ZT} = 0.5 mA $^*N_D = 1.0 \frac{\mu V}{\sqrt{Hz}}$			
1N4916	0.144	0.01	600
1N4916A	0.298	0.01	
1N4917	0.072	0.005	
1N4917A	0.149	0.005	
1N4918	0.029	0.002	
1N4918A	0.060	0.002	
I_{ZT} = 1.0 mA $^*N_D = 0.5 \frac{\mu V}{\sqrt{Hz}}$			
1N4919	0.144	0.01	300
1N4919A	0.298	0.01	
1N4920	0.072	0.005	
1N4920A	0.149	0.005	
1N4921	0.029	0.002	
1N4921A	0.060	0.002	
I_{ZT} = 2.0 mA $^*N_D = 0.25 \frac{\mu V}{\sqrt{Hz}}$			
1N4922	0.144	0.01	150
1N4922A	0.298	0.01	
1N4923	0.072	0.005	
1N4923A	0.149	0.005	
1N4924	0.029	0.002	
1N4924A	0.060	0.002	
I_{ZT} = 4.0 mA $^*N_D = 0.22 \frac{\mu V}{\sqrt{Hz}}$			
1N4925	0.144	0.01	75
1N4925A	0.298	0.01	
1N4926	0.072	0.005	
1N4926A	0.149	0.005	
1N4927	0.029	0.002	
1N4927A	0.060	0.002	
1N4928	0.014	0.001	
1N4928A	0.030	0.001	
I_{ZT} = 7.5 mA $^*N_D = 0.20 \frac{\mu V}{\sqrt{Hz}}$			
1N4929	0.144	0.01	36
1N4929A	0.298	0.01	
1N4930	0.072	0.005	
1N4930A	0.149	0.005	
1N4931	0.029	0.002	
1N4931A	0.060	0.002	
1N4932	0.014	0.001	
1N4932A	0.030	0.001	

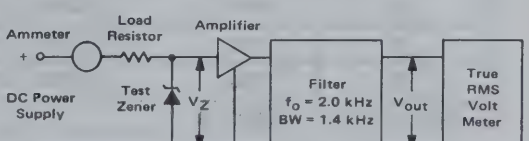
NOTE 1:
Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. V_Z is measured and recorded at each temperature specified. The ΔV_Z between the highest and lowest values must not exceed the max ΔV_Z given. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 2: Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. A cathode-ray tube curve-trace test on a sample basis is used to ensure that the zener has a sharp and stable knee region.

*NOISE DENSITY MEASUREMENT METHOD



$$\text{Noise Density (Volts per Square Root Bandwidth)} = \frac{V_{out}}{\text{Overall Gain} \quad BW}$$

Where BW = Filter Bandwidth (Hz)
V_{out} = Output Noise (Volts RMS)

The input voltage and load resistance are high so that the zener diode is driven from a constant current source. The amplifier is low noise so that the amplifier noise is negligible compared to that of the test TC zener. The filter bandpass is known so that the noise density can be calculated from the formula shown.

1N4933 thru 1N4937 (SILICON)

1N3879 thru 1N3883 — 1N3889 thru 1N3893
1N3899 thru 1N3903 — 1N3909 thru 1N3913
MR830 thru MR836 — MR1366, MR1376,
MR1386, MR1396

$V_R = 50\text{-}600$ V
$I_O = 1.0\text{-}30$ A

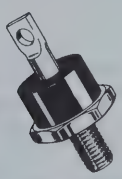
Fast recovery silicon rectifiers designed for special applications such as high frequency rectification, inverters, free-wheeling diodes, and other fast switching circuits. A complete line of rectifiers having typical recovery time of 0.1 microseconds providing high efficiency at frequencies of 250 kHz and higher.



MR830-MR836
CASE 60



1N4933-1N4937
CASE 59
(DO-41)



1N3899-1N3903
MR1386

1N3909-1N3913
MR1396

CASE 42
(DO-5)



1N3879-1N3883
MR1366

1N3889-1N3893
MR1376

CASE 56A
(DO-4)

MAXIMUM RATINGS

I_{O*} Ampere	$I_{FM(surge)**}$ Ampere	$V_{RM(rep)}$ $V_{RM(wkg)}$, V_R(Volts)					
		50	100	200	300	400	600
1.0	30	1N4933	1N4934	1N4935	—	1N4936	1N4937
3.0	100	MR830	MR831	MR832	—	MR834	MR836
6.0	150	1N3879	1N3880	1N3881	1N3882	1N3883	MR1366
12	200	1N3889	1N3890	1N3891	1N3892	1N3893	MR1376
20	225	1N3899	1N3900	1N3901	1N3902	1N3903	MR1386
30	300	1N3909	1N3910	1N3911	1N3912	1N3913	MR1396

* Figure 3 ** Figure 4

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Maximum Junction Operating Temperature Range	T_J	-65 to +150	°C
Maximum Case Storage Temperature Range	T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
1N4933 thru 1N4937			
DC Forward Voltage Drop (I_F = 1.0 Adc, T_A = 25°C)	V_F	1.2	Vdc
DC Reverse Current (Rated V_R) T_A = 25°C	I_R	5.0	μA
T_A = 100°C		100	
MR830 thru MR836			
DC Forward Voltage Drop (I_F = 3.0 Adc, T_A = 25°C)	V_F	1.1	Vdc
DC Reverse Current (Rated V_R) T_A = 25°C	I_R	0.05	mA
T_A = 100°C		2.5	
1N3879 thru 1N3883, MR1366			
DC Forward Voltage Drop (I_F = 6.0 Adc, T_C = 25°C)	V_F	1.4	Vdc
DC Reverse Current (Rated V_R) T_A = 25°C	I_R	0.015	mA
T_A = 100°C		1.0	
1N3889 thru 1N3893, MR1376			
DC Forward Voltage Drop (I_F = 12 Adc, T_C = 25°C)	V_F	1.4	Vdc
DC Reverse Current (Rated V_R) T_C = 25°C	I_R	0.025	mA
T_C = 100°C		3.0	
1N3899 thru 1N3903, MR1386			
DC Forward Voltage Drop (I_F = 20 Adc, T_A = 25°C)	V_F	1.4	Vdc
DC Reverse Current (Rated V_R) T_A = 25°C	I_R	0.05	mA
T_A = 100°C		6.0	
1N3909 thru 1N3913, MR1396			
DC Forward Voltage Drop (I_F = 30 Adc, T_A = 25°C)	V_F	1.4	Vdc
DC Reverse Current (Rated V_R) T_A = 25°C	I_R	0.08	mA
T_A = 100°C		10	

REVERSE RECOVERY TIME CHARACTERISTICS

Characteristics	Symbol	Max Limit	Unit
Maximum Reverse Recovery Time (I_F = 1.0 Amp min, Figure 2 test circuit)	t_{rr}	0.2	μs
Maximum Overshoot Current (Figure 2)	I_{os}		Amp
1N4933, MR830, 1N3879, 1N3889 Series MR1366, MR1367		2.0	
1N3899, 1N3909 Series MR1386, MR1396		3.0	

FIGURE 1 — TYPICAL RECOVERY PATTERN

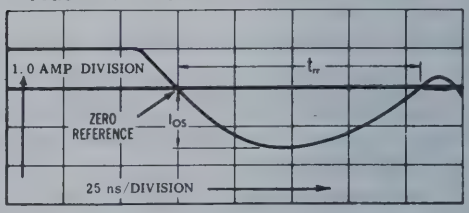
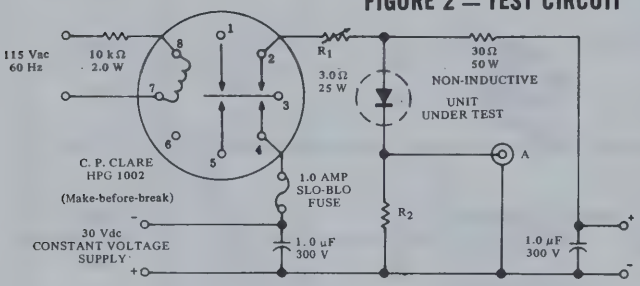


FIGURE 2 — TEST CIRCUIT



A — TEKTRONIX 545A, K PLUG-IN PRE-AMP, P6000 PROBE OR EQUIVALENT

R_1 — ADJUST TO APPROXIMATELY 1.4 Ω TO GIVE A MAX I_{os} WHICH IS NOT GREATER THAN THE MAX SPECIFIED VALUE. t_{rr} IS THEN MEASURED.

R_2 — TEN 1.0 W, 10 Ω, 1% CARBON COMPOUND RESISTORS IN PARALLEL

$T_A = 25^{+10}_{-0}$ °C FOR RECTIFIER

MINIMIZE ALL LEAD LENGTHS

1.0 Adc FROM CONSTANT VOLTAGE SUPPLY
RIPPLE = 3.0 mV RMS MAX

Z_{out} = 1/2 Ω Max dc to 2.0 kHz.

FIGURE 3 — MAXIMUM CURRENT RATING

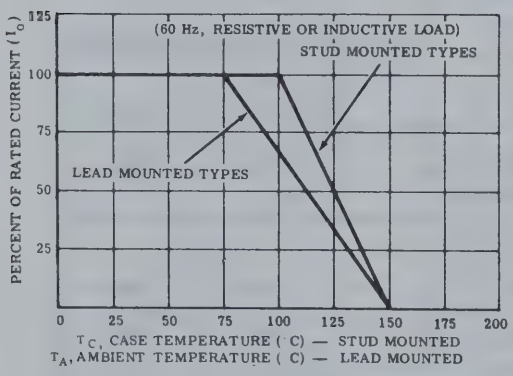
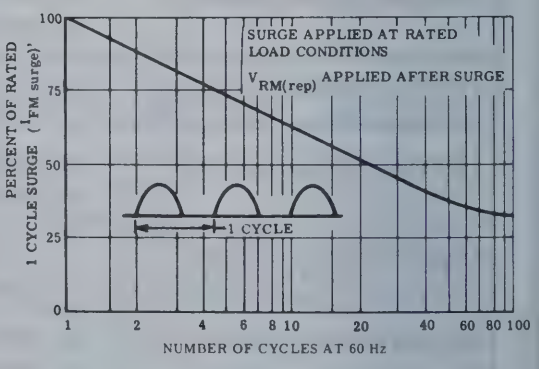


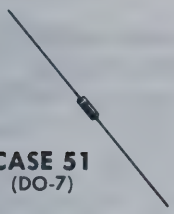
FIGURE 4 — MAXIMUM ALLOWABLE SURGE CURRENT



IN4997 thru IN5003

For Specifications, See 1N4719 Data.

1N5139,A thru 1N5148,A



CASE 51
(DO-7)

Polarity band on cathode end

Silicon voltage-variable capacitance diodes, designed for electronic tuning and harmonic-generation applications, and providing solid-state reliability to replace mechanical tuning methods.

MAXIMUM RATINGS ($T_C = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	60	Vdc
Forward Current	I_F	250	mAdc
RF Power Input†	P_{in}†	5	Watts
Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.67	mW mW/°C
Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_C	2 13.3	Watts mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

† The RF power input rating assumes that an adequate heat sink is provided.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic–All Types	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	B_{VR}	60	70	—	Vdc
Reverse Voltage Leakage Current	V_R = 55 Vdc, T_A = 25°C V_R = 55 Vdc, T_A = 150°C	I_R	— —	— —	0.02 20	μAdc
Series Inductance	f = 250 MHz, L ≈ 1/16"	L_S	—	5	—	nH
Case Capacitance	f = 1 MHz, L ≈ 1/16"	C_C	—	0.25	—	pF
Diode Capacitance Temperature Coefficient	V_R = 4 Vdc, f = 1 MHz	TC_C	—	200	300	ppm/°C

	C_T, Diode Capacitance V_R = 4 Vdc, f = 1 MHz pF			Q, Figure of Merit V_R = 4 Vdc, f = 50 MHz	α V_R = 4 Vdc, f = 1 MHz		TR, Tuning Ratio C_4/C_{60} f = 1 MHz	
Device	Min	Typ	Max	Min	Min	Typ	Min	Typ
1N5139	6.1	6.8	7.5	350	0.37	0.40	2.7	2.9
1N5139A	6.5	6.8	7.1	350	0.37	0.40	2.7	2.9
1N5140	9.0	10.0	11.0	300	0.38	0.41	2.8	3.0
1N5140A	9.5	10.0	10.5	300	0.38	0.41	2.8	3.0
1N5141	10.8	12.0	13.2	300	0.38	0.41	2.8	3.0
1N5141A	11.4	12.0	12.6	300	0.38	0.41	2.8	3.0
1N5142	13.5	15.0	16.5	250	0.38	0.41	2.8	3.0
1N5142A	14.3	15.0	15.7	250	0.38	0.41	2.8	3.0
1N5143	16.2	18.0	19.8	250	0.38	0.41	2.8	3.0
1N5143A	17.1	18.0	18.9	250	0.38	0.41	2.8	3.0
1N5144	19.8	22.0	24.2	200	0.43	0.45	3.2	3.4
1N5144A	20.9	22.0	23.1	200	0.43	0.45	3.2	3.4
1N5145	24.3	27.0	29.7	200	0.43	0.45	3.2	3.4
1N5145A	25.7	27.0	28.3	200	0.43	0.45	3.2	3.4
1N5146	29.7	33.0	36.3	200	0.43	0.45	3.2	3.4
1N5146A	31.4	33.0	34.6	200	0.43	0.45	3.2	3.4
1N5147	36.1	39.0	42.9	200	0.43	0.45	3.2	3.4
1N5147A	37.1	39.0	40.9	200	0.43	0.45	3.2	3.4
1N5148	42.3	47.0	51.7	200	0.43	0.45	3.2	3.4
1N5148A	44.7	47.0	49.3	200	0.43	0.45	3.2	3.4

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE

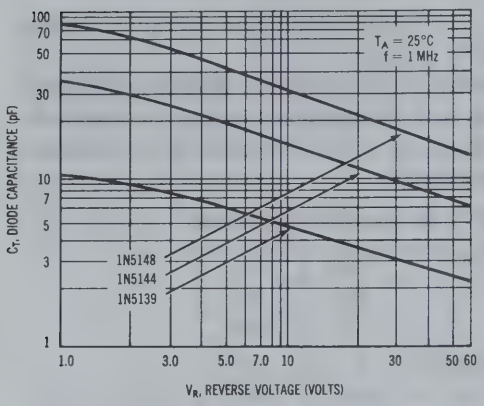


FIGURE 2 — FIGURE OF MERIT versus REVERSE VOLTAGE

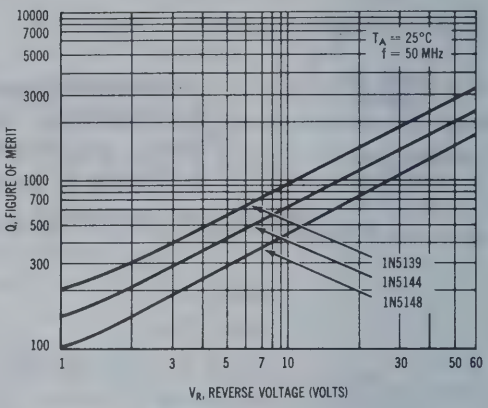


FIGURE 3 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

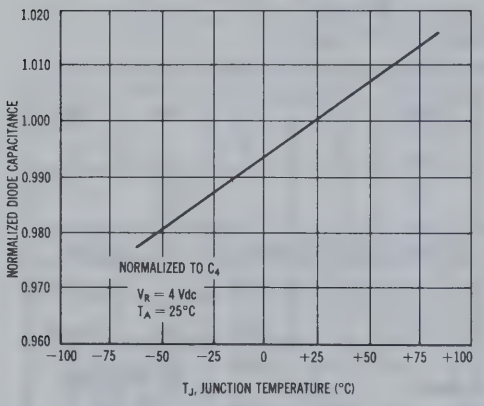


FIGURE 4 — NORMALIZED FIGURE OF MERIT versus JUNCTION TEMPERATURE

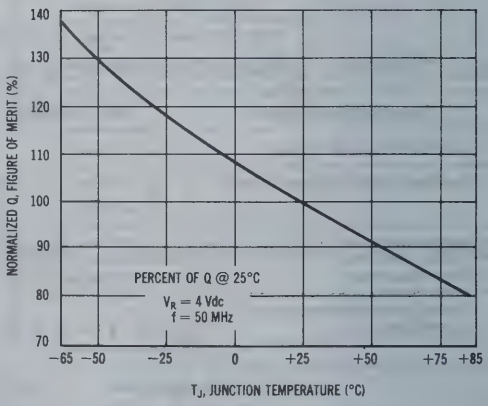


FIGURE 5 — REVERSE CURRENT versus REVERSE BIAS VOLTAGE

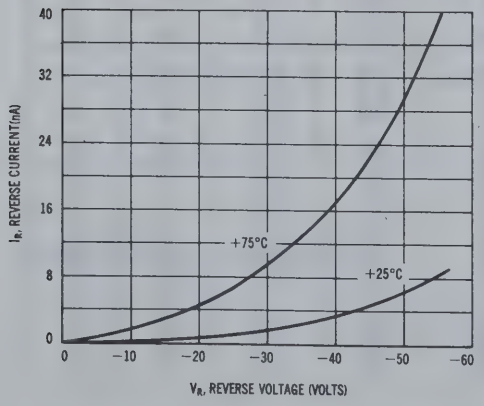
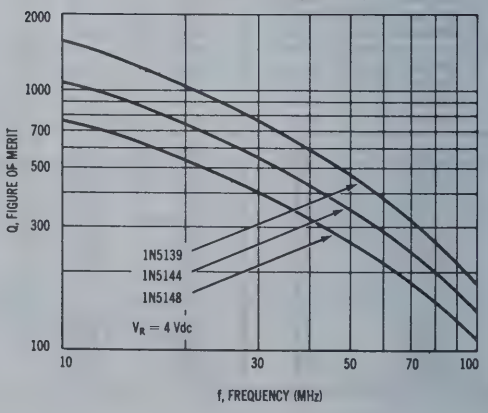


FIGURE 6 — FIGURE OF MERIT versus FREQUENCY



1N5149
(MV1806C)

1N5150
(MV1807C)

Silicon high-frequency step-recovery power varactors for 100 MHz to 2.0 GHz harmonic-generation applications with output power to 25 watts at 1.0 GHz.

CASE 47



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating		Symbol	Value	Unit
Reverse Voltage		V_R	80	Vdc
Forward Current		I_F	1.0	Amp
RF Power Input	1N5149 1N5150	P_{in}	25 40	Watts
Total Device Dissipation @ T_A = 75°C	1N5149 1N5150	P_D	10 14	Watts
Derate above 75°C	1N5149 1N5150		0.08 0.11	W/°C
Junction Temperature		T_J	+200	°C
Storage Temperature Range		T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	I_R = 10 μAdc	80	90	—	Vdc
Reverse Current	I_R	V_R = 70 Vdc	—	—	2	μAdc
		V_R = 70 Vdc, T_A = 150°C	—	—	100	
Diode Capacitance	C_T	V_R = 6 Vdc, f = 1.0 MHz	5	11.5	20	pF
Figure of Merit	Q	V_R = 6 Vdc, f = 50 MHz	—	800	—	—
Thermal Resistance	θ_{JC}	IN5150	—	—	9	°C/W

FUNCTIONAL TEST

1N5149

RF Power Output	P_{out}	Test Setup Figure 1 P_{in} = 20 W f_{in} = 0.5 GHz f_{out} = 1.0 GHz	11	—	—	Watts
Doubler Efficiency	η		55	—	—	%

1N5150

RF Power Output	P_{out}	Test Setup Figure 1 P_{in} = 37 W f_{in} = 0.5 GHz f_{out} = 1.0 GHz	24	25	—	Watts
Doubler Efficiency	η		65	68	—	%

FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT

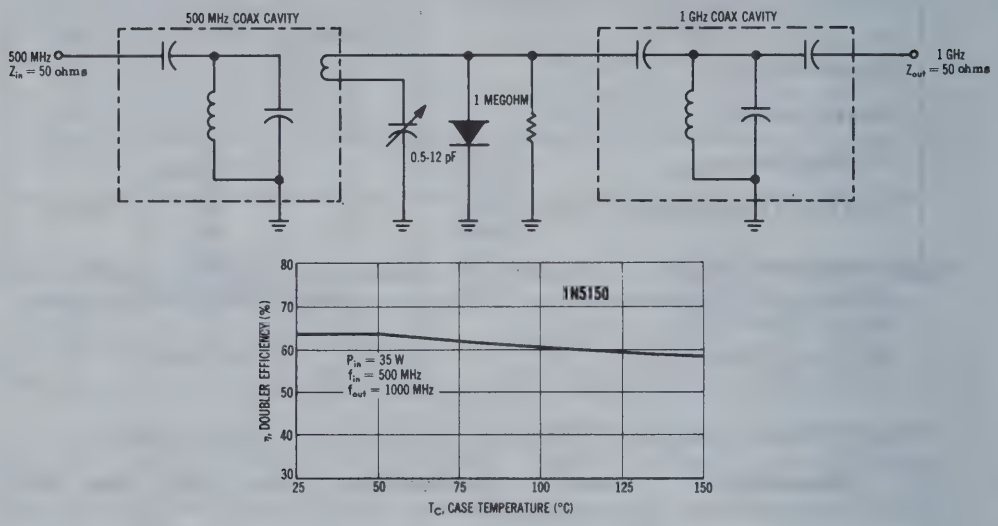


FIGURE 2 — LINEARITY CHARACTERISTIC WITHOUT RETUNING

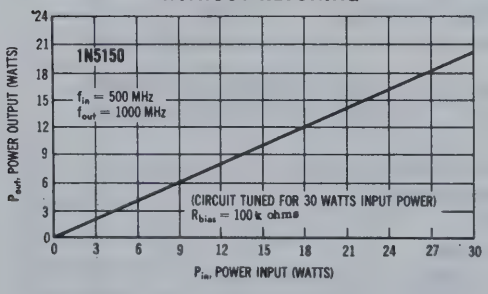
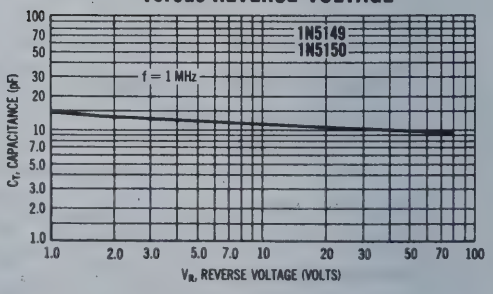


FIGURE 3 — CAPACITANCE versus REVERSE VOLTAGE



POWER OUTPUT versus OUTPUT FREQUENCY

1N5149

FIGURE 4A — DOUBLING (X2)

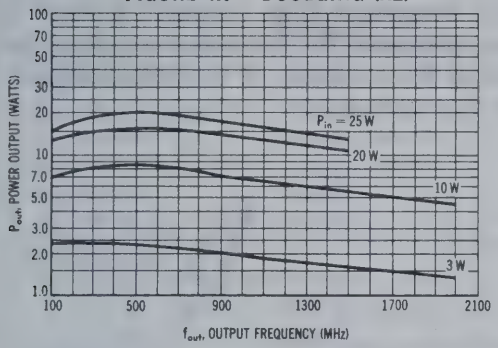


FIGURE 4B — TRIPLING (X3)

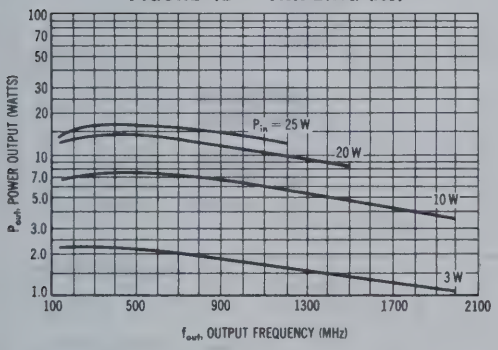
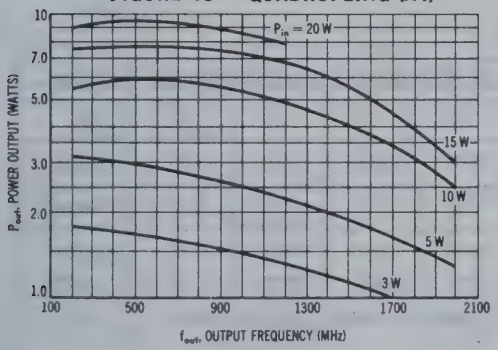


FIGURE 4C — QUADRUPLING (X4)



1N5150

FIGURE 5A — DOUBLING (X2)

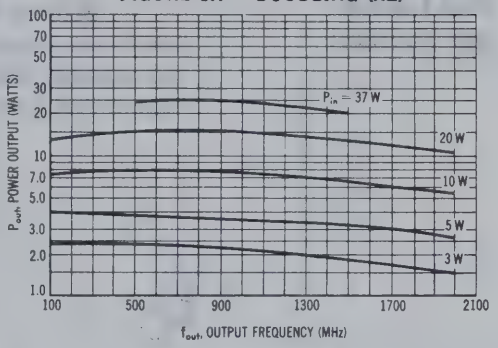


FIGURE 5B — TRIPLING (X3)

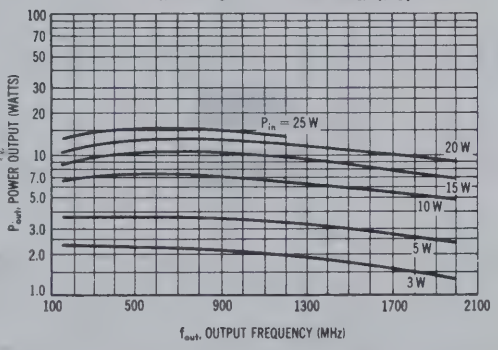
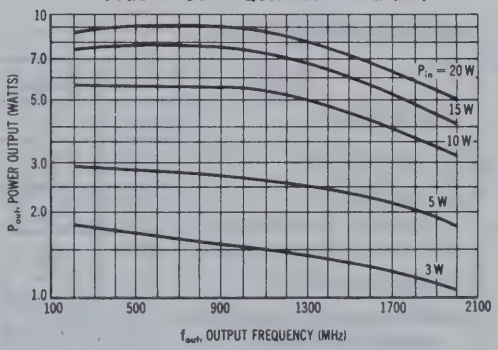


FIGURE 5C — QUADRUPLING (X4)



IN5150A (SILICON)
(MV1807C1)
IN5152A
(MV1808B1)
IN5153A
(MV1808C1)
IN5155A
(MV1810B1)

Silicon high-frequency step-recovery power varactor devices optimized for critical multiplier applications requiring tight control of junction capacitance and power dissipation.



CASE 46

1N5152A
MV1808B1

1N5155A
MV1810B1



CASE 47

1N5150A
MV1807C1

1N5153A
MV1808C1

MAXIMUM RATINGS

Rating	Symbol	1N5150A	1N5152A	1N5153A	1N5155A	Unit
Reverse Voltage	V_R	80	75	75	35	Vdc
Forward Current	I_F	1000	250	250	200	mAdc
RF Power Input	P_{in}	40	15	15	7.0	Watts
Total Device Dissipation @ T_C = 25°C	P_D	29.2	11.7	11.7	8.75	Watts
Derate above 25°C		167	66.7	66.7	50	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	1N5150A	BV_R	80	-	-	Vdc
	1N5152A, 1N5153A		75	-	-	
	1N5155A		35	-	-	
Reverse Current		I_R				μAdc
(V_R = 70 Vdc)	1N5150A		-	-	2.0	
(V_R = 70 Vdc, T_A = 150°C)	1N5150A		-	-	100	
(V_R = 60 Vdc)	1N5152A, 1N5153A		-	-	1.0	
(V_R = 60 Vdc, T_A = 150°C)	1N5152A, 1N5153A		-	-	100	
(V_R = 26 Vdc)	1N5155A		-	-	1.0	
(V_R = 26 Vdc, T_A = 150°C)	1N5155A		-	-	100	
Series Resistance (V_R = 6.0 Vdc, f = self-resonant frequency)		R_S				Ohms
	1N5150A		-	0.25	-	
	1N5152A, 1N5153A		-	0.5	-	
	1N5155A		-	0.9	-	
Series Inductance		L_S				nH
	1N5150A		-	1.5	-	
	1N5152A		-	0.8	-	
	1N5153A		-	1.7	-	
	1N5155A		-	0.9	-	
Diode Capacitance (C_J + C_C)		C_T				pF
(V_R = 6.0 Vdc, f = 1.0 MHz)	1N5150A		10.8	-	13.2	
	1N5152A		5.4	-	6.6	
	1N5153A		5.8	-	7.0	
	1N5155A		1.71	-	2.09	
Figure of Merit		Q				-
(V_R = 6.0 Vdc, f = 50 MHz)	1N5150A		-	800	-	
	1N5152A, 1N5153A		-	1100	-	
	1N5155A		-	1700	-	
Thermal Resistance		θ_{JC}				°C/W
	1N5150A		-	-	6.0	
	1N5152A, 1N5153A		-	-	15	
	1N5155A		-	-	20	

FUNCTIONAL TEST

1N5150A

RF Power Output	P_{in} = 37 W, f_{in} = 500 MHz,	P_{out}	25.1	-	-	Watts
Doubling Efficiency	f_{out} = 1.0 GHz	η	68	-	-	%

1N5152A, 1N5153A

RF Power Output	P_{in} = 12 W, f_{in} = 1.0 GHz,	P_{out}	7.2	-	-	Watts
Doubling Efficiency	f_{out} = 2.0 GHz	η	60	-	-	%

1N5155A

RF Power Output	P_{in} = 5.0 W, f_{in} = 2.0 GHz,	P_{out}	2.0	-	-	Watts
Tripling Efficiency	f_{out} = 6.0 GHz	η	40	-	-	%

For typical curves and test circuits, see the following data sheets: 1N5149-1N5150, 1N5151 thru 1N5153, and 1N5154-1N5155.

1N5151
(MV1808A)

1N5152
(MV1808B)

1N5153
(MV1808C)

Silicon high-frequency step-recovery power varactors, designed for high-power, high-frequency harmonic generation applications.



CASE 48
(1N5151)
(pill)



CASE 46
(1N5152)
(pill with prongs)



CASE 47
(1N5153)
(cartridge)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	75	Vdc
Forward Current	I_F	0.25	Adc
RF Power Input	P_{in}	15	Watts
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	5.5 45	Watts mW/°C
Junction Temperature	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Condition	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	75	80	—	Vdc
Reverse Current	V_R = 60 Vdc V_R = 60 Vdc, T_A = 150°C	I_R	— —	0.5 —	1 100	μAdc
Series Resistance	V_R = 6 Vdc, f = 50 MHz	R_S	—	0.5	—	Ohms
Diode Capacitance	V_R = 6 Vdc, f = 1.0 MHz V_R = 70 Vdc, f = 1.0 MHz	C_T*	5.0 —	5.8 4	7.5 —	pF
Figure of Merit	V_R = 6 Vdc, f = 50 MHz	Q	—	1100	—	—
Power Output	DOUBLER TEST CIRCUIT (Figure 1) P_{in} = 12 W, f_{in} = 1GHz f_{out} = 2 GHz	P_{out}	6.0	7.2	—	Watts
Efficiency		η	50	60	—	%
Thermal Resistance		θ_J	—	19	23	°C/Watt

*$C_T = C_J + C_C$

FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT

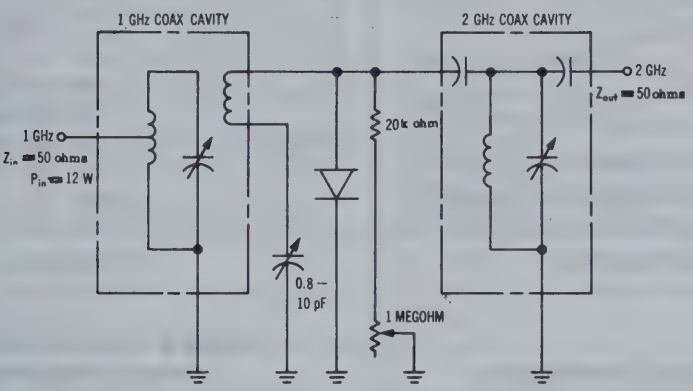
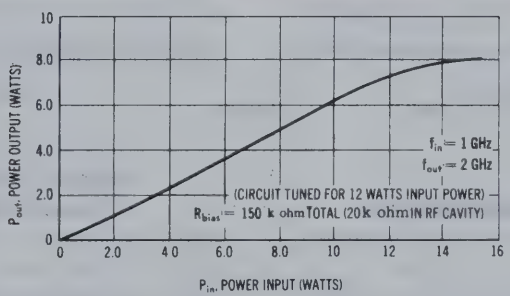


FIGURE 2 — LINEARITY CHARACTERISTIC WITHOUT RETUNING



POWER OUTPUT
versus OUTPUT FREQUENCY

FIGURE 3A — DOUBLING (X2)

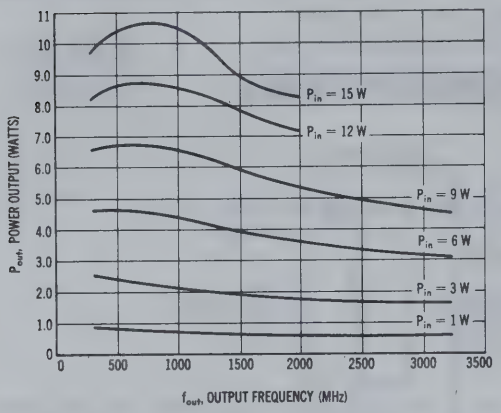


FIGURE 3B — TRIPLING (X3)

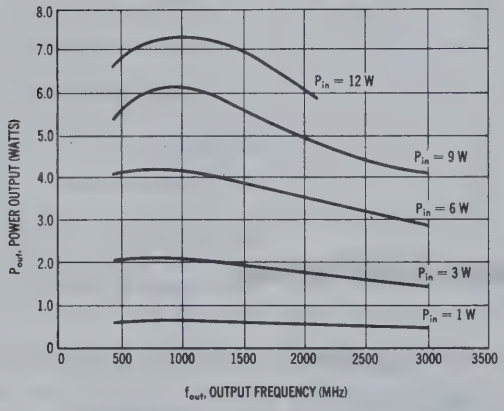
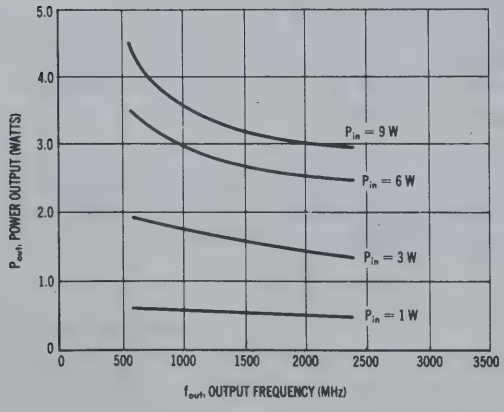


FIGURE 3C — QUADRUPLING (X4)



TYPICAL CHARACTERISTICS at 25°C

FIGURE 4 — FIGURE OF MERIT versus REVERSE VOLTAGE

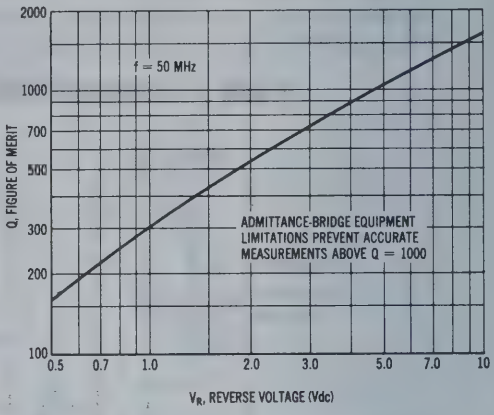


FIGURE 5 — VARACTOR CAPACITANCE versus REVERSE VOLTAGE

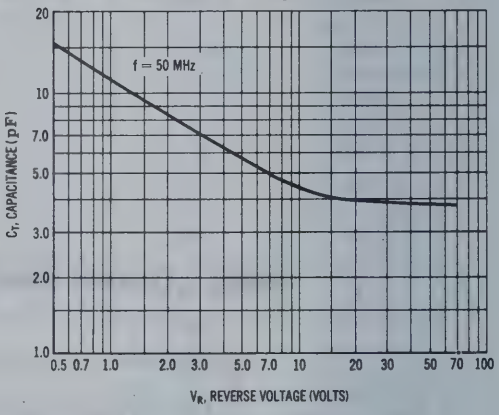
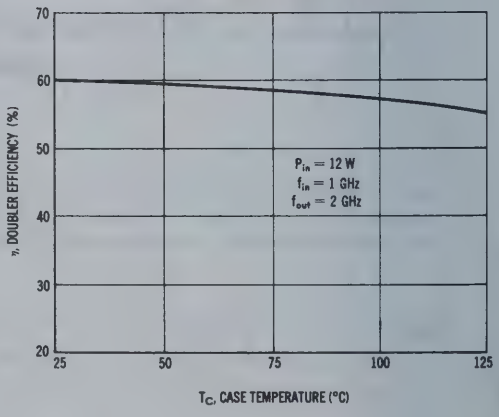


FIGURE 6 — DOUBLER EFFICIENCY versus CASE TEMPERATURE



1N5154
(MV1810A)
1N5155
(MV1810B)

CASE 48
(1N5154)
(pill)



CASE 46
(1N5155)
(pill with prongs)



Silicon high-frequency step-recovery power varactors, for multiplier applications from 2 to 8.5 GHz with 2 watts minimum power output guaranteed at 6 GHz.

MAXIMUM RATINGS ($T_C = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Vdc
Forward Current	I_F	200	mAdc
RF Power Input	P_{in}	7	Watts
Total Device Dissipation @ $T_C = 75°C$ Derate above 75°C	P_D	3.5 30	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	35	45	—	Vdc
Reverse Current	V_R = 26 Vdc V_R = 26 Vdc, T_A = 150°C	I_R	— —	— —	1 100	μAdc
Series Resistance	V_R = 6 Vdc, f = 50 MHz	R_S	—	0.9	—	Ohms
Diode Capacitance	V_R = 6 Vdc, f = 1 MHz	C_T	1.0	2.1	3.0	pF
Figure of Merit	V_R = 6 Vdc, f = 50 MHz	Q	—	1700	—	—
Thermal Resistance		θ_{JC}	—	—	35	°C/W

FUNCTIONAL TEST

RF Power Output	Test Circuit Figure 5 P_{in} = 5 watts, f_{in} = 2 GHz, f_{out} = 6 GHz	P_{out}	2	—	—	Watts
Tripling Efficiency		η	40	—	—	%

POWER OUTPUT versus OUTPUT FREQUENCY

FIGURE 1A — DOUBLING (X2)

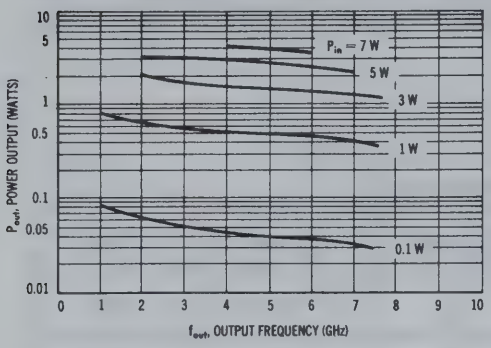


FIGURE 1B — TRIPLING (X3)

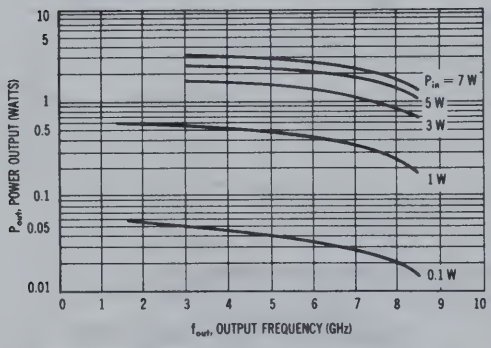
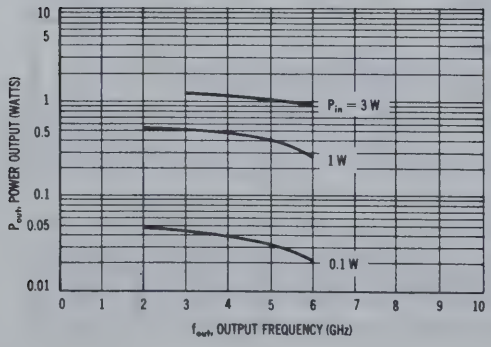


FIGURE 1C — QUADRUPLING (X4)



TYPICAL CHARACTERISTICS $T_C = 25°C$

FIGURE 2 — VARACTOR CAPACITANCE versus REVERSE VOLTAGE

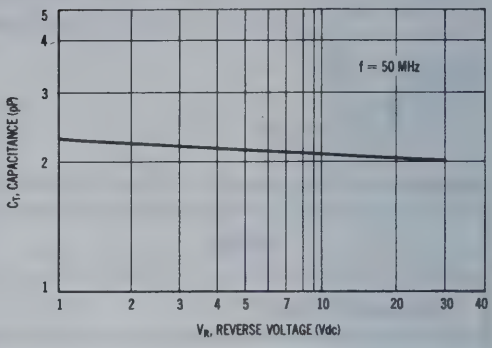


FIGURE 3 — TRIPLER POWER OUTPUT versus TEMPERATURE 2 GHz to 6 GHz

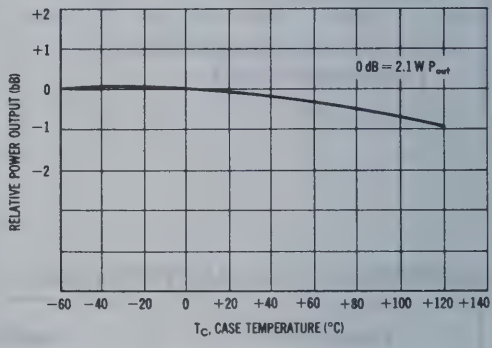


FIGURE 4 — TRIPLER LINEARITY CHARACTERISTIC

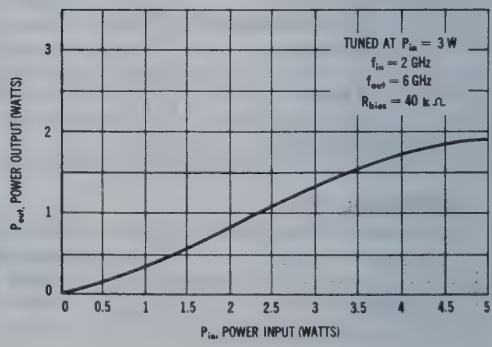


FIGURE 5 — HARMONIC TRIPLER — 2 GHz to 6 GHz

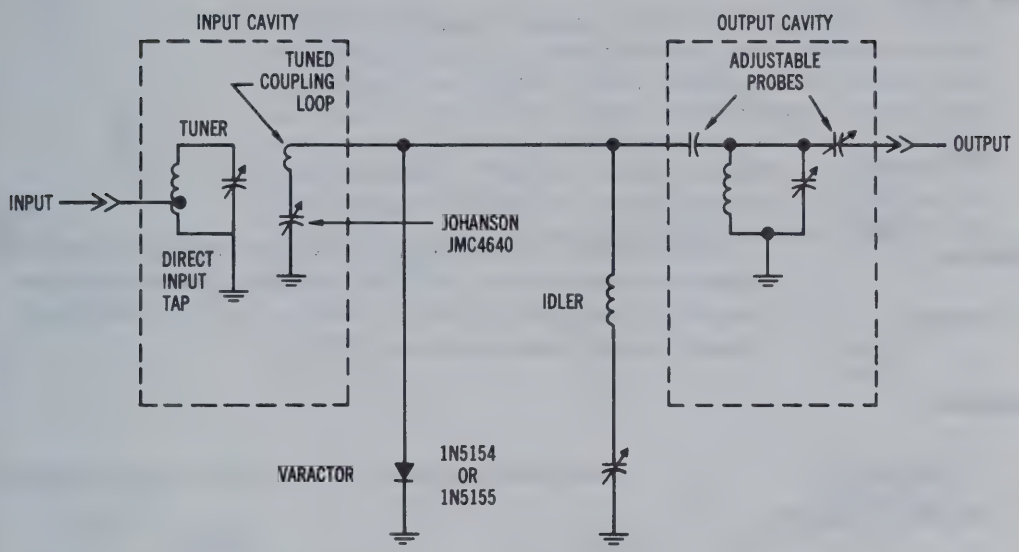
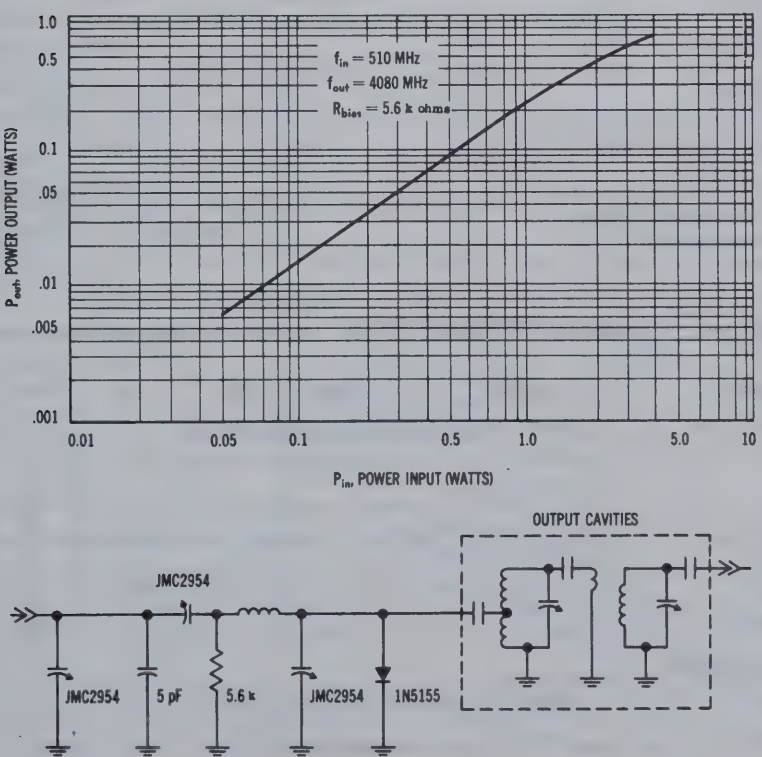
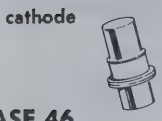


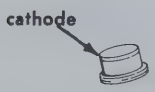
FIGURE 6 — HARMONIC OCTUPLER — 510 MHz to 4080 MHz



IN5156
(MV1812A)
IN5157
(MV1812B)



CASE 46



CASE 48

AVAILABLE IN
PILL PACKAGE
ON SPECIAL REQUEST

Silicon high-frequency step-recovery power varactors; epitaxial-passivated devices designed for multiplier applications from 1.0 to 13 GHz with 1.0 W minimum power output guaranteed at 10 GHz.

MAXIMUM RATINGS ($T_C = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Vdc
Forward Current	I_F	160	mAdc
RF Power Input	P_{in}	5.0	Watts
Total Device Dissipation @ $T_C = 75°C$ Derate above 75°C	P_D	3.25 26	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	20	–	–	Vdc
Reverse Current	V_R = 16 Vdc	I_R	–	–	0.1	μAdc
	V_R = 16 Vdc, T_A = 150°C		–	–	100	
Series Resistance	V_R = 6.0 Vdc, f = 50 MHz	R_S	–	1.1	–	Ohms
Diode Capacitance	V_R = 6.0 Vdc, f = 1.0 MHz	C_T	0.6	–	1.0	pF
Figure of Merit	V_R = 6.0 Vdc, f = 50 MHz	Q	–	3600	–	–
Thermal Resistance		θ_{JC}	–	–	38.5	°C/W

FUNCTIONAL TEST

RF Power Output	P_{in} = 2.6 W , f_{in} = 5.0 GHz	P_{out}	1.0	–	–	Watt
Doubling Efficiency	f_{out} = 10 GHz	η	38.5	–	–	%

1N5158 thru 1N5160 (SILICON)
M4L3052 thru M4L3056



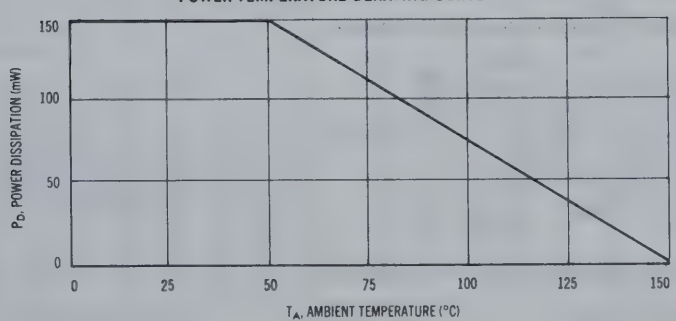
CASE 51
(DO-7)

PNPN 4-layer diodes, two-terminal, fast switching devices specifically designed for low voltage applications such as logic circuits, pulse generators, memory and relay devices, relay replacement, alarm circuit, multivibrators, ring counters, and signal switching circuits. These devices feature low breakover (switching) voltage, fast switching speeds, low junction capacitance, low breakover currents, and sub-miniature package.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage 1N5158 (M4L3052) 1N5159 (M4L3053) 1N5160 (M4L3054) (M4L3055) (M4L3056)	$V_{RM(rep)}$	 10 11 12 13 14	Volts
Continuous Forward Current	I_F	150	mA
Steady State Power Dissipation @ $T_A = 50°C$ Derate above $50°C$	P_D	150 1.5	mW mW/°C
Peak Pulse Current (50 μs maximum pulse width)	I_{pulse}	 10	Amp
Operating Junction Temperature Range	T_J	-65 to +150	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

POWER-TEMPERATURE DERATING CURVE

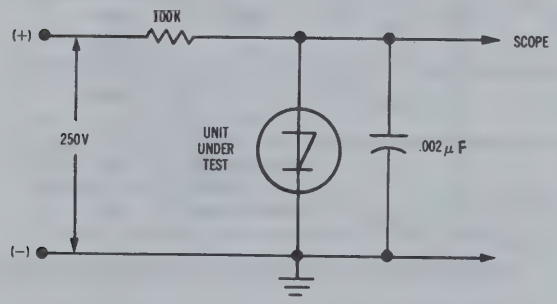


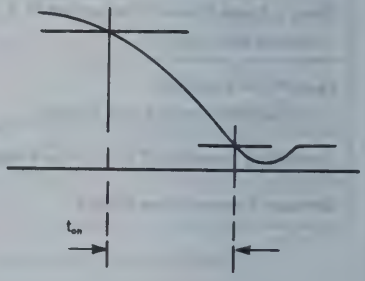
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Forward Breakover (Switching) Voltage	$V_{(BR)F}$				Volts
1N5158 (M4L3052)		8.0	–	10	
1N5159 (M4L3053)		9.0	–	11	
1N5160 (M4L3054)		10	–	12	
(M4L3055)		–	–	13	
(M4L3056)		–	–	14	
Forward Breakover (Switching) Current	$I_{(BR)F}$	–	5.0	50	μA
Forward Blocking Current (Measured at 75% of $V_{(BR)F}$)	I_{FM}	–	1.0	5.0	μA
Reverse Blocking Current (Measured at rated $V_{RM(rep)}$)	I_{RM}	–	2.0	10	μA
Holding Current	I_{HO}	1.0	4.0	20	mA
Forward On Voltage (I_F = 150 mAdc)	V_F	–	1.0	1.5	Volts
Junction Capacitance (AC Voltage = 10 mV, V_F = 0, f = 100 kHz)	C_J	–	42	–	pF
Turn-On Time*	t_{on}	–	50*	–	ns
Turn-Off Time*	t_{off}	–	100*	–	ns

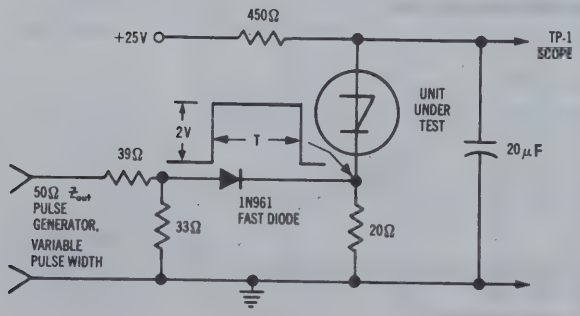
*Time depends on a wide variety of circuit conditions. Consult manufacturer for further information.

TURN-ON TIME TEST CIRCUIT





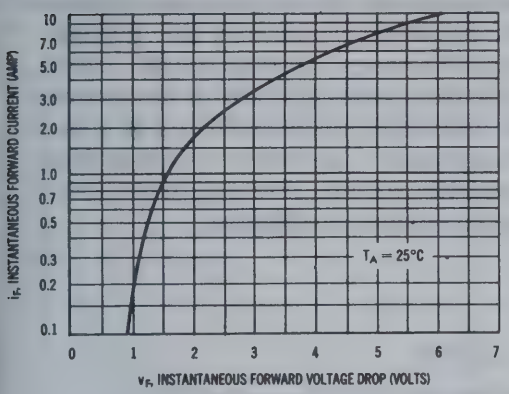
TURN-OFF TIME TEST CIRCUIT



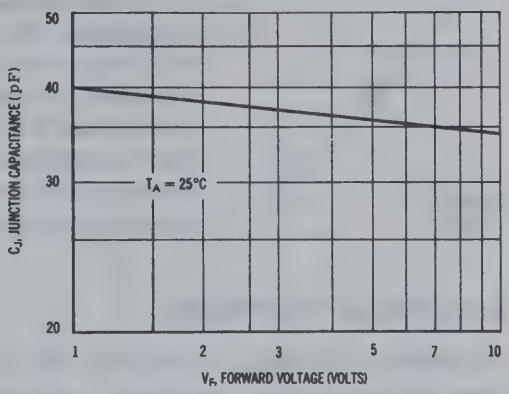


When sawtooth waveform appears at TP-1, $T = t_{off}$

TYPICAL FORWARD CONDUCTION CHARACTERISTICS

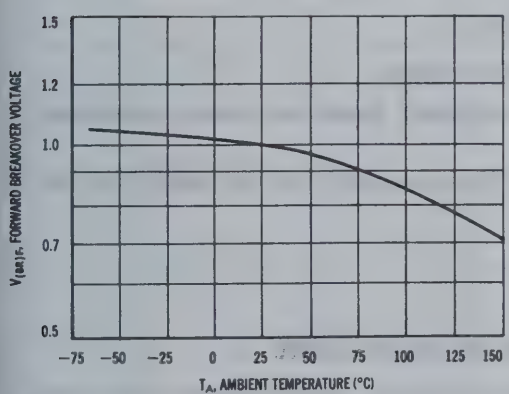


TYPICAL CAPACITANCE

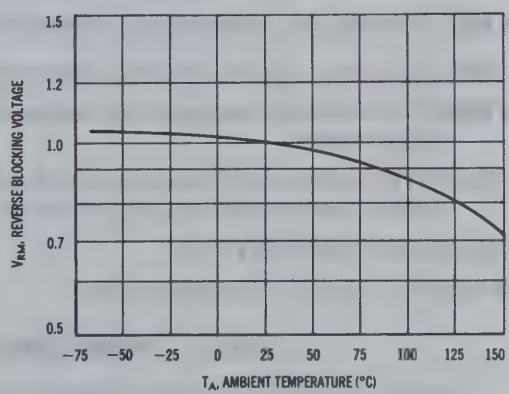


TYPICAL DC CHARACTERISTICS versus TEMPERATURE
(NORMALIZED to 25°C VALUE)

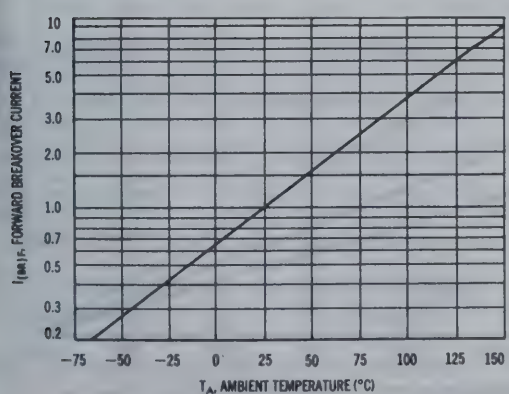
FORWARD BREAKOVER VOLTAGE



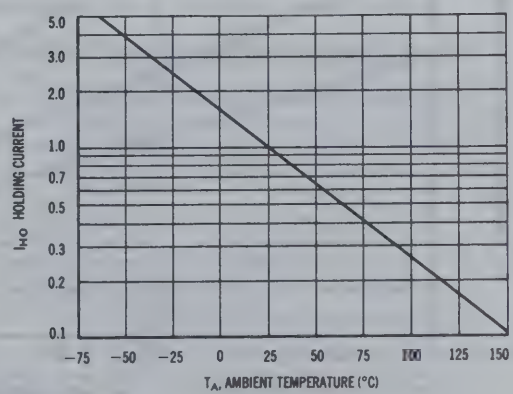
REVERSE BLOCKING VOLTAGE



FORWARD BREAKOVER CURRENT

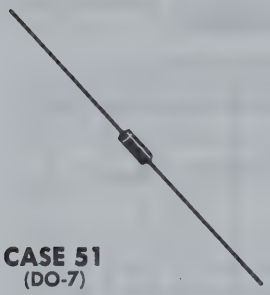


HOLDING CURRENT



1N5221 thru 1N5281 series

P_D = 500 mW
V_Z = 2.4-200 V



CASE 51
(DO-7)

500 Milliwatt surmetic 20 silicon zener diodes-a complete series of Zener Diodes in the popular DO-7 case with higher ratings, tighter limits, better operating characteristics and a full set of designers' curves that reflect the superior capabilities of silicon-oxide-passivated junctions. All this in an axial-lead, transfer-molded plastic package offering protection in all common environmental conditions.

MAXIMUM RATINGS

Junction and Storage Temperature: −65 to +200°C

Lead Temperature not less than 1/16" from the case for 10 seconds: 230°C

DC Power Dissipation: 500 mW @ T_L = 75°C, Lead Length = 3/8"
(Derate 4.0 mW/°C above 75°C)

Surge Power: 10 Watts (Non-recurrent square wave @ PW = 8.3 ms, T_J = 55°C, Figure 16)

MECHANICAL CHARACTERISTICS

CASE: Void free, transfer molded, thermosetting plastic.

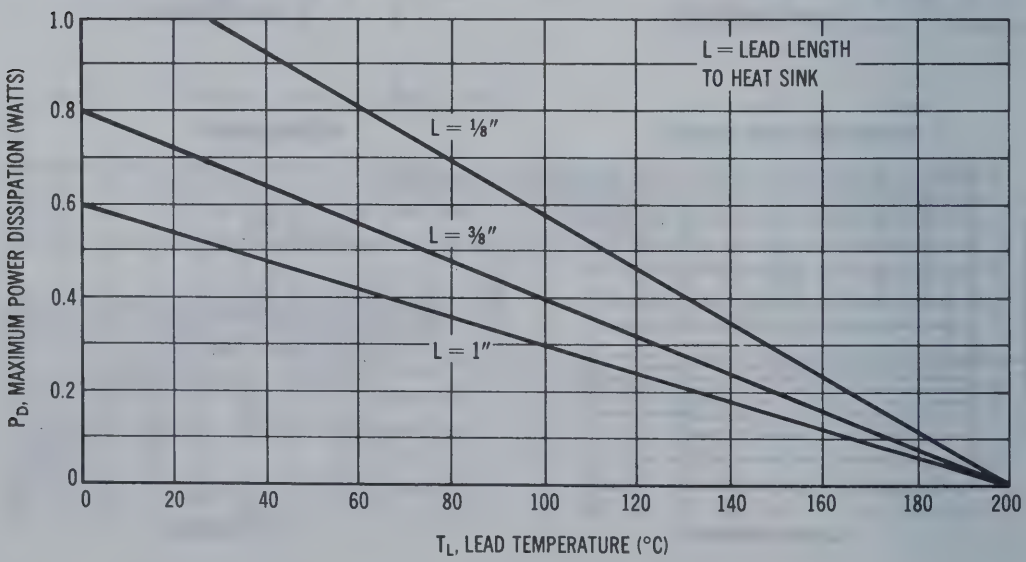
FINISH: All external surfaces are corrosion resistant. Leads are readily solderable and weldable.

POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.

MOUNTING POSITION: Any.

WEIGHT: 0.18 gram (approximately).

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted. Based on dc measurements at thermal equilibrium; lead length = 3/8"; thermal resistance of heat sink = 30°C/W) $V_F = 1.1$ Max @ $I_F = 200$ mA for all types.

JEDEC Type No. (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mA	Max Zener Impedance A & B Suffix Only		Max Reverse Leakage Current				Max Zener Voltage Temp. Coeff. (A & B Suffix Only) θ_{VZ} (%/°C) (Note 3)
					A & B Suffix Only			Non-Suffix	
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} = 0.25 mA Ohms	I_R μA	@ V_R Volts A	B	I_R @ V_R Used For Suffix A μA	
1N5221	2.4	20	30	1200	100	0.95	1.0	200	-0.085
1N5222	2.5	20	30	1250	100	0.95	1.0	200	-0.085
1N5223	2.7	20	30	1300	75	0.95	1.0	150	-0.080
1N5224	2.8	20	30	1400	75	0.95	1.0	150	-0.080
1N5225	3.0	20	29	1600	50	0.95	1.0	100	-0.075
1N5226	3.3	20	28	1600	25	0.95	1.0	100	-0.070
1N5227	3.6	20	24	1700	15	0.95	1.0	100	-0.065
1N5228	3.9	20	23	1900	10	0.95	1.0	75	-0.060
1N5229	4.3	20	22	2000	5.0	0.95	1.0	50	±0.055
1N5230	4.7	20	19	1900	5.0	1.9	2.0	50	±0.030
1N5231	5.1	20	17	1600	5.0	1.9	2.0	50	±0.030
1N5232	5.6	20	11	1600	5.0	2.9	3.0	50	+0.038
1N5233	6.0	20	7.0	1600	5.0	3.3	3.5	50	+0.038
1N5234	6.2	20	7.0	1000	5.0	3.8	4.0	50	+0.045
1N5235	6.8	20	5.0	750	3.0	4.8	5.0	30	+0.050
1N5236	7.5	20	6.0	500	3.0	5.7	6.0	30	+0.058
1N5237	8.2	20	8.0	500	3.0	6.2	6.5	30	+0.062
1N5238	8.7	20	8.0	600	3.0	6.2	6.5	30	+0.065
1N5239	9.1	20	10	600	3.0	6.7	7.0	30	+0.068
1N5240	10	20	17	600	3.0	7.6	8.0	30	+0.075
1N5241	11	20	22	600	2.0	8.0	8.4	30	+0.076
1N5242	12	20	30	600	1.0	8.7	9.1	10	+0.077
1N5243	13	9.5	13	600	0.5	9.4	9.9	10	+0.079
1N5244	14	9.0	15	600	0.1	9.5	10	10	+0.082
1N5245	15	8.5	16	600	0.1	10.5	11	10	+0.082
1N5246	16	7.8	17	600	0.1	11.4	12	10	+0.083
1N5247	17	7.4	19	600	0.1	12.4	13	10	+0.084
1N5248	18	7.0	21	600	0.1	13.3	14	10	+0.085
1N5249	19	6.6	23	600	0.1	13.3	14	10	+0.086
1N5250	20	6.2	25	600	0.1	14.3	15	10	+0.086
1N5251	22	5.6	29	600	0.1	16.2	17	10	+0.087
1N5252	24	5.2	33	600	0.1	17.1	18	10	+0.088
1N5253	25	5.0	35	600	0.1	18.1	19	10	+0.089
1N5254	27	4.6	41	600	0.1	20	21	10	+0.090
1N5255	28	4.5	44	600	0.1	20	21	10	+0.091
1N5256	30	4.2	49	600	0.1	22	23	10	+0.091
1N5257	33	3.8	58	700	0.1	24	25	10	+0.092
1N5258	36	3.4	70	700	0.1	26	27	10	+0.093
1N5259	39	3.2	80	800	0.1	29	30	10	+0.094
1N5260	43	3.0	93	900	0.1	31	33	10	+0.095
1N5261	47	2.7	105	1000	0.1	34	36	10	+0.095
1N5262	51	2.5	125	1100	0.1	37	39	10	+0.096
1N5263	56	2.2	150	1300	0.1	41	43	10	+0.096
1N5264	60	2.1	170	1400	0.1	44	46	10	+0.097
1N5265	62	2.0	185	1400	0.1	45	47	10	+0.097
1N5266	68	1.8	230	1600	0.1	49	52	10	+0.097
1N5267	75	1.7	270	1700	0.1	53	56	10	+0.098
1N5268	82	1.5	330	2000	0.1	59	62	10	+0.098
1N5269	87	1.4	370	2200	0.1	65	68	10	+0.099
1N5270	91	1.4	400	2300	0.1	66	69	10	+0.099
1N5271	100	1.3	500	2600	0.1	72	76	10	+0.110
1N5272	110	1.1	750	3000	0.1	80	84	10	+0.110
1N5273	120	1.0	900	4000	0.1	86	91	10	+0.110
1N5274	130	0.95	1100	4500	0.1	94	99	10	+0.110
1N5275	140	0.90	1300	4500	0.1	101	106	10	+0.110
1N5276	150	0.85	1500	5000	0.1	108	114	10	+0.110
1N5277	160	0.80	1700	5500	0.1	116	122	10	+0.110
1N5278	170	0.74	1900	5500	0.1	123	129	10	+0.110
1N5279	180	0.68	2200	6000	0.1	130	137	10	+0.110
1N5280	190	0.66	2400	6500	0.1	137	144	10	+0.110
1N5281	200	0.65	2500	7000	0.1	144	152	10	+0.110

NOTE 1 — TOLERANCE AND VOLTAGE DESIGNATION

Tolerance designation — The JEDEC type numbers shown indicate a tolerance of ±10% with guaranteed limits on only V_Z, I_R and V_F as shown in the above table. Units with guaranteed limits on all six parameters are indicated by suffix "A" for ±10% tolerance and suffix "B" for ±5.0% units.

Non-Standard voltage designation — To designate units with zener voltages other than those assigned JEDEC numbers, the type number should be used.

EXAMPLE:



NOTE 2 — SPECIAL SELECTIONS AVAILABLE INCLUDE:

— Nominal zener voltages between those shown.

2 — Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.

a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.

b. Two or more units matched to one another with any specified tolerance.

3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

NOTE 3 — TEMPERATURE COEFFICIENT (θ_{VZ})

Test conditions for temperature coefficient are as follows:

a. $I_{ZT} = 7.5$ mA, $T_1 = 25°C$, $T_2 = 125°C$ (1N5221A, B thru 1N5242A, B.)

b. I_{ZT} = Rated I_{ZT}, $T_1 = 25°C$, $T_2 = 125°C$ (1N5243A, B thru 1N5281A, B.)

Device to be temperature stabilized with current applied prior to reading breakdown voltage at the specified ambient temperature.

TYPICAL REVERSE CHARACTERISTICS FOR SELECTED ZENER DIODES

Curves marked T_A were obtained from dc measurements at thermal equilibrium; lead length = ⅜"; thermal resistance of heat sink = 30°C/W.
Curves marked T_J were obtained from pulse tests; mounting conditions are not a factor.

$V_{Z(Nominal)} = 3.3$ Volts

FIGURE 2

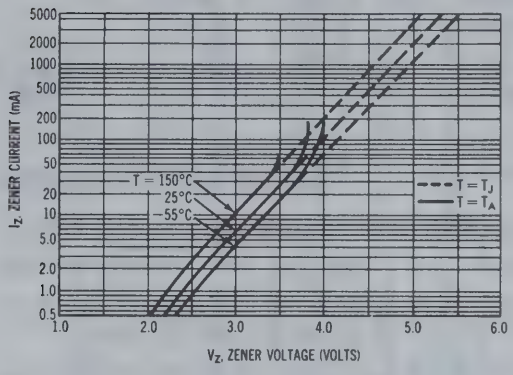
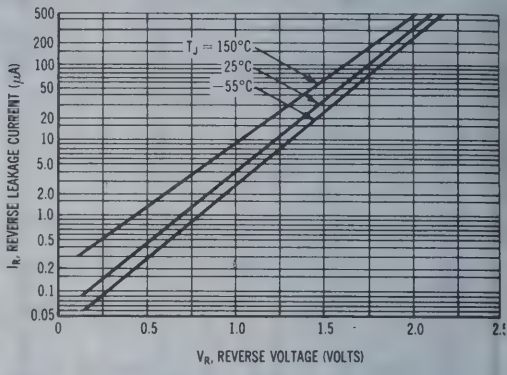


FIGURE 3



$V_{Z(Nominal)} = 5.1$ Volts

FIGURE 4

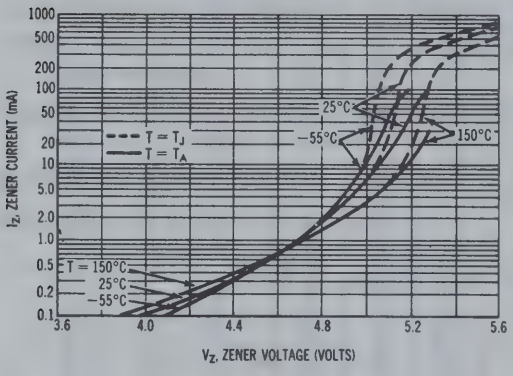
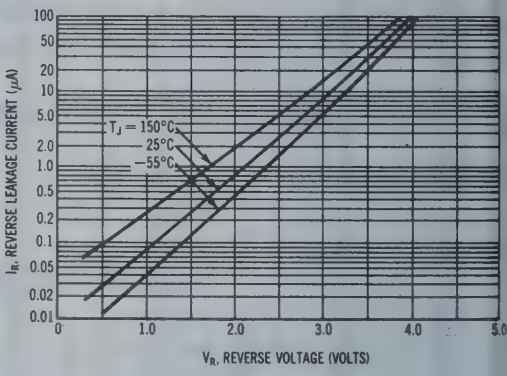


FIGURE 5



$V_{Z(Nominal)} = 27$ Volts

FIGURE 6

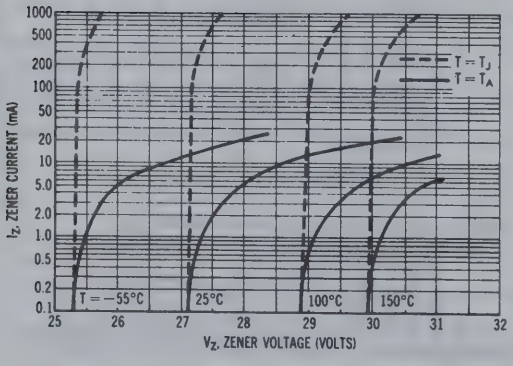
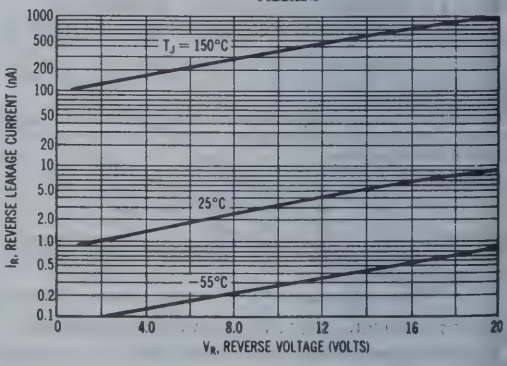


FIGURE 7



TEMPERATURE COEFFICIENTS AND VOLTAGE REGULATION

(90% of the units are in the ranges indicated)

FIGURE 8 — RANGE FOR UNITS TO 12 VOLTS

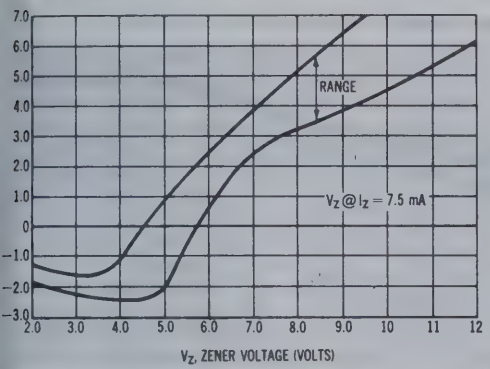


FIGURE 9 — RANGE FOR UNITS 12 TO 200 VOLTS

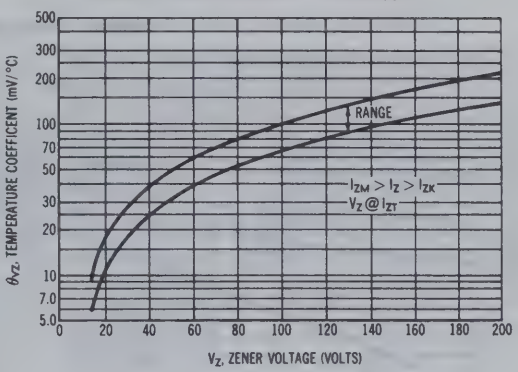


FIGURE 10 — EFFECT OF ZENER CURRENT

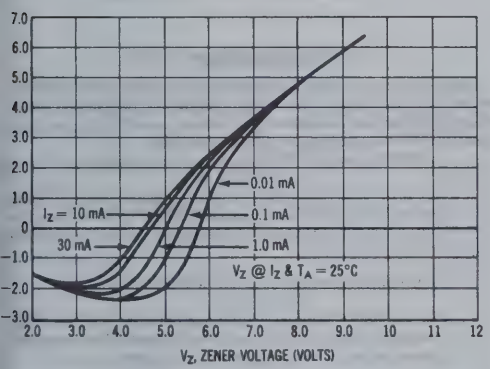
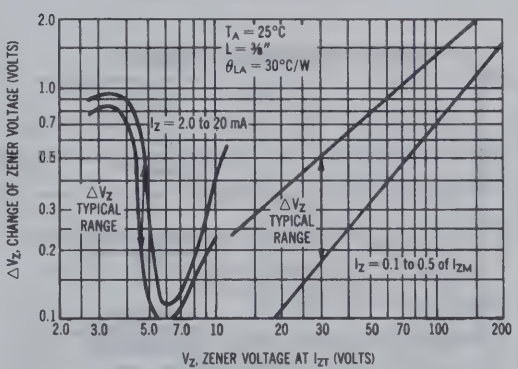


FIGURE 11 — VOLTAGE REGULATION



TYPICAL ZENER IMPEDANCE

FIGURE 12 — EFFECT OF ZENER CURRENT

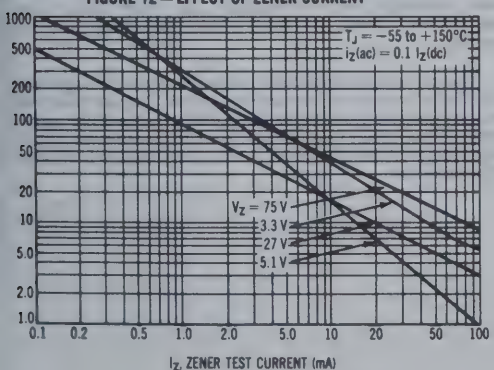


FIGURE 13 — EFFECT OF ZENER VOLTAGE

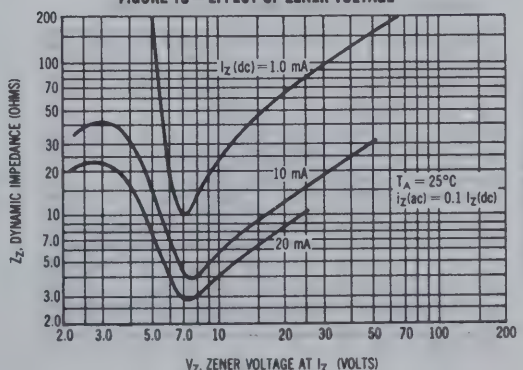


FIGURE 14 — TYPICAL THERMAL RESPONSE

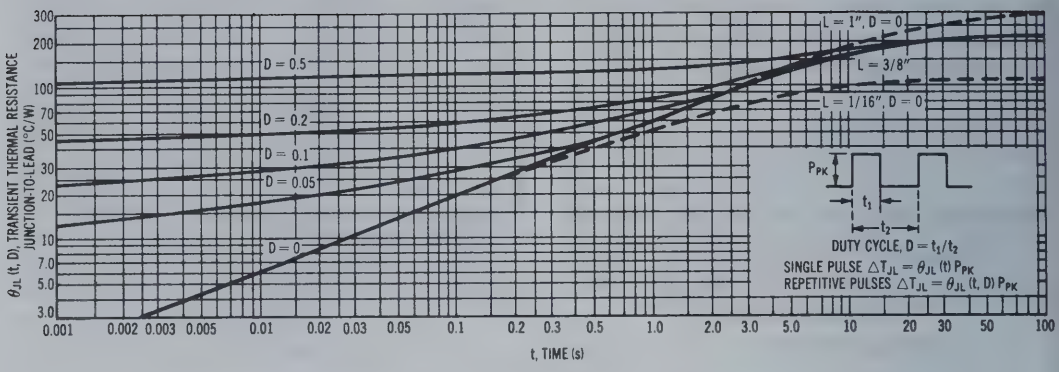


FIGURE 15 — TYPICAL THERMAL RESISTANCE

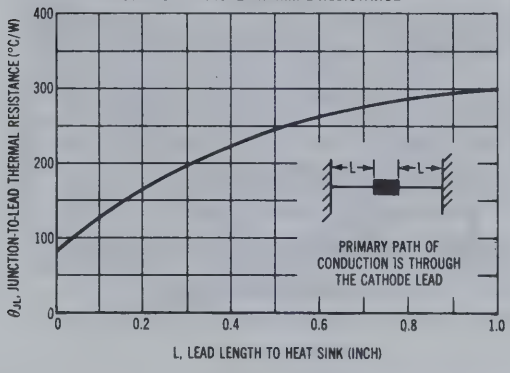
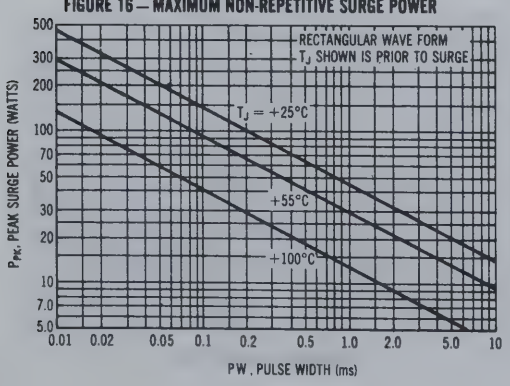


FIGURE 16 — MAXIMUM NON-REPETITIVE SURGE POWER



APPLICATION NOTE

Since the actual voltage available from a given zener diode is temperature dependent, it is necessary to determine junction temperature under any set of operating conditions, in order to calculate its value. The following procedure is recommended:

Lead Temperature, T_L, should be determined from:

$$T_L = \theta_{LA} P_D + T_A$$

θ_{LA} is the lead-to-ambient thermal resistance and P_D is the power dissipation. θ_{LA} is generally 30-40°C/W for the various clips and tie points in common use and for printed circuit board wiring.

Junction Temperature, T_J, may be found from:

$$T_J = T_L + \Delta T_{JL}$$

ΔT_{JL} is the increase in junction temperature above the lead temperature and may be found from Figure 14 for a train of power pulses or from Figure 15 for dc power.

For worst-case design, using expected limits of I_Z, limits of P_D and the extremes of T_J (ΔT_J) may be estimated. Changes in voltage, V_Z, can then be found from:

$$\Delta V = \theta_{VZ} \Delta T_J$$

θ_{VZ}, the zener voltage temperature coefficient, is found from Figures 8, 9, and 10.

Under high power-pulse operation, the zener voltage will vary with time and may also be affected significantly by the zener resistance. For best regulation, use short leads, especially to the cathode, and keep current excursions as low as possible.

Data of Figure 14 should not be used to compute surge capability. Surge limitations are given in Figure 16. They are lower than would be expected by considering only junction temperature, as current crowding effects cause temperatures to be extremely high in small spots resulting in device degradation should the limits of Figure 16 be exceeded.

FIGURE 17 — TYPICAL CAPACITANCE

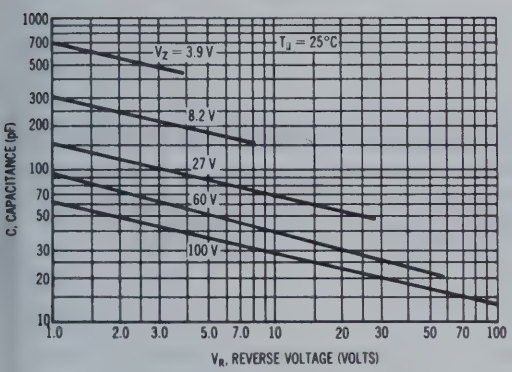


FIGURE 18 — TYPICAL FORWARD CHARACTERISTICS

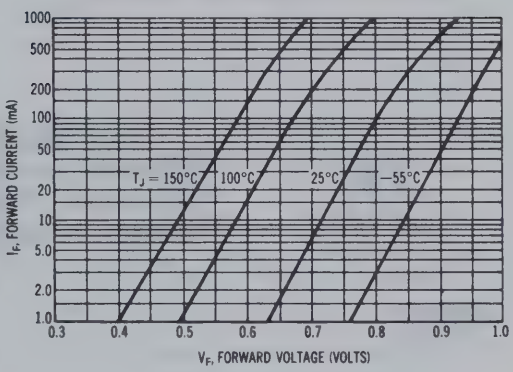


FIGURE 19 — TYPICAL NOISE DENSITY

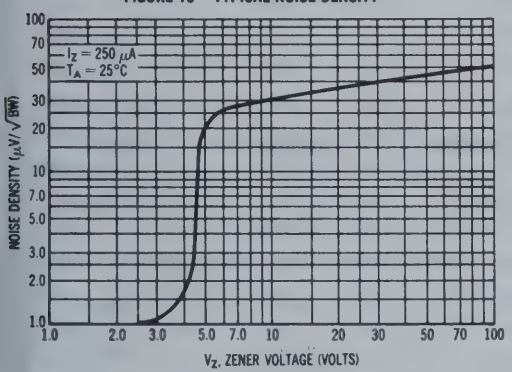
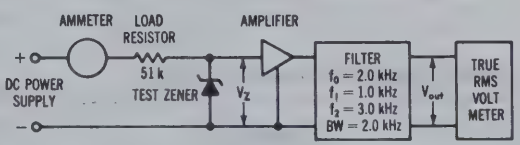


FIGURE 20 — NOISE DENSITY MEASUREMENT METHOD



$$\text{NOISE DENSITY (VOLTS PER SQUARE ROOT BANDWIDTH)} = \frac{V_{out}}{\text{OVERALL GAIN } \sqrt{BW}}$$

WHERE: BW = FILTER BANDWIDTH (Hz)
V_{out} = OUTPUT NOISE (VOLTS RMS)

The input voltage and load resistance are high so that the zener diode is driven from a constant current source. The amplifier is low noise so that the amplifier noise is negligible compared to that of the test zener. The filter bandpass is known so that the noise density can be calculated from the formula shown. The data of Figure 19 and the formula can also be used to find noise for any system bandwidth.

1N5283 thru 1N5314



CASE 51
(DO-7)

Field-effect current regulator diodes are circuit elements that provide a current essentially independent of voltage. These diodes are especially designed for maximum impedance over the operating range.

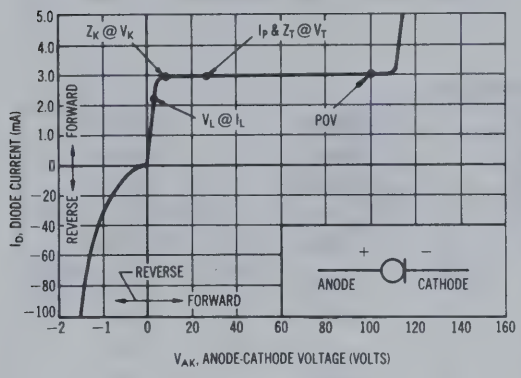
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Operating Voltage (T_J = -55°C to +200°C)	POV	100	Volts
Steady State Power Dissipation @ T_L = 75°C	P_D	600	mW
Derate above T_L = 75°C		4.8	mW/°C
Lead Length = 3/8" (Forward or Reverse Bias)			
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

	Regulator Current I_P (mA) @ V_T = 25 V			Minimum Dynamic Impedance @V_T = 25 V Z_T (MΩ)	Minimum Knee Impedance @V_K = 6.0 V Z_K (MΩ)	Maximum Limiting Voltage @I_L = 0.8 I_P (min) V_L (Volts)
Type No.	nom	min	max			
1N5283	0.22	0.198	0.242	25.0	2.75	1.00
1N5284	0.24	0.216	0.264	19.0	2.35	1.00
1N5285	0.27	0.243	0.297	14.0	1.95	1.00
1N5286	0.30	0.270	0.330	9.0	1.60	1.00
1N5287	0.33	0.297	0.363	6.6	1.35	1.00
1N5288	0.39	0.351	0.429	4.10	1.00	1.05
1N5289	0.43	0.387	0.473	3.30	0.870	1.05
1N5290	0.47	0.423	0.517	2.70	0.750	1.05
1N5291	0.56	0.504	0.616	1.90	0.560	1.10
1N5292	0.62	0.558	0.682	1.55	0.470	1.13
1N5293	0.68	0.612	0.748	1.35	0.400	1.15
1N5294	0.75	0.675	0.825	1.15	0.335	1.20
1N5295	0.82	0.738	0.902	1.00	0.290	1.25
1N5296	0.91	0.819	1.001	0.880	0.240	1.29
1N5297	1.00	0.900	1.100	0.800	0.205	1.35
1N5298	1.10	0.990	1.210	0.700	0.180	1.40
1N5299	1.20	1.08	1.32	0.640	0.155	1.45
1N5300	1.30	1.17	1.43	0.580	0.135	1.50
1N5301	1.40	1.26	1.54	0.540	0.115	1.55
1N5302	1.50	1.35	1.65	0.510	0.105	1.60
1N5303	1.60	1.44	1.76	0.475	0.092	1.65
1N5304	1.80	1.62	1.98	0.420	0.074	1.75
1N5305	2.00	1.80	2.20	0.395	0.061	1.85
1N5306	2.20	1.98	2.42	0.370	0.052	1.95
1N5307	2.40	2.16	2.64	0.345	0.044	2.00
1N5308	2.70	2.43	2.97	0.320	0.035	2.15
1N5309	3.00	2.70	3.30	0.300	0.029	2.25
1N5310	3.30	2.97	3.63	0.280	0.024	2.35
1N5311	3.60	3.24	3.96	0.265	0.020	2.50
1N5312	3.90	3.51	4.29	0.255	0.017	2.60
1N5313	4.30	3.87	4.73	0.245	0.014	2.75
1N5314	4.70	4.23	5.17	0.235	0.012	2.90

FIGURE 1 — TYPICAL CURRENT REGULATOR CHARACTERISTICS



SYMBOLS AND DEFINITIONS

I_D — Diode Current.

I_L — Limiting Current: 80% of I_P minimum used to determine Limiting voltage, V_L.

I_P — Pinch-off Current: Regulator current at specified Test Voltage, V_T.

POV — Peak Operating Voltage: Maximum voltage to be applied to device.

θ_I — Current Temperature Coefficient.

V_{AK} — Anode-to-cathode Voltage.

V_K — Knee Impedance Test Voltage: Specified voltage used to establish Knee Impedance, Z_K.

V_L — Limiting Voltage: Measured at I_L. V_L, together with Knee AC Impedance, Z_K, indicates the Knee characteristics of the device.

V_T — Test Voltage: Voltage at which I_P and Z_T are specified.

Z_K — Knee AC Impedance at Test Voltage: To test for Z_K, a 90 Hz signal v_K with RMS value equal to 10% of test voltage, V_K, is superimposed on V_K:

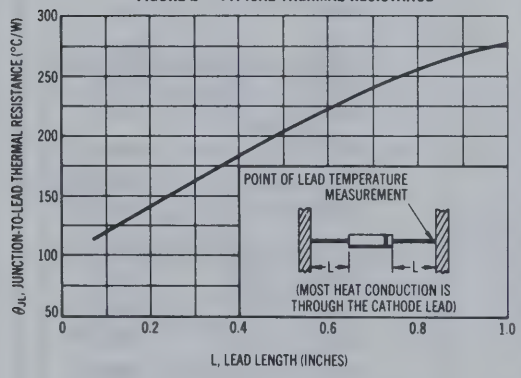
$$Z_K = v_K / i_K$$

where i_K is the resultant ac current due to v_K

To provide the most constant current from the diode, Z_K should be as high as possible; therefore, a minimum value of Z_K is specified.

Z_T — AC Impedance at Test Voltage: Specified as a minimum value. To test for Z_T, a 90 Hz signal with RMS value equal to 10% of Test Voltage, V_T, is superimposed on V_T.

FIGURE 2 — TYPICAL THERMAL RESISTANCE



APPLICATION NOTE

As the current available from the diode is temperature dependent, it is necessary to determine junction temperature, T_J, under specific operating conditions to calculate the value of the diode current. The following procedure is recommended:

Lead Temperature, T_L, shall be determined from:

$$T_L = \theta_{LA} P_D + T_A$$

where θ_{LA} is lead-to-ambient thermal resistance
and P_D is power dissipation.

θ_{LA} is generally 30-40°C/W for the various clips and tie points in common use, and for printed circuit-board wiring.

Junction Temperature, T_J, shall be calculated from:

$$T_J = T_L + \theta_{JL} P_D$$

where θ_{JL} is taken from Figure 2.

For circuit design limits of V_{AK}, limits of P_D may be estimated and extremes of T_J may be computed. Using the information on Figures 4 and 5, changes in current may be found. To improve current regulation, keep V_{AK} low to reduce P_D and keep the leads short, especially the cathode lead, to reduce θ_{JL}.

FIGURE 3 — TYPICAL FORWARD CHARACTERISTICS

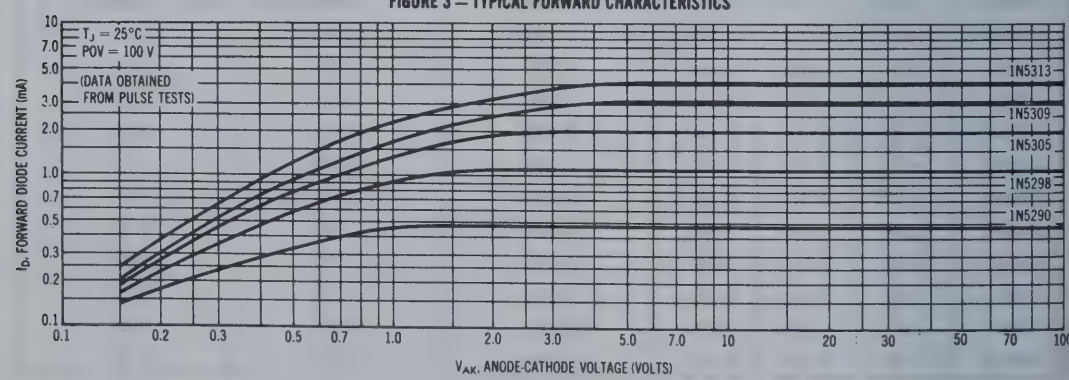


FIGURE 4 — TEMPERATURE COEFFICIENT

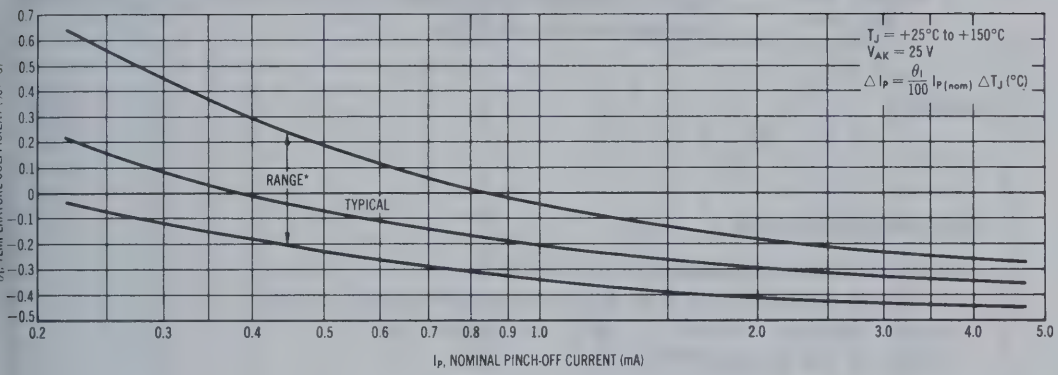


FIGURE 5 — TEMPERATURE COEFFICIENT

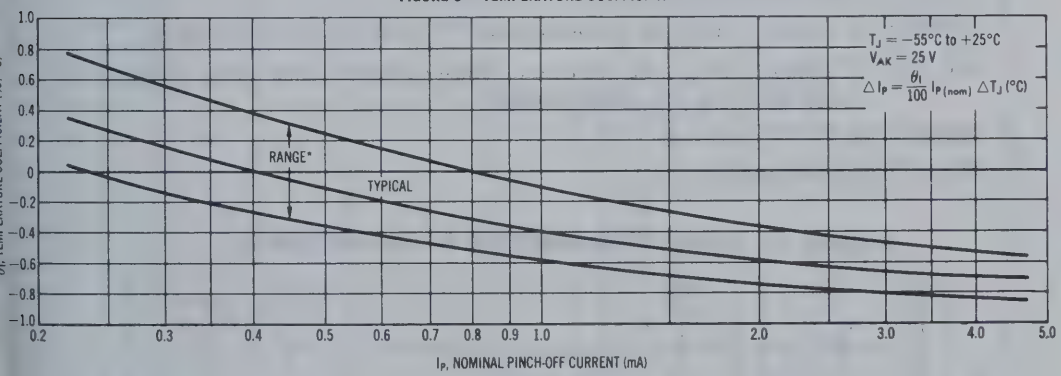
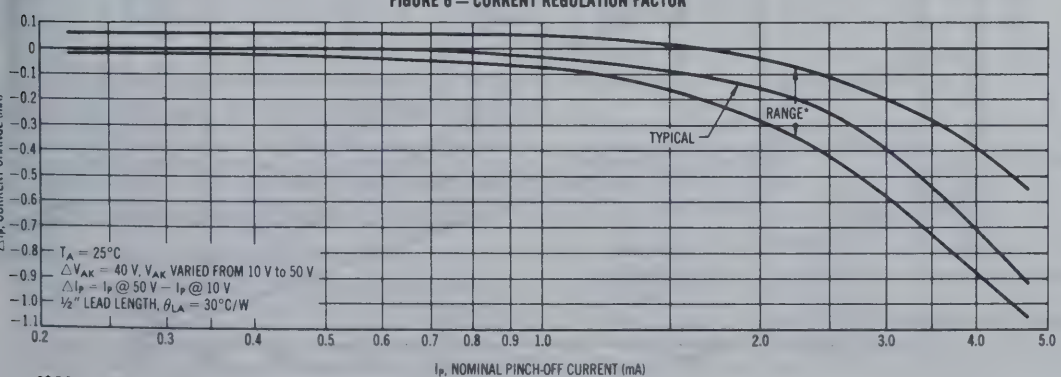


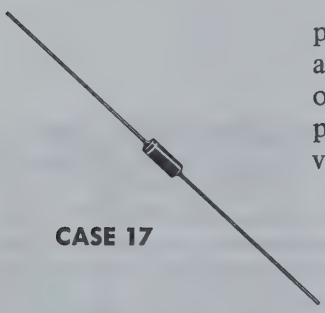
FIGURE 6 — CURRENT REGULATION FACTOR



*90% of the units will be in the ranges shown.

1N5333 (SILICON) thru 1N5388

V_Z = 3.3 to 200 V



CASE 17

5.0 Watt surmetic 40 silicon zener diodes (silicon oxide passivated) with tight limits and better operating characteristics that reflect the superior capabilities of silicon-oxide-passivated junctions. An axial-lead, transfer-molded plastic package that offers protection in all common environmental conditions.

MAXIMUM RATINGS

Junction and Storage Temperature: −65 to +200°C

Lead Temperature not less than 1/16" from the case for 10 seconds: 230°C

DC Power Dissipation: 5.0 W @ T_L = 75°C, Lead Length = 3/8"
(Derate 40 mW/°C above 75°C)

MECHANICAL CHARACTERISTICS

CASE: Void-free, transfer-molded, thermosetting plastic

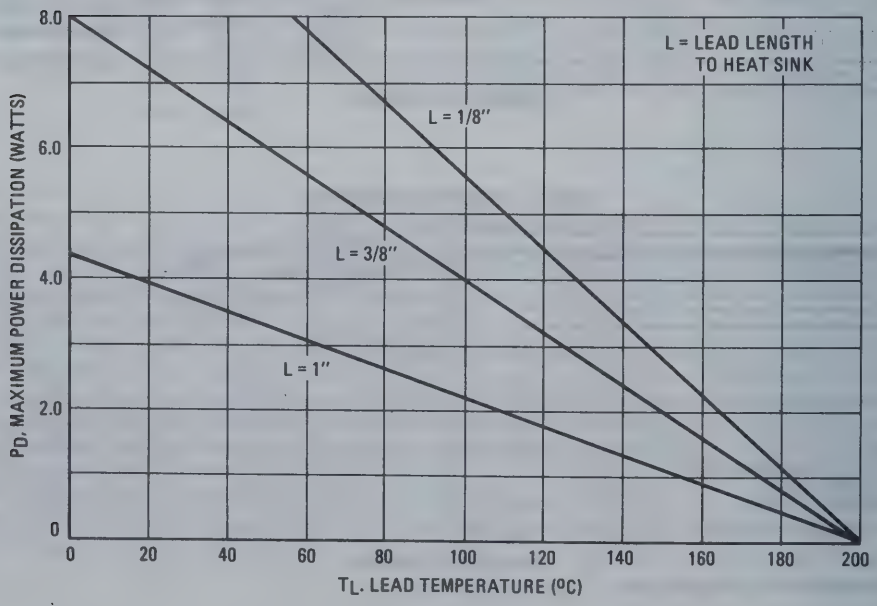
FINISH: All external surfaces are corrosion resistant. Leads are readily solderable

POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.

MOUNTING POSITION: Any

WEIGHT: 0.7 gram (approx)

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE

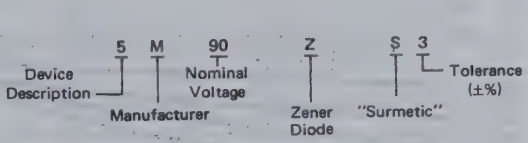


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) V_F = 1.2 Max @ I_F = 1.0 A for all types

JEDEC Type No. (Note 1 & 2)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 3)	Test Current I_{ZT} mA	Max Zener Impedance A & B Suffix Only		Max Reverse Leakage Current			Applies to all Suffix	A & B Suffix Only	Maximum Regulator Current I_{ZM} mA
			Z_{ZT} @ I_{ZT} Ohms (Note 3)	Z_{ZK} @ I_{ZK} = 1.0 mA Ohms (Note 3)	I_R μA	@	V_R Volts	Max Surge Current i_r, Amps	Max Voltage Regulation ΔV_Z, Volts	
						Non & A Suffix	B-Suffix	(Note 4)	(Note 5)	(Note 6)
1N5333	3.3	380	3.0	400	300	1.0	1.0	20.0	0.85	1440
1N5334	3.6	350	2.5	500	150	1.0	1.0	18.7	0.80	1320
1N5335	3.9	320	2.0	500	50	1.0	1.0	17.6	0.54	1220
1N5336	4.3	290	2.0	500	10	1.0	1.0	16.4	0.49	1100
1N5337	4.7	260	2.0	450	5.0	1.0	1.0	15.3	0.44	1010
1N5338	5.1	240	1.5	400	1.0	1.0	1.0	14.4	0.39	930
1N5339	5.6	220	1.0	400	1.0	2.0	2.0	13.4	0.25	865
1N5340	6.0	200	1.0	300	1.0	3.0	3.0	12.7	0.19	790
1N5341	6.2	200	1.0	200	1.0	3.0	3.0	12.4	0.10	765
1N5342	6.8	175	1.0	200	10	4.9	5.2	11.5	0.15	700
1N5343	7.5	175	1.5	200	10	5.4	5.7	10.7	0.15	630
1N5344	8.2	150	1.5	200	10	5.9	6.2	10.0	0.20	580
1N5345	8.7	150	2.0	200	10	6.3	6.6	9.5	0.20	545
1N5346	9.1	150	2.0	150	7.5	6.6	6.9	9.2	0.22	520
1N5347	10	125	2.0	125	5.0	7.2	7.6	8.6	0.22	475
1N5348	11	125	2.5	125	5.0	8.0	8.4	8.0	0.25	430
1N5349	12	100	2.5	125	2.0	8.6	9.1	7.5	0.25	395
1N5350	13	100	2.5	100	1.0	9.4	9.9	7.0	0.25	365
1N5351	14	100	2.5	75	1.0	10.1	10.6	6.7	0.25	340
1N5352	15	75	2.5	75	1.0	10.8	11.5	6.3	0.25	315
1N5353	16	75	2.5	75	1.0	11.5	12.2	6.0	0.30	295
1N5354	17	70	2.5	75	0.5	12.2	12.9	5.8	0.35	280
1N5355	18	65	2.5	75	0.5	13.0	13.7	5.5	0.40	264
1N5356	19	65	3.0	75	0.5	13.7	14.4	5.3	0.40	250
1N5357	20	65	3.0	75	0.5	14.4	15.2	5.1	0.40	237
1N5358	22	50	3.5	75	0.5	15.8	16.7	4.7	0.45	216
1N5359	24	50	3.5	100	0.5	17.3	18.2	4.4	0.55	198
1N5360	25	50	4.0	110	0.5	18.0	19.0	4.3	0.55	190
1N5361	27	50	5.0	120	0.5	19.4	20.6	4.1	0.60	176
1N5362	28	50	6.0	130	0.5	20.1	21.2	3.9	0.60	170
1N5363	30	40	8.0	140	0.5	21.6	22.8	3.7	0.60	158
1N5364	33	40	10	150	0.5	23.8	25.1	3.5	0.60	144
1N5365	36	30	11	160	0.5	25.9	27.4	3.3	0.65	132
1N5366	39	30	14	170	0.5	28.1	29.7	3.1	0.65	122
1N5367	43	30	20	190	0.5	31.0	32.7	2.8	0.70	110
1N5368	47	25	25	210	0.5	33.8	35.8	2.7	0.80	100
1N5369	51	25	27	230	0.5	36.7	38.8	2.5	0.90	93.0
1N5370	56	20	35	280	0.5	40.3	42.6	2.3	1.00	86.0
1N5371	60	20	40	350	0.5	43.0	45.5	2.2	1.20	79.0
1N5372	62	20	42	400	0.5	44.6	47.1	2.1	1.35	76.0
1N5373	68	20	44	500	0.5	49.0	51.7	2.0	1.50	70.0
1N5374	75	20	45	620	0.5	54.0	56.0	1.9	1.60	63.0
1N5375	82	15	65	720	0.5	59.0	62.2	1.8	1.80	58.0
1N5376	87	15	75	760	0.5	63.0	66.0	1.7	2.00	54.5
1N5377	91	15	75	760	0.5	65.5	69.2	1.6	2.20	52.5
1N5378	100	12	90	800	0.5	72.0	76.0	1.5	2.50	47.5
1N5379	110	12	125	1000	0.5	79.2	83.6	1.4	2.50	43.0
1N5380	120	10	170	1150	0.5	86.4	91.2	1.3	2.50	39.5
1N5381	130	10	190	1250	0.5	93.6	98.8	1.2	2.50	36.6
1N5382	140	8.0	230	1500	0.5	101	106	1.2	2.50	34.0
1N5383	150	8.0	330	1500	0.5	108	114	1.1	3.00	31.6
1N5384	160	8.0	350	1650	0.5	115	122	1.1	3.00	29.4
1N5385	170	8.0	380	1750	0.5	122	129	1.0	3.00	28.0
1N5386	180	5.0	430	1750	0.5	130	137	1.0	4.00	26.4
1N5387	190	5.0	450	1850	0.5	137	144	0.9	5.00	25.0
1N5388	200	5.0	480	1850	0.5	144	152	0.9	5.00	23.6

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

TOLERANCE DESIGNATION – The JEDEC type numbers shown indicate a tolerance of ±20% with guaranteed limits on only V_Z, I_R, i_r, and V_F as shown in the electrical characteristics table. Units with guaranteed limits on all seven parameters are indicated by suffix "A" for ±10% tolerance and suffix "B" for ±5.0% units.



Example: **5M90ZS3**

NOTE 2 – SPECIALS AVAILABLE INCLUDE:

(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES: To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances (±3%, ±2%, ±1%), the Mfg. type number should be used.

(B) MATCHED SETS: (Standard Tolerances are ±5.0%, ±2.0%, ±1.0%).

Zener diodes can be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets is similar to the one described in (A) for specifying units

with a special voltage and/or tolerance except that two extra suffixes are added to the code number described.

These units are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number, which is different for each set being ordered.

5	M	5 1	Z	S	5	B	1
Device Description	Manufacturer	51 Volts (each device)	Zener Diodes	"Surmetic"	Tolerance per device (±5%) (omit for ±20% units)	Code* (A-Not used)	Overall Tolerance of set (±1%)

*Code:
B – Two devices in series
C – Three devices in series
D – Four devices in series

Example: **5M51ZS5B1**

(C) ZENER CLIPPERS: (Standard Tolerance ±10% and ±5%).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:

5	M	20,	Z	Z	10
Device Description	Manufacturer	Nominal Voltage	Zener Diodes	Clipper	Tolerance for each of the two Zener voltages (not a matching requirement)

Example: **5M20ZZ10**

NOTE 3 – ZENER VOLTAGE (V_Z) AND IMPEDANCE (Z_{ZT} & Z_{ZK})

Test conditions for Zener voltage and impedance are as follows: I_Z is applied 40 ± 10 ms prior to reading. Mounting contacts are located 3/8" to 1/2" from the inside edge of mounting clips to the body of the diode. ($T_A = 25^oC \, ^{+8}_{-2}{}^oC$).

NOTE 4 – SURGE CURRENT (i_r)

Surge current is specified as the maximum allowable peak, non-recurrent square-wave current with a pulse width, PW, of 8.3 ms. The data given in Figure 6 may be used to find the maximum surge current for a square wave of any pulse width between 1.0 ms and 1000 ms by plotting the applicable points on logarithmic paper. Examples of this, using the 3.3 V and 200 V zeners, are shown in Figure 7. Mounting contact located as specified in Note 3. ($T_A = 25^oC \, ^{+8}_{-2}{}^oC$).

NOTE 5 – VOLTAGE REGULATION (ΔV_Z)

Test conditions for voltage regulation are as follows: V_Z measurements are made at 10% and then at 50% of the I_Z max value listed in the electrical characteristics table. The test currents are the same for the 5% and 10% tolerance devices. The test current time duration for each V_Z measurement is 40 ± 10 ms. ($T_A = 25^oC \, ^{+8}_{-2}{}^oC$). Mounting contact located as specified in Note 3.

NOTE 6 – MAXIMUM REGULATOR CURRENT (I_{ZM})

The maximum current shown is based on the maximum voltage of a 5% type unit, therefore, it applies only to the B-suffix device. The actual I_{ZM} for any device may not exceed the value of 5.0 watts divided by the actual V_Z of the device. $T_L = 75^oC$ at 3/8" maximum from the device body.

TEMPERATURE COEFFICIENTS

FIGURE 2 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS 3.0 TO 10 VOLTS

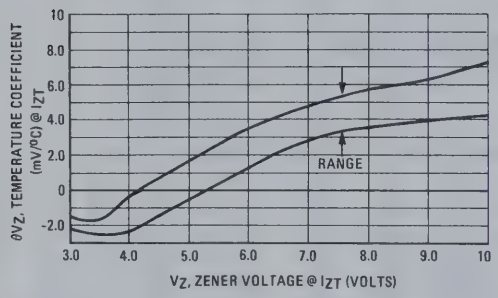


FIGURE 3 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS 10 TO 220 VOLTS

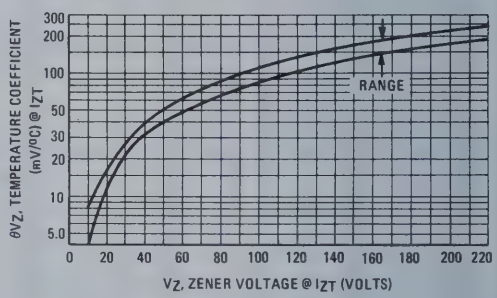


FIGURE 4 – TYPICAL THERMAL RESPONSE

L, LEAD LENGTH = 3/8 INCH

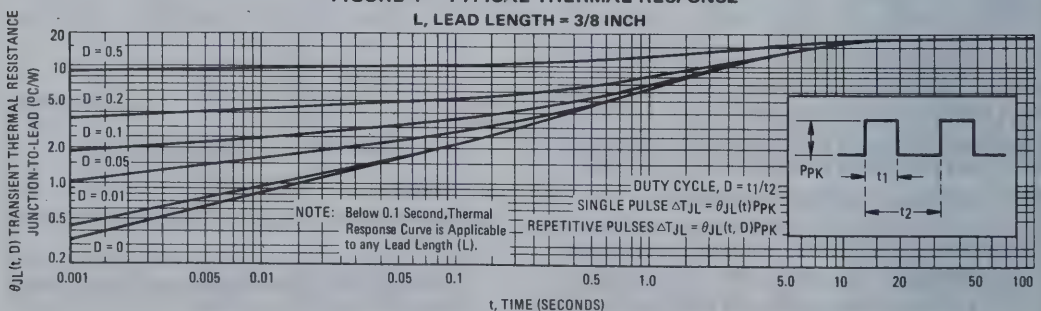


FIGURE 5 – TYPICAL THERMAL RESISTANCE

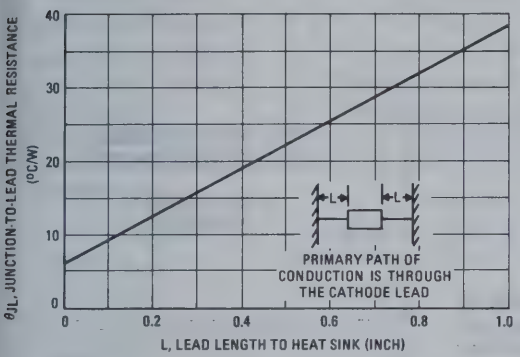


FIGURE 6 – MAXIMUM NON-REPETITIVE SURGE CURRENT versus NOMINAL ZENER VOLTAGE
(See Note 4)

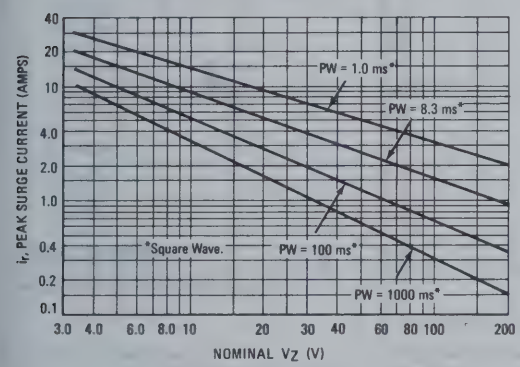
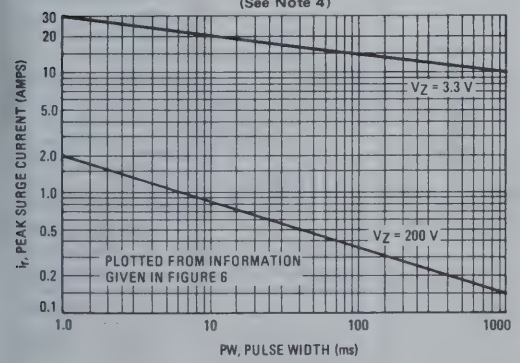


FIGURE 7 – PEAK SURGE CURRENT versus PULSE WIDTH
(See Note 4)



APPLICATION NOTE

Since the actual voltage available from a given zener diode is temperature dependent, it is necessary to determine junction temperature under any set of operating conditions, in order to calculate its value. The following procedure is recommended:

Lead Temperature, T_L, should be determined from:

$$T_L = \theta_{LA} P_D + T_A$$

θ_{LA} is the lead-to-ambient thermal resistance and P_D is the power dissipation.

Junction Temperature, T_J, may be found from:

$$T_J = T_L + \Delta T_{JL}$$

ΔT_{JL} is the increase in junction temperature above the lead temperature and may be found from Figure 4 for a train of power pulses or from Figure 5 for dc power.

$$\Delta T_{JL} = \theta_{JL} P_D$$

For worst-case design, using expected limits of I_Z, limits of P_D and the extremes of $T_J(\Delta T_J)$ may be estimated. Changes in voltage, V_Z, can then be found from:

$$\Delta V = \theta_{VZ} \Delta T_J$$

θ_{VZ}, the zener voltage temperature coefficient, is found from Figures 2 and 3.

Under high power-pulse operation, the zener voltage will vary with time and may also be affected significantly by the zener resistance. For best regulation, keep current excursions as low as possible.

Data of Figure 4 should not be used to compute surge capability. Surge limitations are given in Figure 6. They are lower than would be expected by considering only junction temperature, as current crowding effects cause temperatures to be extremely high in small spots resulting in device degradation should the limits of Figure 6 be exceeded.

1N5441A,B,C thru 1N5456A,B,C

VVC

SILICON EPICAP DIODES

. . . epitaxial passivated abrupt junction tuning diodes designed for electronic tuning, FM, AFC and harmonic-generation applications in AM through UHF ranges, providing solid-state reliability to replace mechanical tuning methods.

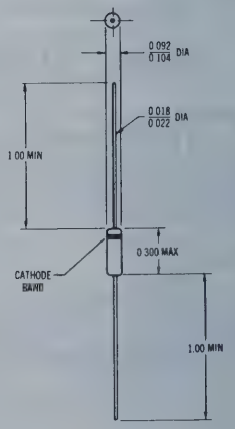
- Excellent Q Factor at High Frequencies
- Guaranteed Capacitance Change — 2.0 to 30 V
- Guaranteed Temperature Coefficient
- Capacitance Tolerance — 10%, 5.0%, and 2.0%
- Complete Typical Design Curves

VOLTAGE-VARIABLE CAPACITANCE DIODES

6.8 – 100 pF
30 VOLTS



DO-7 GLASS



CASE 51
DO-7

** MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	400 2.67	mW $mW/^oC$
Operating Junction Temperature Range	T_J	+175	^oC
Storage Temperature Range	T_{stg}	–65 to +200	^oC

**Indicates JEDEC Registered Data.

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current	V_R = 25 Vdc, T_A = 25°C V_R = 25 Vdc, T_A = 150°C	I_R	– –	– –	0.02 20	μAdc
Series Inductance	f = 250 MHz, lead length≈1/16"	L_S	–	4.0	10	nH
Case Capacitance	f = 1.0 MHz, lead length≈1/16"	C_C	0.1	0.17	0.25	pF
Diode Capacitance Temperature Coefficient (Note 6)	V_R = 4.0 Vdc, f = 1.0 MHz	TC_C	–	300	400	ppm/°C

Device	C_T, Diode Capacitance* V_R = 4.0 Vdc, f = 1.0 MHz pF			TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		Q, Figure of Merit V_R = 4.0 Vdc f = 50 MHz
	Min (Nom -10%)	Nom	Max (Nom +10%)	Min	Max	Min
1N5441A	6.1	6.8	7.5	2.5	3.1	450
1N5442A	7.4	8.2	9.0	2.5	3.1	450
1N5443A	9.0	10.0	11.0	2.6	3.1	400
1N5444A	10.8	12.0	13.2	2.6	3.1	400
1N5445A	13.5	15.0	16.5	2.6	3.1	400
1N5446A	16.2	18.0	19.8	2.6	3.1	350
1N5447A	18.0	20.0	22.0	2.6	3.1	350
1N5448A	19.8	22.0	24.2	2.6	3.2	350
1N5449A	24.3	27.0	29.7	2.6	3.2	350
1N5450A	29.7	33.0	36.3	2.6	3.2	350
1N5451A	35.1	39.0	42.9	2.6	3.2	300
1N5452A	42.3	47.0	51.7	2.6	3.2	250
1N5453A	50.4	56.0	61.6	2.6	3.3	200
1N5454A	61.2	68.0	74.8	2.7	3.3	175
1N5455A	73.8	82.0	90.2	2.7	3.3	175
1N5456A	90.0	100.0	110.0	2.7	3.3	175

*To order devices with C_T Nom ±5.0% or ±2.0% add Suffix B or C respectively.

**Indicates JEDEC Registered Data.

PARAMETER TEST METHODS

1. **L_S, Series Inductance**
   L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter or equivalent).
2. **C_C, Case Capacitance**
   C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. **C_T, Diode Capacitance**
   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
4. **TR, Tuning Ratio**
   TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.
5. **Q, Figure of Merit**
   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

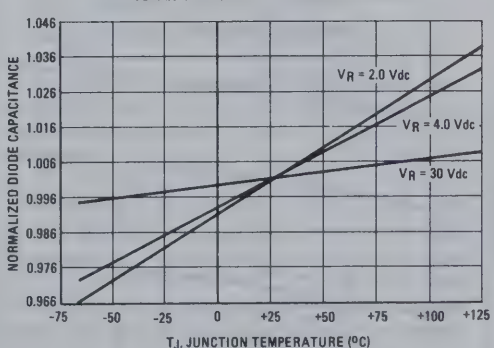
(Boonton Electronics Model 33AS8 or equivalent).

6. **TC_C, Diode Capacitance Temperature Coefficient**
   TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = -65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation, which defines TC_C:

$$TC_C = \left| \frac{C_T(+85^\circ C) - C_T(-65^\circ C)}{85 + 65} \right| \frac{10^6}{C_T(25^\circ C)}$$

Accuracy limited by C_T measurement to ±0.1 pF.

FIGURE 1 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE



TYPICAL DEVICE PERFORMANCE

FIGURE 2 – DIODE CAPACITANCE versus REVERSE VOLTAGE

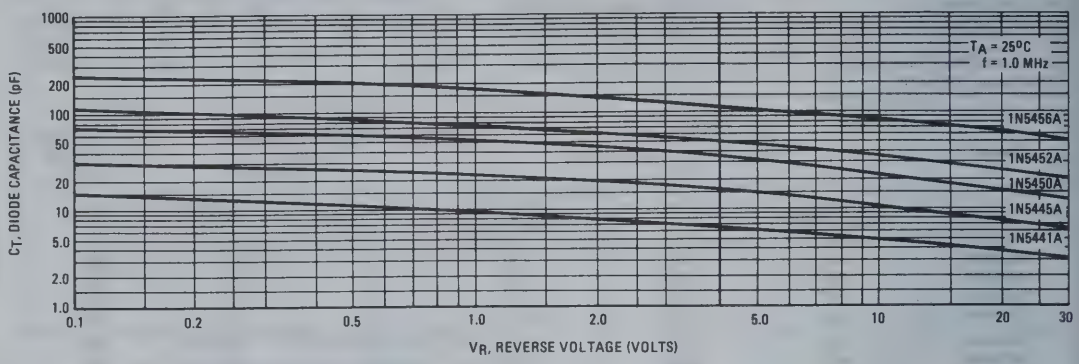


FIGURE 3 – FIGURE OF MERIT versus REVERSE VOLTAGE

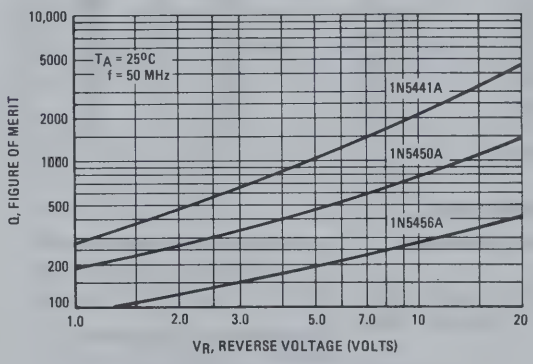


FIGURE 4 – FIGURE OF MERIT versus FREQUENCY

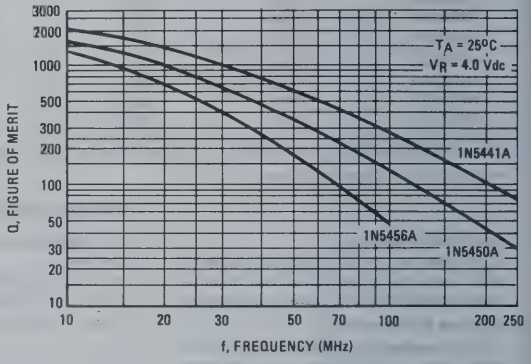


FIGURE 5 – REVERSE CURRENT versus REVERSE BIAS VOLTAGE

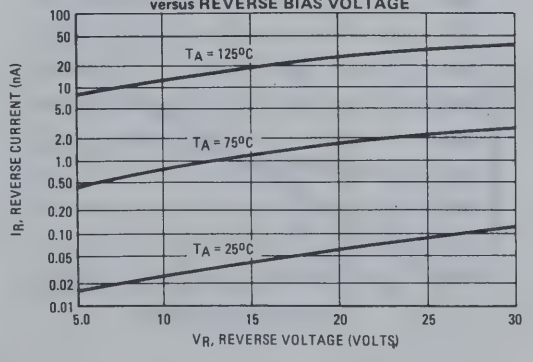
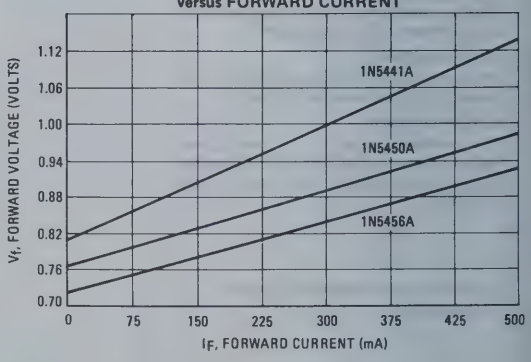


FIGURE 6 – FORWARD VOLTAGE versus FORWARD CURRENT



1N5461A,B,C thru 1N5476A,B,C

VVC

SILICON EPICAP DIODES

. . . a PREMIUM line of epitaxial, passivated, abrupt-junction tuning diodes for critical and sophisticated frequency control applications through the UHF range.

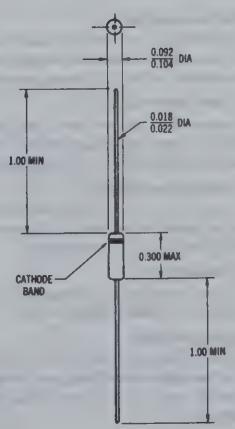
- High Q at High Frequencies
- Guaranteed High Capacitance Tuning Range
- Excellent Unit-to-Unit Uniformity
- Guaranteed Temperature Coefficient
- Capacitance Tolerances – 10%, 5.0%, and 2.0%
- Complete Typical Design Curves

VOLTAGE-VARIABLE CAPACITANCE DIODES

6.8 – 100 pF
30 VOLTS



DO-7 GLASS



CASE 51
DO-7

****MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Operating Junction Temperature Range	T_J	+175	°C
Storage Temperature Range	T_{stg}	–65 to +200	°C

**Indicates JEDEC Registered Data.

**ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current	V_R = 25 Vdc, T_A = 25°C V_R = 25 Vdc, T_A = 150°C	I_R	– –	– –	0.02 20	μAdc
Series Inductance	f = 250 MHz, lead length ≈1/16"	L_S	–	4.0	10	nH
Case Capacitance	f = 1.0 MHz, lead length ≈ 1/16"	C_C	0.1	0.17	0.25	pF
Diode Capacitance Temperature Coefficient (Note 6)	V_R = 4.0 Vdc, f = 1.0 MHz	TC_C	–	300	400	ppm/°C

Device	C_T, Diode Capacitance* V_R = 4.0 Vdc, f = 1.0 MHz pF			TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		Q, Figure of Merit V_R = 4.0 Vdc f = 50 MHz
	Min (Nom –10%)	Nom	Max (Nom +10%)	Min	Max	Min
1N5461A	6.1	6.8	7.5	2.7	3.1	600
1N5462A	7.4	8.2	9.0	2.8	3.1	600
1N5463A	9.0	10.0	11.0	2.8	3.1	550
1N5464A	10.8	12.0	13.2	2.8	3.1	550
1N5465A	13.5	15.0	16.5	2.8	3.1	550
1N5466A	16.2	18.0	19.8	2.9	3.1	500
1N5467A	18.0	20.0	22.0	2.9	3.1	500
1N5468A	19.8	22.0	24.2	2.9	3.2	500
1N5469A	24.3	27.0	29.7	2.9	3.2	500
1N5470A	29.7	33.0	36.3	2.9	3.2	500
1N5471A	35.1	39.0	42.9	2.9	3.2	450
1N5472A	42.3	47.0	51.7	2.9	3.2	400
1N5473A	50.4	56.0	61.6	2.9	3.3	300
1N5474A	61.2	68.0	74.8	2.9	3.3	250
1N5475A	73.8	82.0	90.2	2.9	3.3	225
1N5476A	90.0	100.0	110.0	2.9	3.3	200

*To order devices with C_T Nom ±5.0% or ±2.0% add Suffix B or C respectively.

**Indicates JEDEC Registered Data.

PARAMETER TEST METHODS

1. **L_S, Series Inductance**
   L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter or equivalent).
2. **C_C, Case Capacitance**
   C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. **C_T, Diode Capacitance**
   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
4. **TR, Tuning Ratio**
   TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.
5. **Q, Figure of Merit**
   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

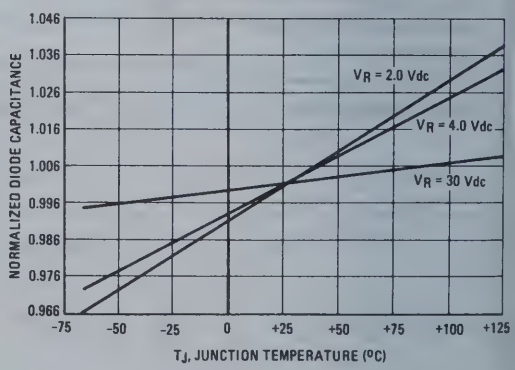
(Boonton Electronics Model 33AS8 or equivalent).

6. **TC_C, Diode Capacitance Temperature Coefficient**
   TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = –65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation, which defines TC_C:

$$TC_C = \left| \frac{C_T(+85^\circ C) - C_T(-65^\circ C)}{85 + 65} \right| \frac{10^6}{C_T(25^\circ C)}$$

Accuracy limited by C_T measurement to ±0.1 pF.

FIGURE 1 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE



TYPICAL DEVICE PERFORMANCE

FIGURE 2 – DIODE CAPACITANCE versus REVERSE VOLTAGE

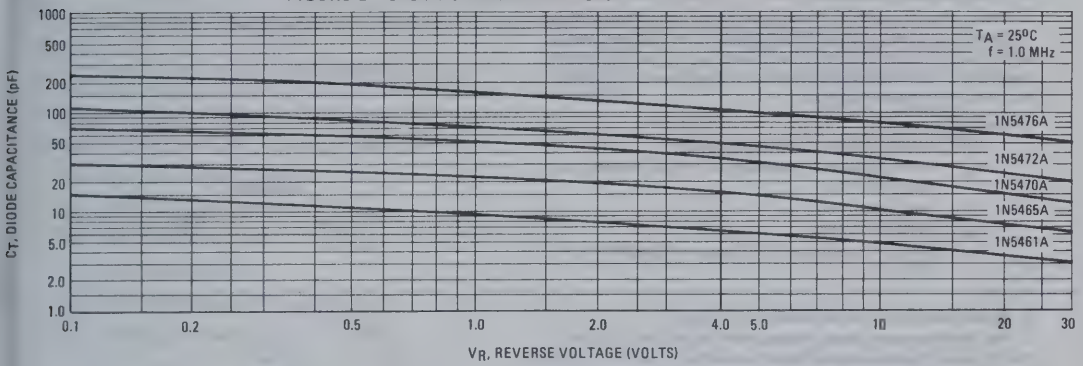


FIGURE 3 – FIGURE OF MERIT versus REVERSE VOLTAGE

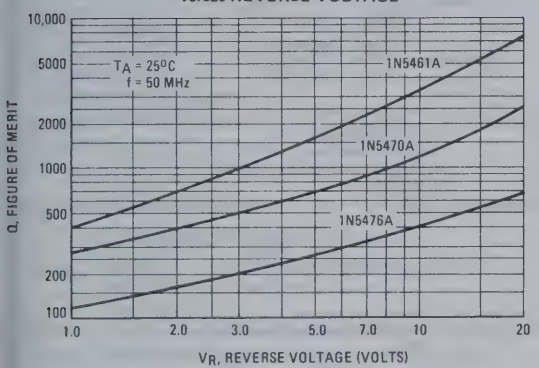


FIGURE 4 – FIGURE OF MERIT versus FREQUENCY

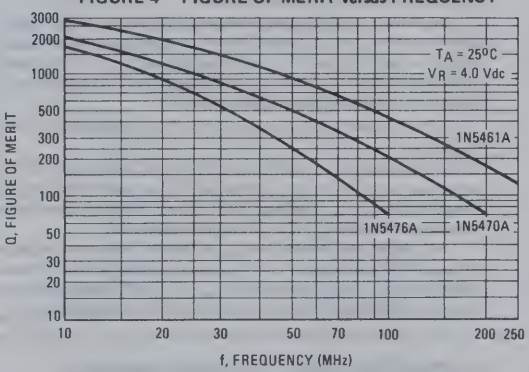


FIGURE 5 – REVERSE CURRENT versus REVERSE BIAS VOLTAGE

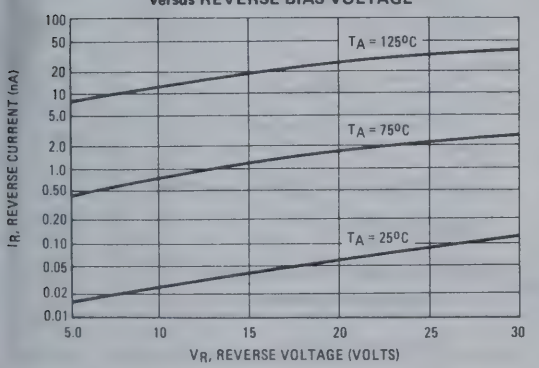
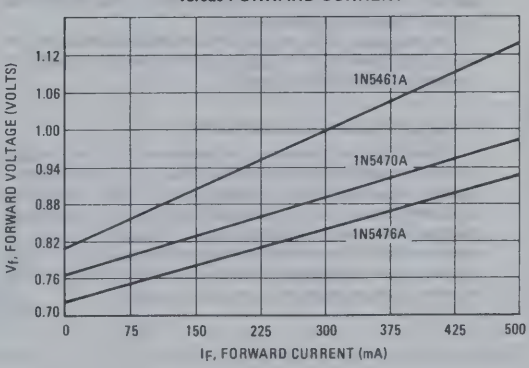


FIGURE 6 – FORWARD VOLTAGE versus FORWARD CURRENT



EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. Epicap Network Presentation

The equivalent circuit in Figure 7 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 8 represents the diode under these conditions.

Definitions:

- C_J — Voltage-Variable Junction Capacitance
- R_S — Series Resistance (semiconductor bulk, contact, and lead resistance)
- C_C — Case Capacitance
- L_S — Series Inductance
- R_J — Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 7

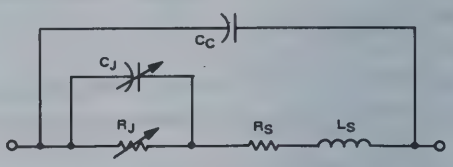
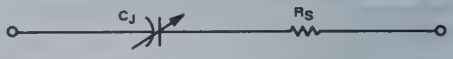


FIGURE 8



B. Epicap Capacitance versus Reverse Bias Voltage

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Tuning Ratio, TR, between any two voltage points on curve of equation (2) is determined from equations (3) and (4).

$$C_T = C_C + C_J \tag{1}$$

$$C_T = C_C + \frac{C_o}{\left(1 + \frac{V_R}{\phi}\right)^{\gamma}} \tag{2}$$

$$\text{TR Junction} = \frac{C_{J1}}{C_{J2}} = \left(\frac{V_{R2} + \phi}{V_{R1} + \phi}\right)^{\gamma} \tag{3}$$

$$\text{TR Diode} = \frac{C_{T1}}{C_{T2}} = \frac{C_{J1} + C_C}{C_{J2} + C_C} \tag{4}$$

$C_o = C_J$ at $V_R = 0$
V_R = Reverse Bias (Volts)
γ, Diode Power Law, ≈ 0.44
ϕ, Contact Potential, ≈ 0.6 Volt
$C_C \approx 0.17$ pF

C. Epicap Capacitance versus Frequency

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 7, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 5. Examination of equation 5 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_C$.

As frequency is increased from 1.0 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_S C_J$; and as ω^2 is increased from $1/L_S C_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1.0 MHz. As ω approaches $\omega_o = 1/\sqrt{L_S C_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_C + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \tag{5}$$

D. EPICAP Figure of Merit (Q) and Cutoff Frequency (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 6. For very low frequencies, equation 7 applies whereas at high frequencies, where R_J can be neglected, equation 6 may be rewritten into the familiar form of equation 8.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 9 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \tag{6}$$

$$Q_{Lf} = \frac{\omega C_J R_J^2}{R_J + R_S(1 + \omega^2 C_J^2 R_J^2} \tag{7}$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \tag{8}$$

$$f_{co} = Qf_{max} \quad \frac{1}{2\pi R_S C_{BVR}} \tag{9}$$

E. Harmonic Generation Using EPICAPS

Efficient harmonic generation is possible with EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 10 gives the level of maximum input power for the EPICAP and equation 11 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \frac{f_{in}}{f_{co}} \tag{10}$$

M(x2) = 0.0285; M(x3) = 0.0241; M(x4) = 0.196

$$\text{Eff} = 1 - N \frac{f_{out}}{f_{co}} \tag{11}$$

N(x2) = 20.8; N(x3) = 34.8; N(x4) = 62.5

M and N are Constants

1N5518, A, B (SILICON)
thru
1N5546, A, B

LOW VOLTAGE AVALANCHE SILICON OXIDE PASSIVATED ZENER REGULATOR DIODES

Highly reliable silicon regulators utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.

- Low Zener Noise Specified
- Low Maximum Regulation Factor
- Low Zener Impedance
- Low Leakage Current
- Controlled Forward Characteristics
- Temperature Range: -65 to +200°C

LOW VOLTAGE AVALANCHE ZENER DIODES

400 MILLIWATTS
3.3 THRU 33 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ T_A = 50°C Derate above 50°C	P_D	400 2.66	mW mW/°C
DC Power Dissipation @ T_L = 50°C Lead Length = 1/8" Derate above 50°C (Figure 1)	P_D	500 3.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

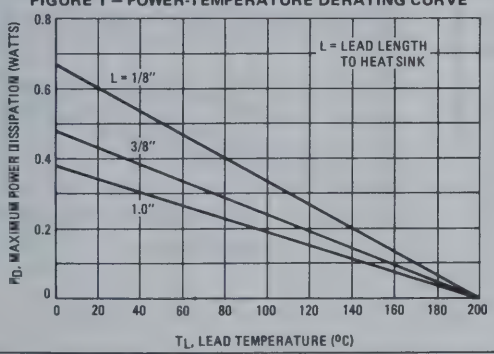
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

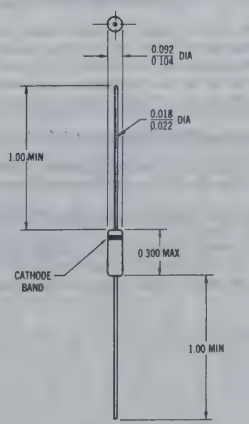
POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





CASE 51
(DO-7)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted. Based on dc measurements at thermal equilibrium; V_F = 1.1 Max @ I_F = 200 mA for all types)

JEDEC Type No. (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mAdc	Max Zener Impedance B-C-D Suffix Z_{ZT} @ I_{ZT} Ohms (Note 3)	Max Reverse Leakage Current I_R µAdc (Note 4)	Max Reverse Leakage Current V_R — Volts Non & A-Suffix	Max Reverse Leakage Current V_R — Volts B-C-D Suffix	B-C-D Suffix Maximum DC Zener Current I_{ZM} mAdc (Note 5)	B-C-D Suffix Max Noise Density at I_Z = 250 µA N_D (Figure 1) (micro-volts per square root cycle)	Regulation Factor ΔV_Z Volts (Note 6)	Low V_Z Current I_{ZL} mAdc
1N5518	3.3	20	26	5.0	0.90	1.0	115	0.5	0.90	2.0
1N5519	3.6	20	24	3.0	0.90	1.0	105	0.5	0.90	2.0
1N5520	3.9	20	22	1.0	0.90	1.0	98	0.5	0.85	2.0
1N5521	4.3	20	18	3.0	1.0	1.5	88	0.5	0.75	2.0
1N5522	4.7	10	22	2.0	1.5	2.0	81	0.5	0.60	1.0
1N5523	5.1	5.0	26	2.0	2.0	2.5	75	0.5	0.65	0.25
1N5524	5.6	3.0	30	2.0	3.0	3.5	68	1.0	0.30	0.25
1N5525	6.2	1.0	30	1.0	4.5	5.0	61	1.0	0.20	0.01
1N5526	6.8	1.0	30	1.0	5.5	6.2	56	1.0	0.10	0.01
1N5527	7.5	1.0	35	0.5	6.0	6.8	51	2.0	0.05	0.01
1N5528	8.2	1.0	40	0.5	6.5	7.5	46	4.0	0.05	0.01
1N5529	9.1	1.0	45	0.1	7.0	8.2	42	4.0	0.05	0.01
1N5530	10.0	1.0	60	0.05	8.0	9.1	38	4.0	0.10	0.01
1N5531	11.0	1.0	80	0.05	9.0	9.9	35	5.0	0.20	0.01
1N5532	12.0	1.0	90	0.05	9.5	10.8	32	10	0.20	0.01
1N5533	13.0	1.0	90	0.01	10.5	11.7	29	15	0.20	0.01
1N5534	14.0	1.0	100	0.01	11.5	12.6	27	20	0.20	0.01
1N5535	15.0	1.0	100	0.01	12.5	13.5	25	20	0.20	0.01
1N5536	16.0	1.0	100	0.01	13.0	14.4	24	20	0.20	0.01
1N5537	17.0	1.0	100	0.01	14.0	15.3	22	20	0.20	0.01
1N5538	18.0	1.0	100	0.01	15.0	16.2	21	20	0.20	0.01
1N5539	19.0	1.0	100	0.01	16.0	17.1	20	20	0.20	0.01
1N5540	20.0	1.0	100	0.01	17.0	18.0	19	20	0.20	0.01
1N5541	22.0	1.0	100	0.01	18.0	19.8	17	20	0.25	0.01
1N5542	24.0	1.0	100	0.01	20.0	21.6	16	20	0.30	0.01
1N5543	25.0	1.0	100	0.01	21.0	22.4	15	20	0.35	0.01
1N5544	28.0	1.0	100	0.01	23.0	25.2	14	20	0.40	0.01
1N5545	30.0	1.0	100	0.01	24.0	27.0	13	20	0.45	0.01
1N5546	33.0	1.0	100	0.01	28.0	29.7	12	20	0.50	0.01

NOTE 1 — TOLERANCE AND VOLTAGE DESIGNATION

The JEDEC type numbers shown are ±20% with guaranteed limits for only V_Z, I_R, and V_F. Units with "A" suffix are ±10% with guaranteed limits for V_Z, I_R, and V_F. Units with guaranteed limits for all six parameters are indicated by a "B" suffix for ±5.0% units, "C" suffix for ±2.0% and "D" suffix for ±1.0%.

NOTE 2 — ZENER VOLTAGE (V_Z) MEASUREMENT

Nominal zener voltage is measured with the device junction in thermal equilibrium with ambient temperature of 25°C.

NOTE 3 — ZENER IMPEDANCE (Z_Z) DERIVATION

The zener impedance is derived from the 60 Hz ac voltage, which results when an ac current having an rms value equal to 10% of the dc zener current (I_{ZT}) is superimposed on I_{ZT}.

NOTE 4 — REVERSE LEAKAGE CURRENT (I_R)

Reverse leakage currents are guaranteed and are measured at V_R as shown on the table.

NOTE 5 — MAXIMUM REGULATOR CURRENT (I_{ZM})

The maximum current shown is based on the maximum voltage of a 5.0% type unit, therefore, it applies only to the "B" suffix device. The actual I_{ZM} for any device may not exceed the value of 400 milliwatts divided by the actual V_Z of the device.

NOTE 6 — MAXIMUM REGULATION FACTOR (ΔV_Z)

ΔV_Z is the maximum difference between V_Z at I_{ZT} and V_Z at I_{ZL} measured with the device junction in thermal equilibrium.

ZENER NOISE DENSITY

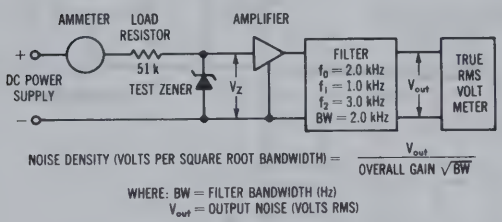
A zener diode generates noise when it is biased in the zener direction. A small part of this noise is due to the internal resistance associated with the device. A larger part of zener noise is a result of the zener breakdown phenomenon and is called microplasma noise. To eliminate the higher frequency components of noise a small shunting capacitor can be used. The lower frequency noise generally must be tolerated since a capacitor required to eliminate the lower frequencies would degrade the regulation properties of the zener in many applications.

Motorola is rating this series with a maximum noise density at 250 microamperes, a bandwidth of 2.0 kHz and a center frequency of 2.0 kHz.

Noise density decreases as zener current increases. The junction temperature will also change the zener noise levels, thus the noise rating must indicate frequency, bandwidth, current level and temperature.

The block diagram shown in Figure 2 represents the method used to measure noise density. The input voltage and load resistance is high so that the zener is driven from a constant current source. The amplifier must be low noise so that the amplifier noise is negligible compared to the test zener. The filter frequency and bandpass is known so that the noise density in volts RMS per square root cycle can be calculated.

FIGURE 2 – NOISE DENSITY MEASUREMENT METHOD



$$\text{NOISE DENSITY (VOLTS PER SQUARE ROOT BANDWIDTH)} = \frac{V_{out}}{\text{OVERALL GAIN } \sqrt{BW}}$$

WHERE: BW = FILTER BANDWIDTH (Hz)
V_{out} = OUTPUT NOISE (VOLTS RMS)

FIGURE 3 – TYPICAL CAPACITANCE

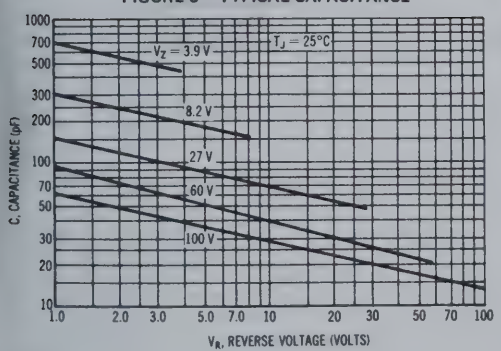


FIGURE 4 – TYPICAL FORWARD CHARACTERISTICS

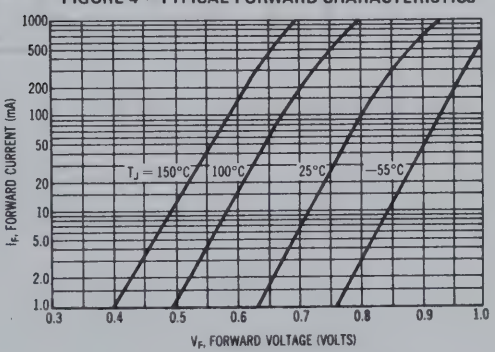
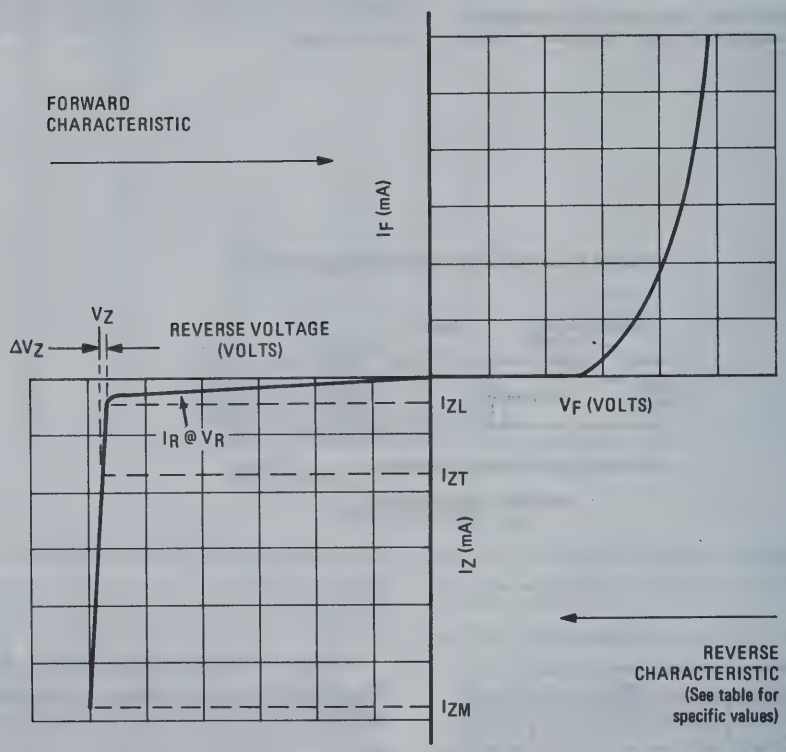


FIGURE 5 – ZENER DIODE CHARACTERISTICS AND SYMBOL IDENTIFICATION



2N... & 3N... JEDEC REGISTERED DEVICE SPECIFICATIONS

TRANSISTORS

- Amplifier
- Chopper
- Light Sensitive
- Multiple Device
- Power
- Switching
- Unijunction

THYRISTORS & TRIGGERS

2N-NUMBERED DEVICES for MILITARY APPLICATIONS

The following tables list devices that comply with military specifications.

SWITCHING AND HIGH FREQUENCY TRANSISTORS

MIL-S-19500		
JAN 2N393 ...../77	†JAN 2N1613 ...../181	†JAN 2N2907A ...../291
JAN 2N499 ...../72	†JAN 2N2218 ...../251	†JAN 2N3250A ...../323
JAN 2N499A ...../72	†JAN 2N2218A ...../251	†JAN 2N3251A ...../323
JAN 2N501A ...../62	†JAN 2N2219 ...../251	JAN 2N3253 ...../347
JAN 2N502A ...../112	†JAN 2N2219A ...../251	JAN 2N3444 ...../347
JAN 2N502B ...../112	†JAN 2N2221 ...../255	JAN 2N3449 ...../338
†JAN 2N559 ...../152	†JAN 2N2221A ...../255	JAN 2N3467 ...../348
JAN 2N703 ...../153	†JAN 2N2222 ...../255	JAN 2N3468 ...../348
JAN 2N705 ...../86	†JAN 2N2222A ...../255	†JAN 2N3485A ...../392
JAN 2N706 ...../120	†JAN 2N2369A ...../317	†JAN 2N3486A ...../392
†JAN 2N708 ...../312	†JAN 2N2481 ...../268	†JAN 2N3498 ...../366
†JAN 2N718A ...../181	JAN 2N2708 ...../302	†JAN 2N3499 ...../366
†JAN 2N914 ...../373	†JAN 2N2857 ...../343	†JAN 2N3500 ...../366
†JAN 2N869A ...../283	†JAN 2N2904 ...../290	†JAN 2N3501 ...../366
JAN 2N916 ...../271	†JAN 2N2904A ...../290	JAN 2N3506 ...../349
†JAN 2N929 ...../253	†JAN 2N2905 ...../290	†JAN 2N3507 ...../349
†JAN 2N930 ...../253	†JAN 2N2905A ...../290	†JAN 2N3634 ...../357
JAN 2N962 ...../258	†JAN 2N2906 ...../291	†JAN 2N3635 ...../357
JAN 2N964 ...../258	†JAN 2N2906A ...../291	†JAN 2N3636 ...../357
JAN 2N1131 ...../177	†JAN 2N2907 ...../291	†JAN 2N3637 ...../357
JAN 2N1132 ...../177		

POWER TRANSISTORS

MIL-S-19500		
JAN 2N174A ...../13	JAN 2N1550A ...../332	JAN 2N1560A ...../330
JAN 2N297A ...../36	JAN 2N1551A ...../332	JAN 2N1651 ...../219
JAN 2N665 ...../58	JAN 2N1552A ...../332	JAN 2N1652 ...../219
JAN 2N1011 ...../67	JAN 2N1553A ...../331	JAN 2N1653 ...../219
JAN 2N1120 ...../68	JAN 2N1554A ...../331	JAN 2N2079A ...../340
JAN 2N1165 ...../178	JAN 2N1555A ...../331	JAN 2N2528 ...../309
JAN 2N1358 ...../122	JAN 2N1556A ...../331	JAN 2N2834 ...../310
JAN 2N1412 ...../76	JAN 2N1557A ...../330	†JAN 2N3868 ...../350
JAN 2N1412A ...../76	JAN 2N1558A ...../330	†JAN 2N3055 ...../407
JAN 2N1549A ...../332	JAN 2N1559A ...../330	†JAN 2N3868 ...../350

†Recommended TX Devices

RF TRANSISTORS

MIL-S-19500
JAN 2N700A ...../123
†JAN 2N918 ...../301
JAN 2N1142 ...../87
JAN 2N1195 ...../71
JAN 2N2273 ...../244
JAN 2N3127 ...../346
†JAN 2N3375 ...../341
†JAN 2N3553 ...../341
JAN 2N3959 ..... ./399
JAN 2N3960 ..... ./399

SILICON CONTROLLED RECTIFIERS

MIL- S -19500
JAN 2N4199 ...../372
JAN 2N4200 ...../372
JAN 2N4201 ...../372
JAN 2N4202 ...../372
JAN 2N4203 ...../372
JAN 2N4204 ...../372

FIELD-EFFECT TRANSISTORS

MIL-S-19500
†JAN 2N3821 ...../375
†JAN 2N3822 ...../375
†JAN 2N3823 ...../375

MULTIPLE DEVICES

MIL-S-19500
†JAN 2N2060 ...../270
JAN 2N2920 ..... /355
JAN 2N3810 ...../336
JAN 2N3811 ...../336

UNIJUNCTION

MIL- S -19500
†JAN 2N4948 ...../388
†JAN 2N4949 ...../388

MILLIWATT TRANSISTORS

MIL-S-19500
JAN 2N331 ...../4
JAN 2N398A ...../174
JAN 2N465 ...../49
JAN 2N466 ...../51
JAN 2N467 ...../49
JAN 2N526 ...../60
JAN 2N650A ...../175
JAN 2N651A ...../175
JAN 2N652A ...../175
JAN 2N1008B ...../196

MIL-T-19500
JAN 2N461 ...../45

†Recommended TX Devices

2N173 (GERMANIUM)

For Specifications, See 2N277 Data.

2N174 (GERMANIUM)
2N1100
2N1358,A



CASE 5
(TO-36)

PNP germanium power transistors. Power dissipation and junction temperature ratings exceed those of EIA registration.

MAXIMUM RATINGS

Rating	Symbol	2N174	2N1100	2N1358	Unit
Collector-Base Voltage	V_{CB}	80	100	80	Vdc
Emitter-Base Voltage	V_{EB}	60	80	60	Vdc
Emitter Current (Continuous)	I_E	15	15	15	Amp
Base Current (Continuous)	I_B	4.0	4.0	4.0	Amp
Junction and Storage Temperature	T_J, T_{stg}	-65 to +110			°C
Thermal Resistance, Junction to Case	θ_{JC}	0.5			°C/W

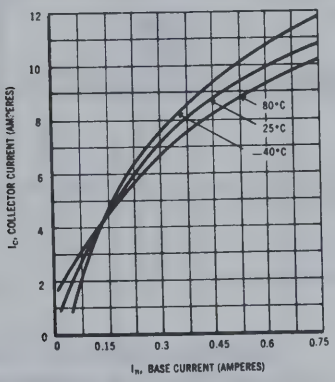
2N174, 2N1100, 2N1358 (continued)

ELECTRICAL CHARACTERISTICS

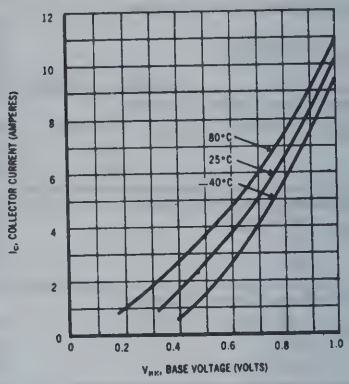
Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current		I_{CBO}				μA
(V_{CB} = 2 volts)	2N174		-	100	-	
	2N1100		-	100	-	
	2N1358		-	100	200	
Collector-Base Cutoff Current		I_{CBO}				mA
(V_{EB} = 1.5 volts, V_{CB} = 80 volts)	2N174		-	2.0	8.0	
100	2N1100		-	2.0	8.0	
80	2N1358		-	2.0	8.0	
Emitter-Base Cutoff Current		I_{EBO}				mA
(V_{EB} = 60 volts)	2N174		-	1.0	8.0	
80	2N1100		-	1.0	8.0	
60	2N1358		-	1.0	8.0	
Collector-Base Cutoff Current		I_{CBO}				mA
(V_{CB} = 80 volts, 71°C)	2N174		-	-	15	
100	2N1100		-	-	15	
60	2N1358		-	4.0	6.0	
Emitter-Base Cutoff Current		I_{EBO}				mA
(V_{EB} = 30 volts, 71°C)	2N1358		-	4.0	6.0	
Collector-Emitter Voltage		BV_{CES}*				Vdc
(I_C = 300 mA, V_{EB} = 0)	2N174		70	-	-	
	2N1100		80	-	-	
	2N1358		70	-	-	
Collector-Emitter Voltage		BV_{CEO}*				Vdc
(I_C = 1.0 amp, I_B = 0)	2N174		55	-	-	
1.0 amp, I_B = 0	2N1100		65	-	-	
300 mA, I_B = 0	2N1358		40	-	-	
Floating Potential		V_{EBF}				volt
(I_E = 0, V_{CB} = 80 volts)	2N174		-	-	1.0	
100	2N1100		-	-	1.0	
80	2N1358		-	0.15	1.0	
Current Gain		h_{FE}				-
(I_C = 1.2 amp, V_{CB} = 2 volts)	2N1358		40	55	80	
(I_C = 5 amp, V_{CB} = 2 volts)	2N174		25	-	50	
	2N1100		25	-	50	
	2N1358		25	35	-	
(I_C = 12 amp, V_{CB} = 2 volts)	2N174		-	20	-	
	2N1100		-	20	-	
Base-Emitter Voltage		V_{BE}				Vdc
(I_C = 1.2 amp, V_{CB} = 2 volts)	2N1358		-	0.35	0.5	
(I_C = 5 amp, V_{CB} = 2 volts)	2N174		-	0.65	0.9	
	2N1100		-	0.65	0.9	
	2N1358		-	0.65	0.9	
Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 12 amp, I_B = 2 amp)	2N174		-	0.3	0.9	
	2N1100		-	0.3	0.7	
	2N1358		-	0.3	0.7	
Common-Emitter Cutoff Frequency		$f_{\alpha e}$				kHz
(I_C = 5 amp, V_{CE} = 6 volts)	2N174		-	10	-	
	2N1100					
Common-Base Cutoff Frequency		$f_{\alpha b}$				kHz
(I_E = 1 amp, V_{CB} = 12 volts)	2N1358		100	-	-	
Rise Time ("on" I_C = 12 Adc, I_B = 2 Adc, V_{CE} = 12 volts)		t_r	-	15	-	μs
Fall Time ("off" I_C = 0, V_{EB} = -6 volts, R_{EB} = 10 ohms)		t_f	-	15	-	μs

* In order to avoid excessive heating of the collector junction, perform test by the sweep method.

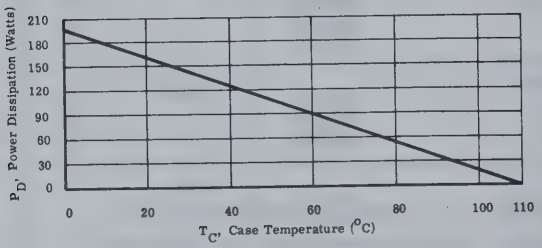
CURRENT TRANSFER CHARACTERISTICS



TRANSCONDUCTANCE CHARACTERISTICS



POWER-TEMPERATURE DERATING CURVE

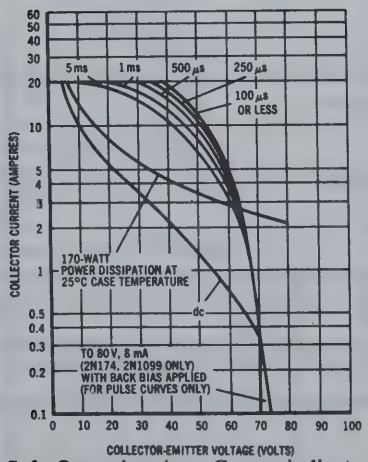


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

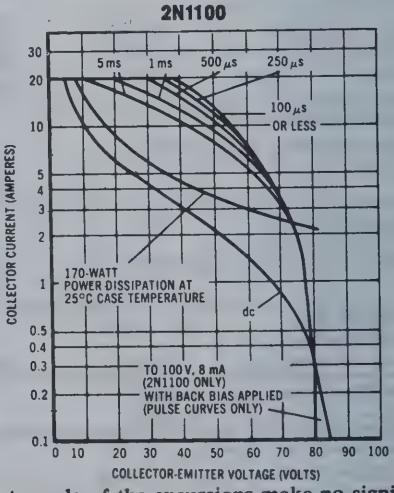
$$\text{allowable } P_D = \frac{110° - T_C}{0.5}$$

2N174 AND 1358



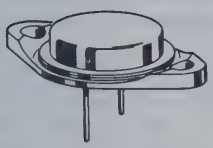
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

2N1100



(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N176 (GERMANIUM)
2N669

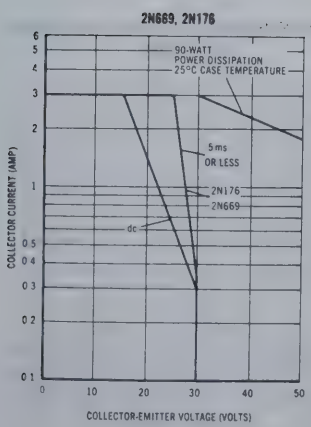


CASE 11
(TO-3)

PNP germanium power transistors for economical power switching circuits and commercial grade power amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector Current (Continuous)	I_C	3.0	Amp
Storage and Junction Temperature	T_J, T_{stg}	−65 to +100	°C
Total Device Dissipation (At 25°C Case Temperature)	P_D	90	Watts
Thermal Resistance (Junction to Case)	θ_{JC}	0.8	°C/W



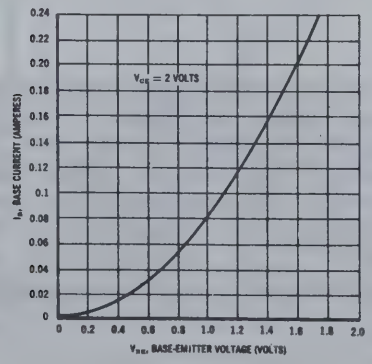
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

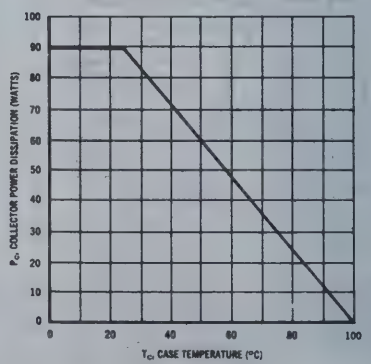
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current		I_{CBO}				
V_{CB} = 30 V, I_E = 0			—	—	3.0	mA
V_{CB} = 2.0 V, I_E = 0			—	50	—	μA
V_{CB} = 30 V, I_E = 0, T_C = 90°C			—	—	20	mA
Emitter-Base Cutoff Current		I_{EBO}				mA
V_{EB} = 10 V, I_C = 0			—	—	2.0	
Collector-Emitter Breakdown Voltage						Vdc
I_C = 330 mA, R_{BE} = 10 Ohms	2N176	BV_{CER}	30	—	—	
	2N669	BV_{CES}	30	—	—	
Collector-Emitter Saturation Voltage		$V_{CE(SAT)}$				Vdc
I_C = 3 A, I_B = 300 mA			—	0.4	—	
DC Forward Current Transfer Ratio		h_{FE}				—
V_{CE} = 2.0 V, I_C = 0.5 A	2N176		25	—	—	
	2N669		75	—	250	
Power Gain		G_{PE}				dB
P_{out} = 2 Watts, V_{CE} = 12 V, I_C = 0.5 Amp,						
f = 1 kHz, R_S = 10 Ohms, R_L = 26.6 Ohms	2N176		34	—	37	
	2N669		38	—	—	
Total Harmonic Distortion						%
(under same conditions of power gain)			—	—	5.0	
Small-Signal Current Gain Cutoff Frequency		$f_{\alpha e}$				kHz
V_{CE} = 12 V, I_C = 0.5 Amp, f = 1 kHz ref	2N176		4.0	7.0	—	
	2N669		3.0	5.0	—	
Small-Signal Forward-Current Transfer Ratio		h_{fe}				—
V_{CE} = 2.0 V, I_C = 0.5 Amp, f = 1 kHz	2N176		—	45	—	
	2N669		—	90	—	
Small-Signal Input Impedance		h_{ie}				Ohms
V_{CE} = 2.0 V, I_C = 0.5 Amp, f = 1 kHz	2N176		7.0	—	25	
	2N669		10	—	50	

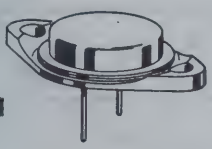
INPUT CURRENT versus EMITTER DRIVE VOLTAGE
(Both Types)



POWER-TEMPERATURE DERATING CURVE
(Both Types)



2N178 (GERMANIUM)
2N554
2N555



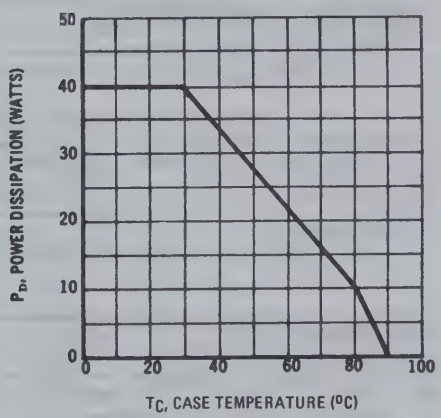
CASE 11
(TO-3)

PNP germanium power transistor for non-critical power amplifier and power switching applications requiring economical components.

MAXIMUM RATINGS

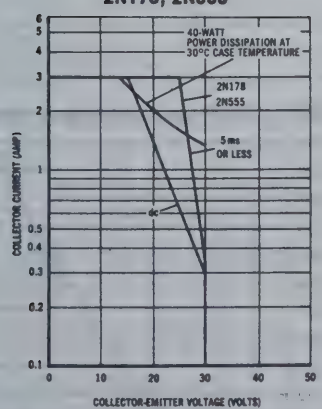
Rating	Symbol	2N178	2N554	2N555	Unit
Collector-Emitter Voltage	V_{CER}	30	16	30	Vdc
Collector-Base Voltage	V_{CB}	30	15	30	Vdc
Emitter-Base Voltage	V_{EB}	20	15	15	Vdc
Collector Current	I_C	3.0			Adc
Total Device Dissipation @ $T_C = 80°C$	P_D	10			Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-40 to +90			°C

POWER-TEMPERATURE DERATING CURVE

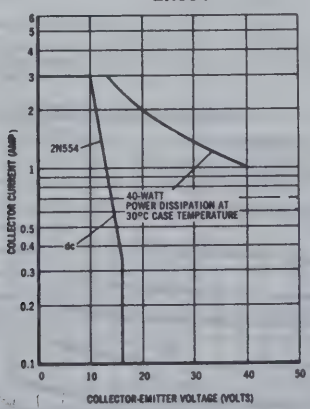


SAFE OPERATING AREAS

2N178, 2N555



2N554



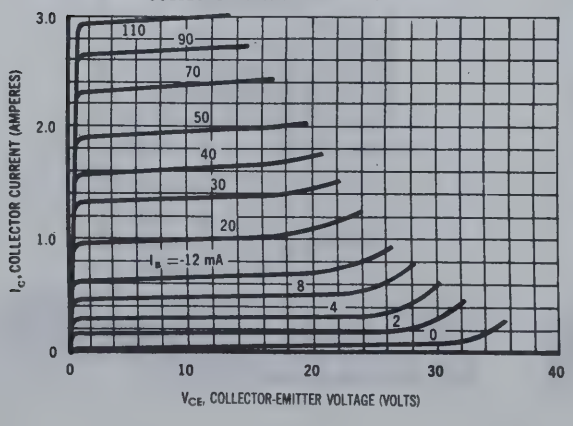
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N178, 2N554, 2N555 (continued)

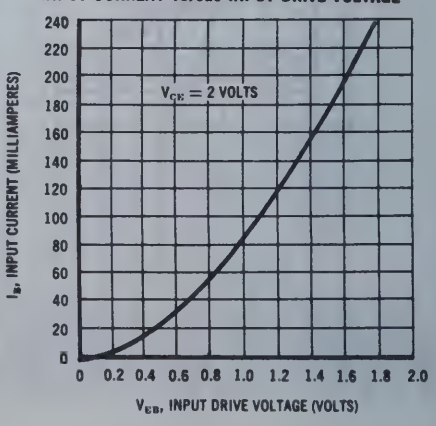
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 330 mAdc, R_{BE} = 10Ω)	2N178	BV_{CER}	30	-	-	Vdc
	2N554		16	-	-	
	2N555		30	-	-	
Collector-Base Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	2N178	I_{CBO}	-	0.05	-	mA
(V_{VB} = 30 Vdc, I_E = 0)	2N178		-	-	3.0	
(V_{CB} = 15 Vdc, I_E = 0)	2N554		-	-	10.0	
(V_{CB} = 30 Vdc, I_E = 0)	2N555		-	-	20.0	
(V_{CB} = 30 Vdc, I_E = 0, T_C = 90°C)	2N178		-	-	20.0	
Emitter-Base Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	2N178	I_{EBO}	-	-	2.0	mA
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)	2N178	h_{FE}	15	-	45	-
	2N554		-	50	-	
	2N555		-	50		
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc)		$V_{CE(sat)}$	-	0.6	-	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Common-Emitter Cutoff Frequency (I_C = 0.5 Adc, V_{CE} = 12 Vdc, f = 1.0 kHz ref)	2N178	$f_{\alpha e}$	5.0	-	-	kHz
	2N554		-	6.0	-	
	2N555		-	6.0	-	
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 2.0 Vdc, f = 1.0 kHz ref)	2N178	h_{fe}	-	30	-	-
	2N554		-	55	-	
	2N555		-	55	-	
Input Impedance (I_C = 0.5 Adc, V_{CE} = 2.0 Vdc, f = 1.0 kHz)	2N178	h_{ie}	8.0	25	-	Ohms
	2N554		-	25	-	
	2N555		-	25	-	
FUNCTIONAL TESTS						
Power Gain (V_{CE} = 12 Vdc, I_C = 0.5 Adc, P_{out} = 2.0 Watts, f = 1.0 kHz, R_S = 10 Ohms, R_L = 26.6 Ohms)	2N178	G_{PE}	28	-	33	dB
	2N554		20	35	-	
	2N555		25	35	-	
Total Harmonic Distortion (Under same conditions as power gain)	2N178		-	-	5.0	%

COLLECTOR CHARACTERISTICS

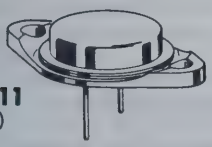


INPUT CURRENT versus INPUT DRIVE VOLTAGE



2N242 (GERMANIUM)

2N307, A



CASE 11
(TO-3)

PNP germanium power transistors for general purpose power amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	2N242	2N307, 307A	Unit
Collector-Base Voltage	V_{CB}	45	35	Volts
Collector-Emitter Voltage (R_{BE} = 30 Ω)	V_{CER}	45	—	Volts
Collector-Emitter Voltage	V_{CEO}	—	35	Volts
Emitter-Base Voltage	V_{EB}	—	10	Volts
Collector Current	I_C	5.0	5.0	Amp
Junction Temperature Range	T_J	-65 to +110	-65 to +110	°C
Collector Dissipation (at T_C = 25°C)	P_D	106	106	Watts

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 2 Vdc)	2N307		—	0.5	
(V_{CB} = 25 Vdc)	2N307		—	5.0	
	2N307A		—	2.0	
(V_{CB} = 1 Vdc, I_E = 0, T_C = 85°C)	2N242		—	5.0	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = 10 Vdc)			—	2.0	
Collector-Emitter Cutoff Current		I_{CER}			mAdc
(V_{CE} = 45 Vdc, R_{BE} = 30 Ω)	2N242		—	5.0	
(V_{CE} = 25 Vdc, R_{BE} = 30 Ω)	2N242		—	1.0	
(V_{CE} = 35 Vdc, R_{BE} = 30 Ω)	2N307		—	15	
	2N307A		—	7.0	
Base-Emitter Voltage		V_{BE}			Vdc
(V_{CE} = 1.5 Vdc, I_C = 1.0 Adc)	2N242		0.3	0.8	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 200 mAdc)	2N242		—	0.8	
(I_C = 0.2 Adc, I_B = 20 mAdc)	2N307		—	1.0	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N307A		—	0.8	
DC Current Gain		h_{FE}			—
(V_{CE} = 12 Vdc, I_C = 500 mAdc)	2N242		30	120	
(V_{CE} = 1 Vdc, I_C = 200 mAdc)	2N307		20	—	
	2N307A		30	—	
Common Emitter Cutoff Frequency		$f_{\alpha e}$			kHz
(V_{CE} = 12 V, I_C = 0.5 A)	2N242		5.0	—	
	2N307A		3.5	—	
(V_{CE} = 6 V, I_C = 1 A)	2N307		3.0	—	
Power Gain		G_e			dB
(I_C = 0.5 A, V_{CE} = -14 V, R_L = 30 Ω, R_g = 10 Ω)	2N242		30		

2N277 (GERMANIUM)
2N278
2N173
2N109



CASE 5
(TO-36)

PNP germanium power transistors for general purpose power amplifier and switching applications. Power and temperature ratings exceed EIA registration.

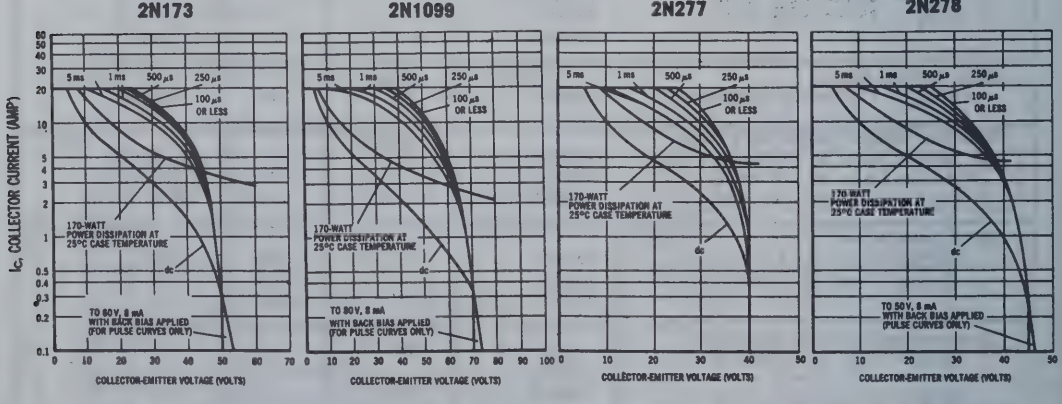
MAXIMUM RATINGS

Rating	Symbol	2N277	2N278	2N173	2N1099	Unit
Collector-Base Voltage	V_{CB}	40	50	60	80	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	40	Vdc
Emitter Current-Continuous	I_E	15				Adc
Base Current	I_B	4.0				Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	170 2.0				Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^oC/W$

SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

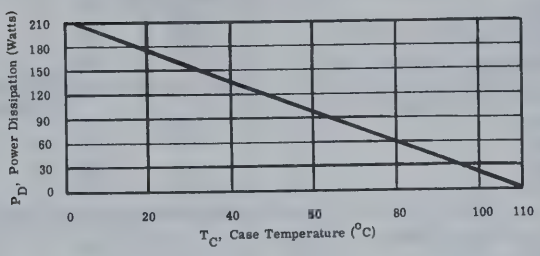
2N277, 2N278, 2N173, 2N1099 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current V_{CBO} = 2 V		I_{CBO}	—	100	—	μA
Collector-Base Cutoff Current		I_{CBX}				mA
V_{EB} = 1.5 V, V_{CB} = 40 V	2N277		—	2.0	8.0	
50	2N278		—	2.0	8.0	
60	2N173		—	2.0	8.0	
80	2N1099		—	2.0	8.0	
Emitter-Base Cutoff Current		I_{EBO}				mA
V_{EBO} = 20 V	2N277		—	1.0	8.0	
30	2N278		—	1.0	8.0	
40	2N173		—	1.0	8.0	
40	2N1099		—	1.0	8.0	
Collector-Base Cutoff Current		I_{CBO}				mA
V_{CBO} = 40 V, 71°C	2N277		—	—	15	
50	2N278		—	—	15	
60	2N173		—	—	15	
80	2N1099		—	—	15	
Collector-Emitter Voltage		BV_{CES}*				Vdc
I_C = 300 mA, V_{EB} = 0	2N277		40	—	—	
	2N278		45	—	—	
	2N173		50	—	—	
	2N1099		70	—	—	
Collector-Emitter Voltage		BV_{CEO}*				Vdc
I_C = 1 Amp, I_B = 0	2N277		25	—	—	
	2N278		30	—	—	
	2N173		45	—	—	
	2N1099		55	—	—	
Floating Potential		V_{fl}				volt
I_E = 0, V_{CB} = 40 V	2N277		—	0.15	1.0	
50	2N278		—	0.15	1.0	
60	2N173		—	0.15	1.0	
80	2N1099		—	0.15	1.0	
Current Gain		h_{FE}				—
I_C = 5 Amp, V_{CB} = 2 V			35	—	70	
I_C = 12 Amp, V_{CB} = 2 V			—	25	—	
Base-Emitter Voltage		V_{BE}				Vdc
I_C = 5 Amp, V_{CB} = 2 V	2N277		—	0.65	—	
	2N278		—	0.65	—	
	2N173		—	0.65	—	
	2N1099		—	0.65	0.9	
Saturation Voltage		$V_{CE(SAT)}$				Vdc
I_C = 12 Amp, I_B = 2 Amp	2N277		—	0.3	—	
	2N278		—	0.3	1.0	
	2N173		—	0.3	1.0	
	2N1099		—	0.3	0.7	
Common-Emitter Current Amplification Cutoff Frequency I_C = 5 Amp, V_{CE} = 6 V		$f_{\alpha e}$	0.3	10	—	kHz
Rise Time "on" I_C = 12 Adc, I_B = 2 Adc, V_{CE} = 12 V		t_r	—	15	—	μs
Fall Time "off" I_C = 0, V_{EB} = 6 V, R_{EB} = 10 Ohms		t_f	—	15	—	μs

* To avoid excessive heating of the collector junction, perform these tests with the sweep method.

POWER-TEMPERATURE DERATING CURVE

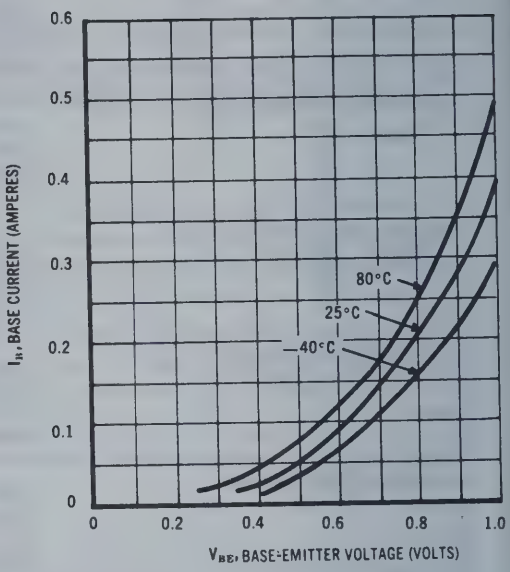


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

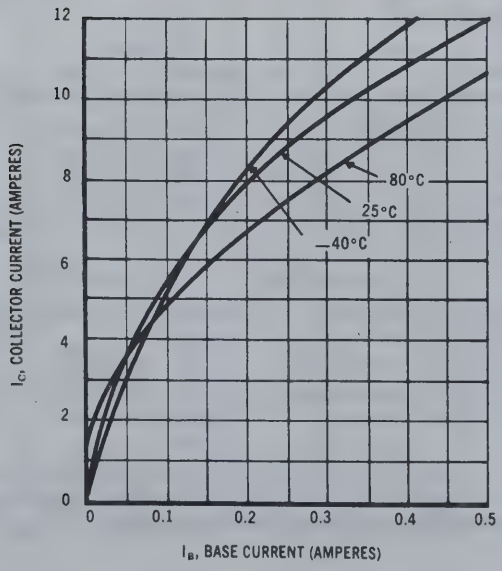
This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110° - T_C}{0.5}$$

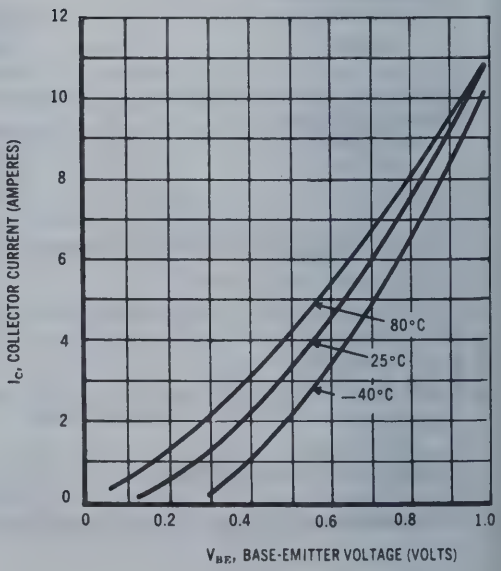
INPUT CHARACTERISTICS



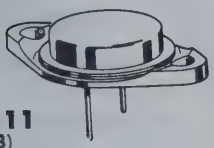
CURRENT TRANSFER CHARACTERISTICS



TRANSCONDUCTANCE CHARACTERISTICS



2N297A (GERMANIUM)



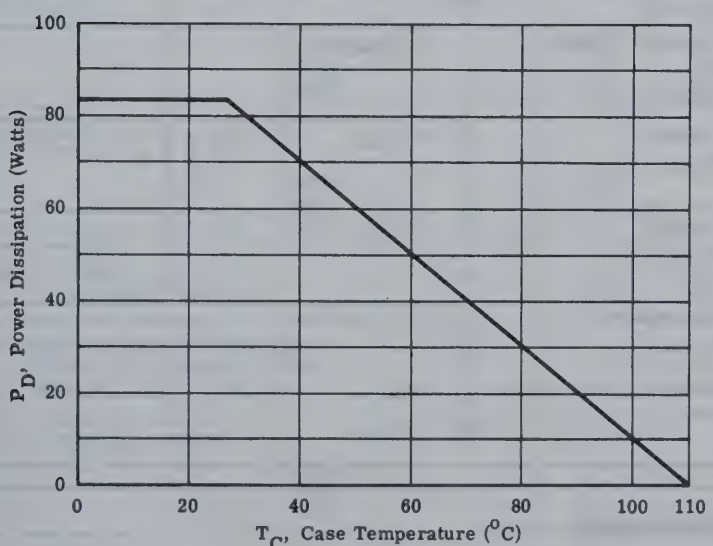
CASE 11
(TO-3)

PNP germanium power transistor for military and industrial power switching and amplifier applications. Operating temperature range and collector dissipation rating exceeds military specifications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
Emitter Current	I_E	5.0	Amp
Operating Temperature Range	T_J	−65 to +110	°C
Collector Dissipation at 25°C Case Temperature (θ_{JC} = 1°C/W max)	P_D	85	Watts

POWER-TEMPERATURE DERATING CURVE



2N297 A (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise specified

Characteristic	Symbol	Minimum	Maximum	Unit
DC Current Transfer Ratio V_{CE} = 2 V I_C = 0.5 Adc	h_{FE}	40	100	—
DC Current Transfer Ratio V_{CE} = 2 V I_C = 2.0 Adc	h_{FE}	20	—	—
Small-Signal Current Transfer Ratio Cutoff Frequency V_{CE} = 14 Vdc I_C = 0.5 Amp	$f_{\alpha e}$	5.0	—	kHz
Emitter-Base Cutoff Current V_{EB} = 40 Vdc I_C = 0	I_{EBO}	—	3.0	mAdc
Collector-Base Cutoff Current V_{CB} = 2 Vdc I_E = 0	I_{CBO}	—	200	μAdc
Collector-Base Cutoff Current V_{CB} = 60 Vdc I_E = 0	I_{CBO}	—	3.0	mAdc
Base Current V_{CE} = 2 Vdc I_C = 0.5 Adc	I_B	5.0	12.5	mAdc
Base Current V_{CE} = 2 Vdc I_C = 2 Adc	I_B	—	100	mAdc
Emitter-Base Voltage V_{CE} = 2 Vdc I_C = 2 Adc	V_{EB}	—	1.5	Vdc
Floating Potential V_{CB} = 60 Vdc (Voltmeter input resistance = 10 Megohm min)	V_{fl}		0.18	Vdc
Collector-Emitter Saturation Voltage I_C = 2 Adc I_B = 200 mAdc	$V_{CE(SAT)}$		1.0	Vdc
Collector-Emitter Voltage I_C = 300 mAdc I_B = 0	BV_{CEO}	40	—	Vdc
Collector-Emitter Voltage I_C = 300 mAdc V_{EB} = 0	BV_{CES}	50	—	Vdc
High-Temperature Operation T_C = +71°C min Collector Cutoff Current V_{CB} = 30 Vdc I_E = 0	I_{CBO}	—	6.0	mAdc

2N307 (GERMANIUM)

2N307 A

For Specifications, See 2N242 Data.

2N319 thru 2N321 (Germanium)



CASE 31(1)
(TO-5)

Base connected to case

PNP germanium transistors for audio amplifier and low-frequency switching applications.

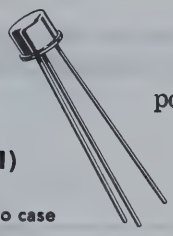
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_J, T_{stg}	-65 to + 100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = -25 Vdc, I_E = 0	I_{CBO}	-	16	μAdc
Emitter Cutoff Current V_{EB} = - 15 Vdc, I_C = 0	I_{EBO}	-	10	μAdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 10 K	BV_{CER}	20	-	Vdc
DC Current Gain I_C = 20 mAdc, V_{CE} = -1 Vdc	h_{FE}			
2N319		25	42	-
2N320		34	65	
2N321		53	121	
DC Current Gain I_C = 100 mAdc, V_{CE} = -1 Vdc	h_{FE}			
2N319		23	-	-
2N320		30	-	
2N321		47	-	
Base Input Voltage V_{CE} = -1 Vdc, I_C = 20 mAdc	V_{BE}	180	320	mVdc
Output Capacitance; Input AC Open Circuit V_{CB} = -5 Vdc, I_E = 1 mAdc, f = 1 MHz	C_{ob}	-	35	pF
Frequency Cutoff V_{CB} = -5 Vdc, I_E = 1 mAdc	$f_{\alpha b}$			
2N319		1.0	-	MHz
2N320		1.5	-	
2N321		2.0	-	

2N322 thru 2N324 (GERMANIUM)
2N508



CASE 31(1)
(TO-5)
Base connected to case

PNP germanium transistors for audio driver and low power output service in entertainment equipment.

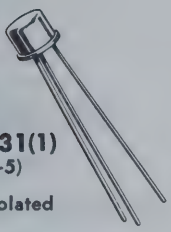
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	18	Vdc
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_J, T_{stg}	-65 to + 100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = -16 Vdc, I_E = 0	I_{CBO}	—	16	μAdc
Emitter Cutoff Current V_{EB} = -3 Vdc, I_C = 0	I_{EBO}	—	16	μAdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 5 K	BV_{CER}	18	—	Vdc
DC Current Gain V_{CE} = -1 Vdc, I_C = 20 mAdc 2N322 2N323 2N324 2N508	h_{FE}	 34 53 72 99	 65 121 198 198	—
Base Input Voltage V_{CE} = -1 Vdc, I_C = 20 mAdc	V_{BE}	180	320	mVdc
Output Capacitance; Input AC Open Circuit V_{CB} = -5 Vdc, I_E = 1 mAdc, f = 1 MHz	C_{ob}	—	35	pF
Frequency Cutoff V_{CB} = -5 Vdc, I_E = 1 mAdc 2N322 2N323 2N324 2N508	$f_{\alpha b}$	 1.0 1.5 2.0 2.5	 — — — —	MHz

2N331 (Germanium)



CASE 31(1)
(TO-5)
All leads isolated

PNP germanium transistor for audio range amplifier and switching service in military equipment. Have collector dissipation and storage temperature ratings significantly higher than those of the military specification (see maximum ratings table below).

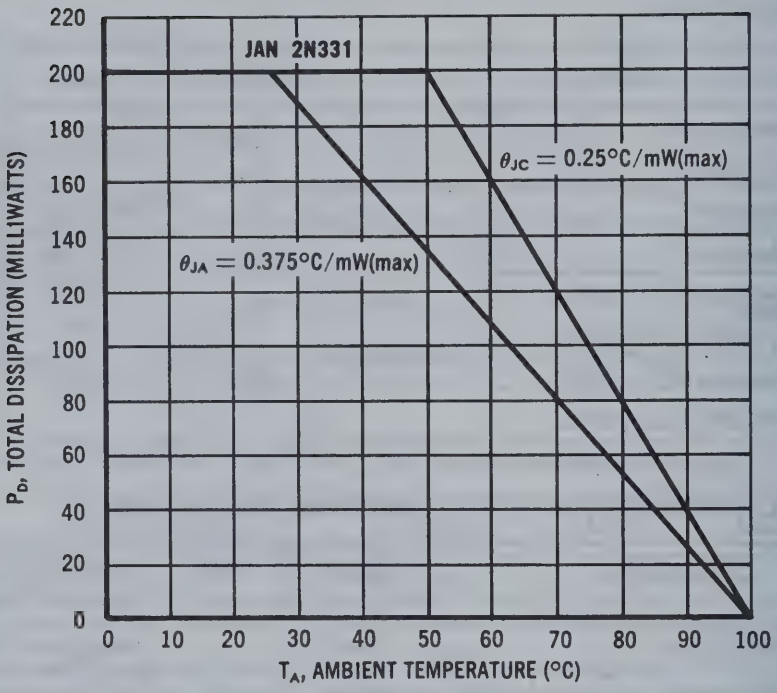
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Volts
Emitter-Base Voltage	V_{EB}	12	Volts
Storage Temperature	T_{stg}	-65 to + 85	°C
Storage Temperature	T_{stg}	-65 to + 100	°C
Collector Dissipation at T_A = 25°C (MIL-S-19500/4C (Derate 1.25 mW/°C above 25°C)	P_D	75	mW
Collector Dissipation at T_A = 25°C (JAN 2N331) (Derate 2.67 mW/°C above 25°C)	P_D	200	mW

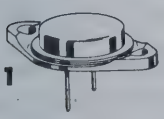
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Emitter Cutoff Current (V_{EB} = -12 Vdc, I_C = 0)	I_{EBO}	—	10	μAdc
Collector Cutoff Current (V_{CB} = -30 Vdc, I_E = 0)	I_{CBO}	—	10	μAdc
Small-Signal Open-Circuit Output Admittance (V_{CB} = -6 Vdc, I_E = 1.0 mAdc, f = 1 kHz)	h_{ob}	—	1.0	μmho
Small-Signal Short-Circuit Input Impedance (V_{CB} = -6 Vdc, I_E = 1.0 mAdc, f = 1 kHz)	h_{ib}	—	50	Ohms
Small-Signal Short-Circuit Forward-Current Transfer Ratio (V_{CE} = -6 Vdc, I_C = 1.0 mAdc, f = 1 kHz)	h_{fe}	30	70	—
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency (V_{CB} = -6 Vdc, I_E = 1 mAdc)	$f_{\alpha b}$	0.4	—	MHz
Output Capacitance (V_{CB} = -6 Vdc, I_E = 1 mAdc)	C_{ob}	—	50	pF
Noise Figure (V_{CB} = -6 Vdc, I_E = 1 mAdc, R_S = 1000, ohms, f = 1 kHz, f = Δ1 Hz)	NF	—	20	dB

POWER-TEMPERATURE DERATING CURVE



2N350A (GERMANIUM)
2N351A
2N376A



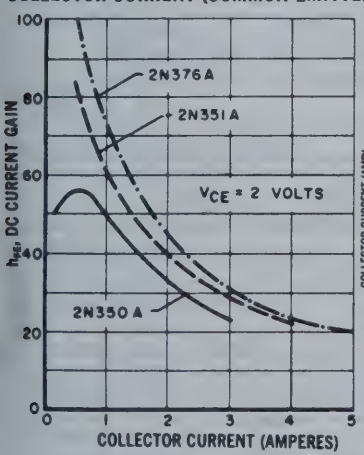
CASE 11
(TO-3)

PNP germanium power transistors for economical power switching applications and for power amplifiers requiring up to 4 watts of output power at relatively low distortion.

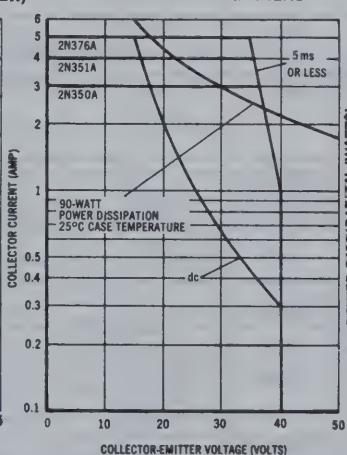
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector Dissipation at 25°C mounting base temperature	P_D	90	Watts
Collector Junction Temperature	T_J	−65 to +100	°C
Thermal Resistance (Junction to Case)	θ_{JC}	0.8	°C/W

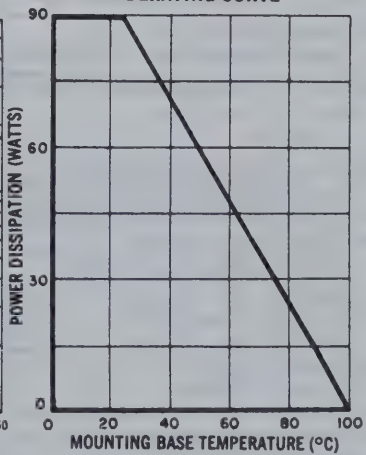
CURRENT GAIN versus COLLECTOR CURRENT (COMMON EMITTER)



SAFE OPERATING AREAS



POWER TEMPERATURE DERATING CURVE



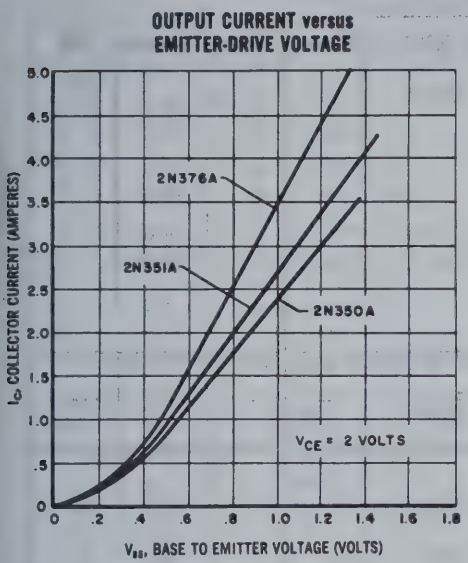
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

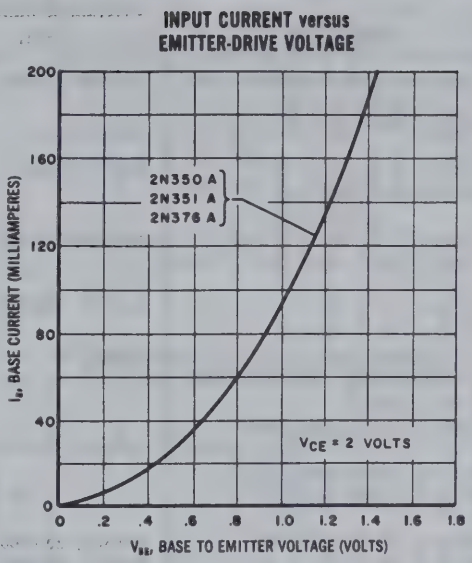
ELECTRICAL CHARACTERISTICS (at mounting base temperature 25°C ± 3°C.)

GENERAL	Symbol	Minimum	Typical	Maximum	Unit
Collector Cutoff Current V_{CB} = 30 V V_{CB} = 2 V V_{CB} = 30 V, T = 100°C	I_{CBO}	— — —	— 50 —	3.0 — 30	mA μA mA
Emitter Cutoff Current V_{EB} = 10 V	I_{EBO}	—	—	2.0	mA
Collector Breakdown Voltage I_C = 1 A (R_{BE} = 10 Ω) I_C = 330 mA, R_{BE} = 0 (This test should be made under dynamic conditions only)	BV_{CES}	40	—	—	Vdc

ELECTRICAL CHARACTERISTICS (at mounting base temperature 25°C ± 3°C.)

COMMON EMITTER		2N350A			2N351A			2N376A			Unit
	Sym	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Power Gain (± 0.5 db) P_{out} = 4 Watts, V_{CE} = 12 V, I_C = 0.7 A, f = 1 kHz	G_{PE}	30	—	33	32	—	35	34	—	37	dB
Total Harmonic Distortion under same conditions as power gain		—	—	7.0	—	—	7.0	—	—	7.0	%
DC Forward Current Gain V_{CE} = 2 V, I_C = 0.7 A	h_{FE}	20	—	60	25	—	90	35	—	120	
Current Gain Frequency Cutoff V_{CE} = 12 V, I_C = 0.7 A, f = 1 kHz ref	$f_{\alpha e}$	5.0	—	—	5.0	—	—	5.0	—	—	kHz
Small-Signal Forward Current Gain f = 1 kHz, V_{CE} = 2 V, I_C = 0.7 A	h_{fe}	—	30	—	—	45	—	—	60	—	
Small-Signal Input Impedance f = 1 kHz, V_{CE} = 2 V, I_C = 0.7 A	h_{ie}	5.0	—	17	6.0	—	20	7.0	—	25	Ohms
Collector Saturation Voltage I_C = 3 A, I_B = 300 mA	$V_{CE(SAT)}$	—	0.8	1.75	—	—	—	—	—	—	Vdc
Base-Emitter Voltage I_C = 3 A, I_B = 300 mA	V_{BE}	—	1.0	2.00	—	—	—	—	—	—	Vdc
Collector Saturation Voltage I_C = 4 A, I_B = 400 mA	$V_{CE(SAT)}$	—	—	—	—	0.8	1.75	—	—	—	Vdc
Base-Emitter Voltage I_C = 4 A, I_B = 400 mA	V_{BE}	—	—	—	—	1.0	2.00	—	—	—	Vdc
Collector Saturation Voltage I_C = 5 A, I_B = 500 mA	$V_{CE(SAT)}$	—	—	—	—	—	—	—	0.8	1.75	Vdc
Base-Emitter Voltage I_C = 5 A, I_B = 500 mA	V_{BE}	—	—	—	—	—	—	—	1.0	2.00	Vdc





2N375 (GERMANIUM)
2N618
2N1359
2N1360
2N1362 thru 2N1365



CASE 11
(TO-3)

PNP germanium power transistors for general purpose switching and amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	2N1359 2N1360	2N375 2N618	2N1362 2N1363	2N1364 2N1365	Unit
Collector-Emitter Voltage	V_{CES}	40	60	75	100	Vdc
Collector-Base Voltage	V_{CB}	50	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	25	40	50	60	Vdc
Collector Current-Continuous Peak	I_C	3.0 10				Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	106 1.25				Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				^oC

THERMAL CHARACTERISTICS

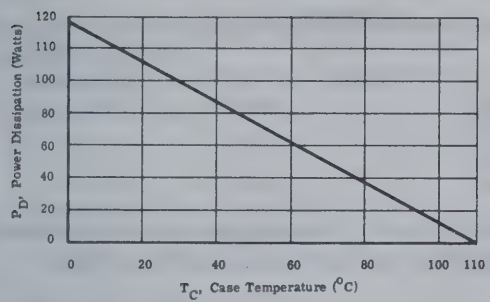
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^oC/W$

2N375, 2N618, 2N1359, 2N1360, 2N1362 thru 2N1365 (continued)

ELECTRICAL CHARACTERISTICS (At = 25°C unless otherwise noted)

Characteristic	Types	Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current	2N1359, 2N1360	I_{CBO}				mA
(V_{CB} = 40 V, I_E = 0)			--	--	3.0	
(V_{CB} = 50 V, I_E = 0)			--	--	20.0	
(V_{CB} = 60 V, I_E = 0)	2N375, 2N618		--	--	3.0	
(V_{CB} = 80 V, I_E = 0)			--	--	20.0	
(V_{CB} = 75 V, I_E = 0)	2N1362, 2N1363		--	--	3.0	
(V_{CB} = 100 V, I_E = 0)			--	--	20.0	
(V_{CB} = 100 V, I_E = 0)	2N1364, 2N1365		--	--	3.0	
(V_{CB} = 120 V, I_E = 0)			--	--	20.0	
Collector-Base Cutoff Current at Tc = +90°C, V_{CB} = 1/2 BV_{CES} rating		I_{CBO}	--	--	20	mA
Emitter-Base Cutoff Current (V_{EB} = 12 V, I_C = 0)		I_{EBO}	--	--	0.5	mA
(V_{EB} = 25 V, I_C = 0)	2N1359, 2N1360		--	--	20	
(V_{EB} = 50 V, I_C = 0)	2N1362, 2N1363		--	--	20	
(V_{EB} = 60 V, I_C = 0)	2N1364, 2N1365		--	--	20	
Collector-Emitter Breakdown Voltage						Vdc
I_C = 500 mA, V_{EB} = 0)	2N1359, 2N1360	BV_{CES}	40	--	--	
	2N375, 2N618		60	--	--	
	2N1362, 2N1363		75	--	--	
	2N1364, 2N1365		100	--	--	
DC Current Transfer Ratio		h_{FE}				--
(V_{CE} = 4 V, I_C = 1.0A)	2N1359, 375, 1362, 64		35	55	90	
	2N1360, 618, 1363, 65		60	90	140	
(V_{CE} = 4 V, I_C = 1.0A)	2N1359, 375, 1362, 64		15	22	--	
	2N1360, 618, 1363, 65		20	35	--	
Transconductance						mhos
(V_{CE} = 4 V, I_C = 1.0A)	2N375	g_{FE}	0.8	1.25	2.2	
	2N618		1.0	1.6	2.5	
	2N1359, 2N1362, 2N1364		0.8	1.25	--	
	2N1360, 2N1363, 2N1365		1.0	1.6	--	
Frequency Cutoff		$f_{\alpha e}$				kHz
(V_{CE} = 4 V, I_C = 1 A)	2N375		5.0	8.5	--	
(V_{CE} = 4 V, I_C = 1 A)	2N618		5.0	8.5	--	
(V_{CE} = 4 V, I_C = 3 A)	2N1359, 2N1362, 2N1364		7.0	10	--	
(V_{CE} = 4 V, I_C = 3 A)	2N1360, 2N1363, 2N1365		5.0	8.5	--	
Collector Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 2.0 A, I_B = 200mA)	2N1359, 375, 1362, 64		--	0.4	1.0	
	2N1360, 618, 1363, 65		--	0.3	0.8	
Base-Emitter Drive Voltage		V_{BE}				Vdc
(I_C = 2.0A, I_B = 200 mA)	2N1359, 375, 1362, 64		--	0.7	--	
	2N1360, 618, 1363, 65		--	0.6	--	
Collector-Emitter Punch-Through Voltage		V_{EBF}				Vdc
(V_{CB} = 50 V, I_C = 0)	2N1359, 2N1360		--	--	1.25	
(V_{CB} = 100 V, I_C = 0)	2N1362, 2N1363		--	--	1.25	
(V_{CB} = 120 V, I_C = 0)	2N1364, 2N1365		--	--	1.25	

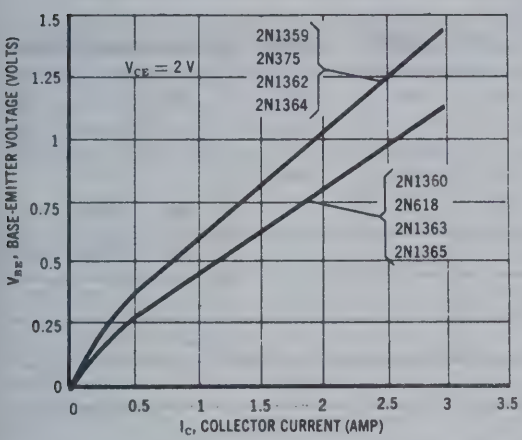
POWER-TEMPERATURE DERATING CURVE



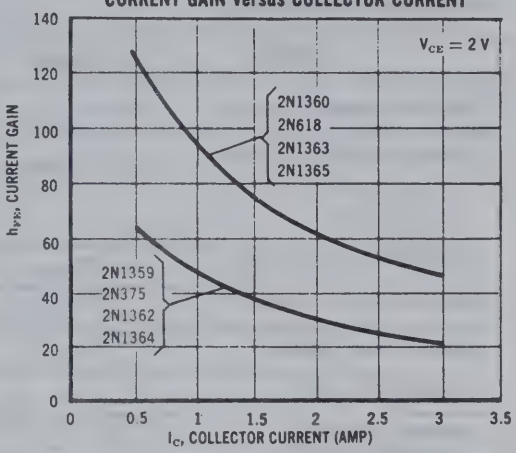
The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For d.c. or frequencies below 25 cps the transistor must be operated within the constant $P_D = Vc \times Ic$ hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{110^{\circ} - Tc}{0.8}$$

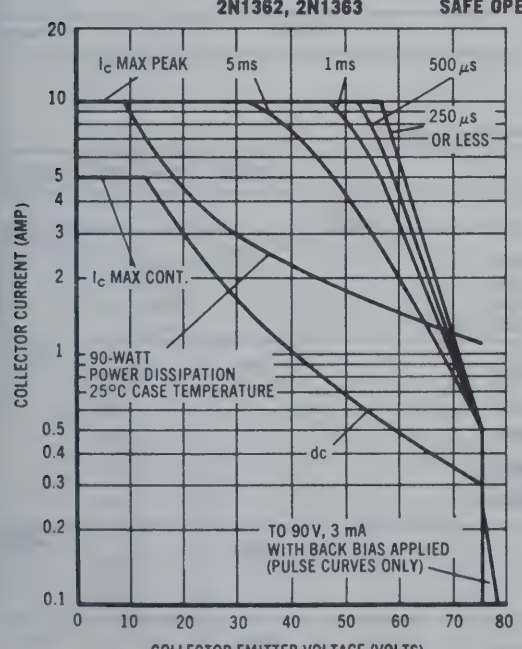
BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

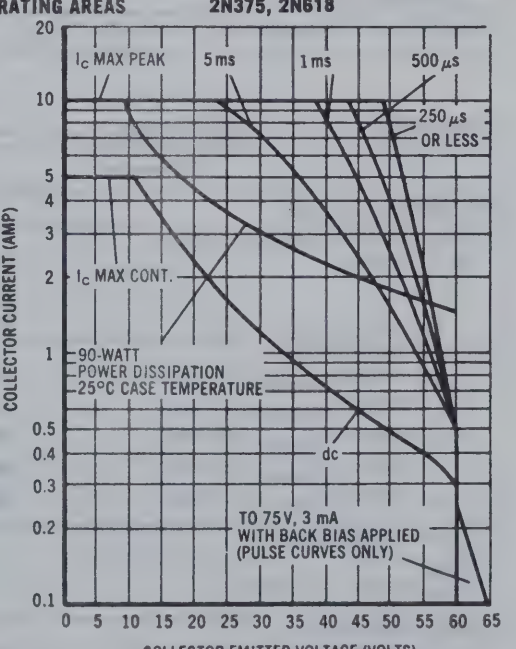


CURRENT GAIN versus COLLECTOR CURRENT



2N1362, 2N1363 SAFE OPERATING AREAS 2N375, 2N618





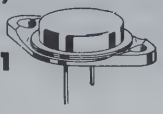
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N376A (GERMANIUM)

For Specifications, See 2N350A Data.

2N378 thru 2N380 (GERMANIUM)

2N459, A



CASE 11
(TO-3)

PNP germanium power transistors for general purpose power amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	2N378	2N379	2N380	2N459	2N459A	Unit
Collector-Emitter Voltage	V_{CEO}	20	40	30	60	60	Vdc
Collector-Emitter Voltage	V_{CEX}						Vdc
(V_{BE} = 1.5 V)		40	80	60	-	-	
(V_{BE} = 1.0 V)		-	-	-	105	105	
Collector-Emitter Voltage	V_{CES}	-	-	-	70	70	Vdc
Collector-Base Voltage	V_{CB}	-	-	-	-	105	Vdc
Emitter-Base Voltage	V_{EB}	-	-	-	10	25	Vdc
Collector Current	I_C	5.0					Adc
Operating Junction Temperature Range	T_J	-65 to +110					°C
Total Device Dissipation @ T_C = 25° C	P_D	106					Watts

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 100 mAdc)	2N378		20	-	
	2N379		40	-	
	2N380		30	-	
	2N459, 2N459A		60	-	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N378		-	10	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N380		-	10	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N379		-	10	
(V_{CE} = 105 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N459		-	10	
(V_{CE} = 105 Vdc, $V_{BE(off)}$ = 1.0 Vdc)	2N459A		-	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 25 Vdc)			-	0.5	
(V_{CB} = 25 Vdc, T_C = 85° C)			-	7.5	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 10 Vdc)	2N380		-	1.5	
	2N459		-	2.0	
(V_{BE} = 25 Vdc)	2N459A		-	2.0	

2N378, thru 2N380 2N459, 2N459 A (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N378		40	80	
	2N379, 2N459		20	70	
	2N380		30	70	
	2N459A		40	70	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N459A		20	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)	2N378-2N380, 2N459		-	1.0	
	2N459A		-	0.3	
Base-Emitter Voltage		$V_{BE(on)}$			Vdc
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N378		-	1.6	
	2N379, 2N459, 2N459A		-	1.3	
	2N380		-	1.0	
DYNAMIC CHARACTERISTICS					
Common-Emitter Cutoff Frequency		$f_{\alpha e}$			kHz
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	2N378-2N380, 2N459		5.0	-	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N459A		5.0	-	

2N381 thru 2N383 (GERMANIUM)

2N2171



CASE 31(1)
(TO-5)

Base connected to case

PNP germanium transistors for small-signal audio amplifiers, Class B push-pull output stages and medium-speed switching circuits.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Volts
Collector-Emitter Voltage (R_{BE} = 10K)	V_{CER}	25	Volts
Emitter-Base Voltage	V_{EB}	20	Volts
Collector Current	I_C	400	mA
Junction Temperature	T_J	-65 to +100	°C
Collector Dissipation	P_D		
T_A = 25°C		225	mW
derate		3.0	mW/°C
T_C = 25°C		500	mW
derate		6.7	mW/°C

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Typical	Max	Unit
Collector-Base Cutoff Current (V_{CB} = -25 Vdc)		I_{CBO}	- - -	6.0	10	μAdc
Emitter-Base cutoff Current (V_{EB} = -20 Vdc)		I_{EBO}	- - -	5.0	10	μAdc
Collector-Emitter Voltage (I_C = 500 μAdc, R_{BE} = 10K)		BV_{CER}	25	- - -	- - -	Vdc
Collector-Emitter Voltage (I_C = 50 μAdc, V_{BE} = 1.0 Vdc)	2N381	BV_{CER}	- - -	50	- - -	Vdc
	2N382, 2N383, 2N2171		- - -	45	- - -	
DC Current Gain		h_{FE}				- - -
(I_C = 20 mAdc, V_{CE} = -1.0 Vdc)	2N381		35	- - -	65	
	2N382		60	- - -	95	
	2N383		75	- - -	120	
	2N2171		110	- - -	250	
(I_C = 100 mAdc, V_{CE} = -1.0 Vdc)	2N381		30	- - -	- - -	
	2N382		50	- - -	- - -	
	2N383		65	- - -	- - -	
	2N2171		90	- - -	- - -	

ELECTRICAL CHARACTERISTICS (continued)

Characteristics		Symbol	Min	Typical	Max	Unit
Small Signal Current Gain (I_C = 10 mA, V_{CE} = -5.0 V, f = 1 kHz)		h_{fe}				- - -
	2N381		35	60	85	
	2N382		70	90	135	
	2N383		90	115	155	
	2N2171		120	210	310	
Voltage Feedback Ratio (I_C = 10 mA, V_{CE} = -5 V, f = 1 kHz)		h_{re}				$X10^{-3}$
	2N381		- - -	0.66	- - -	
	2N382		- - -	0.69	- - -	
	2N383		- - -	0.72	- - -	
	2N2171		- - -	0.75	- - -	
Input Impedance (I_C = 10 mA, V_{CE} = -5.0 V, f = 1 kHz)		h_{ie}				ohms
	2N381		- - -	300	- - -	
	2N382		- - -	450	- - -	
	2N382		- - -	550	- - -	
	2N2171		- - -	850	- - -	
Output Admittance (I_C = 10 mA, V_{CE} = -5.0 V, f = 1 kHz)		h_{oe}				μmhos
	2N381		- - -	420	- - -	
	2N382		- - -	400	- - -	
	2N383		- - -	380	- - -	
	2N2171		- - -	500	- - -	
Transducer Gain		G_T				dB
(R_g = 300 Ω, R_L = 500 Ω)	2N381		- - -	36	- - -	
(R_g = 450 Ω, R_L = 500 Ω)	2N382		- - -	38	- - -	
(R_g = 550 Ω, R_L = 500 Ω)	2N383		- - -	39.5	- - -	
(R_g = 785 Ω, R_L = 500 Ω)	2N2171		- - -	42.5	- - -	
Output Capacitance (I_C = 1 mA, V_{CB} = -6V)		C_{ob}	- - -	20	- - -	pF
Noise Figure (I_C = 1 mA, V_{CE} = -6V, R_g = 1 kc, f = 1 kHz)		NF				dB
	2N381		- - -	6.0	- - -	
	2N382		- - -	5.5	- - -	
	2N383		- - -	5.0	- - -	
	2N2171		- - -	3.5	- - -	
Cutoff Frequency (I_C = 1 mA, V_{CB} = -6V)		$f_{\alpha b}$				MHz
	2N381		- - -	3.0	- - -	
	2N382		- - -	4.0	- - -	
	2N383		- - -	5.0	- - -	
	2N2171		- - -	7.5	- - -	

2N398, 2N398A (GERMANIUM)



CASE 31(1)
(TO-5)
All leads isolated

PNP germanium transistor for high-voltage, audio-frequency applications.

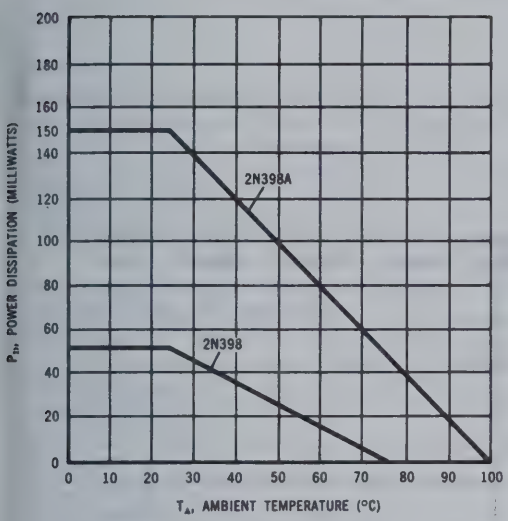
MAXIMUM RATINGS

Rating	Symbol	2N398A	2N398	Unit
Collector-Base Voltage	V_{CB}	105	105	Vdc
Collector-Emitter Voltage	V_{CEO}	105	105	Vdc
Emitter-Base Voltage	V_{EB}	50	50	Vdc
DC Collector Current	I_C	200	100	mA
Emitter Current	I_E	200	100	mA
Junction Temperature	T_J	-65 to +100	-65 to +85	°C
Storage Temperature	T_{stg}	-65 to +100	-65 to +85	°C
Collector Dissipation @ 25°C	P_D	150	50	mW
Thermal Resistance, Junction to Ambient	θ_{JA} max	0.5	1.2	°C/mW

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

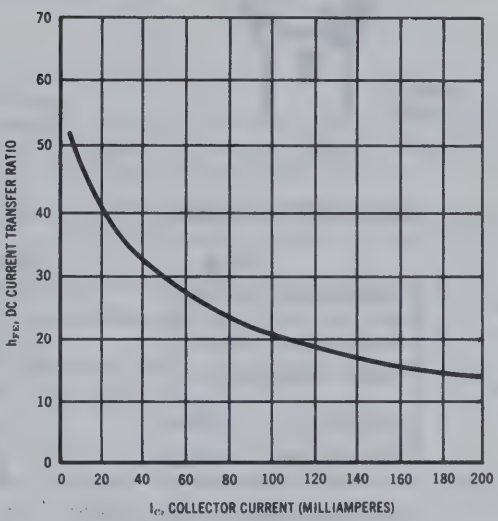
Characteristics	Symbol	Min	Typical	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 105 V, I_B = 0)	I_{CBO}	-	12.0	50	μA
Collector-Base Cutoff Current (V_{CB} = 2.5 V, I_B = 0)	I_{CBO}	-	5.0	14	μA
Emitter-Base Cutoff Current (V_{EB} = 50 V, I_C = 0)	I_{EBO}	-	3.0	50	μA
Collector-Emitter Saturation Voltage (I_C = 5 mAdc; I_B = 0.25 mAdc)	$V_{CE\ (SAT)}$	-	0.11	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 5 mAdc; I_B = 0.25 mAdc)	$V_{BE\ (SAT)}$	-	0.22	0.40	Vdc
DC Current Transfor Ratio (I_C = 5 mAdc; V_{CE} = 0.35 Vdc)	h_{FE}	20	65	-	-
DC Collector-Emitter Punch-Through Voltage (V_{CB} necessary to obtain V_{EB} of -1 V max, using instrument with Z_{in} > 11 megohm to measure V_{BE})	V_{PT}	105	160	-	Vdc
Small-Signal Short-Circuit, Forward Current Transfer Ratio Cutoff Frequency (V_{CB} = 6 Vdc; I_E = 1 mAdc)	$f_{\alpha b}$	-	1.0	-	MHz

POWER — TEMPERATURE DERATING CURVE



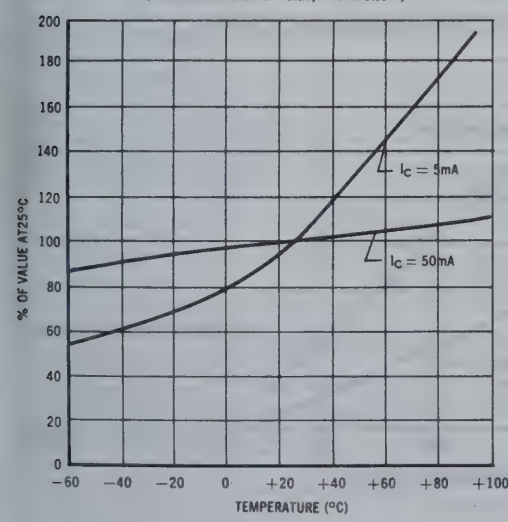
DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT

$V_{CE} = 0.35V$



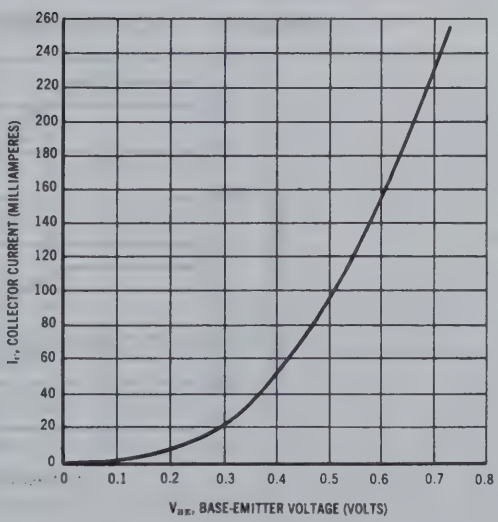
LARGE SIGNAL CURRENT GAIN (H_{FE}) versus TEMPERATURE

(Normalized to 25°C Value; $V_{CB} = 0.35V$)



OUTPUT CURRENT versus BASE-DRIVE VOLTAGE

($V_{CE} = -1$ V)



2N441 (GERMANIUM)
2N442
2N443

PNP germanium power transistors for power switching and amplifier applications. Power and temperature ratings exceed EIA registration.



CASE 5
(TO-36)

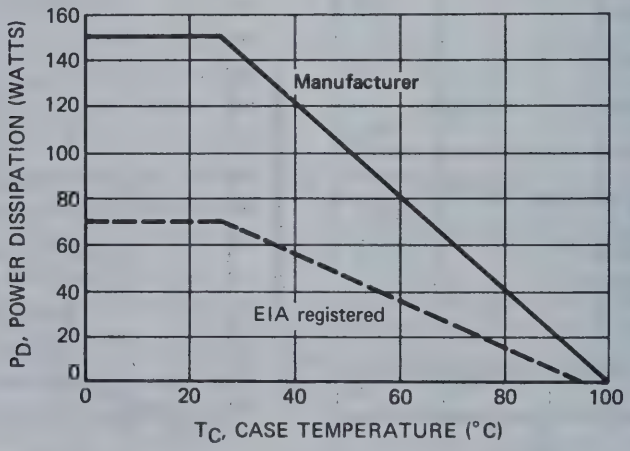
MAXIMUM RATINGS

Rating	Symbol	2N441	2N442	2N443	Unit
Collector-Emitter Voltage	V_{CES}	40	45	50	Vdc
Collector-Base Voltage	V_{CB}	40	50	60	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	Vdc
Base Current — Continuous	I_B	4.0			Adc
Emitter Current — Continuous	I_E	15			Adc
Total Device Dissipation @ T_C = 25°C	P_D	150			Watts
Operating Junction Temperature Range (EIA Registered)	T_J	-65 to +95			°C
Operating Junction Temperature Range	T_J	-65 to +100			°C

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case (EIA Registered)	θ_{JC}	1.0	°C/W
Thermal Resistance, Junction to Case	θ_{JC}	0.5	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor.

This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 100°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{100^\circ - T_C}{0.5}.$$

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1.0 Adc, I_B = 0)	2N441	BV_{CEO}*	25	-	-	Vdc
	2N442		30	-	-	
	2N443		45	-	-	
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc, V_{BE} = 0)	2N441	BV_{CES}*	40	-	-	Vdc
	2N442		45	-	-	
	2N443		50	-	-	
Floating Potential		V_{EBF}				Vdc
(V_{CB} = 40 Vdc, I_E = 0)	2N441		-	-	1.0	
(V_{CB} = 50 Vdc, I_E = 0)	2N442		-	-	1.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N443		-	-	1.0	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 2.0 Vdc, I_E = 0)			-	0.1	-	
(V_{CB} = 40 Vdc, I_E = 0)	2N441		-	2.0	8.0	
(V_{CB} = 50 Vdc, I_E = 0)	2N442		-	2.0	8.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N443		-	2.0	8.0	
(V_{CB} = 40 Vdc, I_E = 0, T_B = 71°C)	2N441		-	-	15	
(V_{CB} = 50 Vdc, I_E = 0, T_B = 71°C)	2N442		-	-	15	
(V_{CB} = 50 Vdc, I_E = 0, T_B = 71°C)	2N443		-	-	15	
Emitter Cutoff Current		I_{EBO}				mAdc
(V_{BE} = 20 Vdc, I_C = 0)	2N441		-	1.0	8.0	
(V_{BE} = 30 Vdc, I_C = 0)	2N442		-	1.0	8.0	
(V_{BE} = 40 Vdc, I_C = 0)	2N443		-	1.0	8.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			20	-	40	
(I_C = 12 Adc, V_{CE} = 2.0 Vdc)			-	20	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 12 Adc, I_B = 2.0 Adc)	2N441		-	0.3	-	
	2N442		-	0.3	-	
	2N443		-	0.3	1.0	
Base-Emitter Voltage		V_{BE}				Vdc
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N441		-	0.65	-	
	2N442		-	0.65	-	
	2N443		-	0.65	0.9	
DYNAMIC CHARACTERISTICS						
Common-Emitter Cutoff Frequency (I_C = 5.0 Adc, V_{CE} = 6.0 Vdc)		$f_{\alpha e}$	-	10	-	kHz
SWITCHING CHARACTERISTICS						
Rise Time (V_{CE} = 12 Vdc, I_C = 12 Adc, I_B = 2.0 Adc)		t_r	-	15	-	μs
Fall Time (I_C = 0, V_{BE} = 6.0 Vdc, R_{BE} = 10 ohms)		t_f	-	15	-	μs

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TYPICAL COMMON-EMITTER CHARACTERISTICS

FIGURE 2 – OUTPUT CHARACTERISTICS

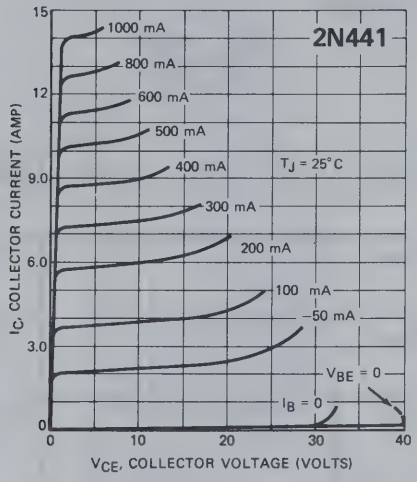


FIGURE 3 – OUTPUT CHARACTERISTICS

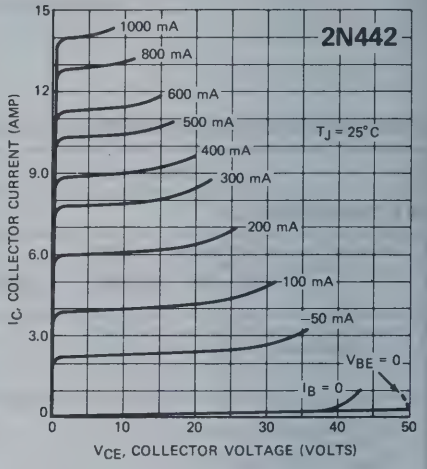


FIGURE 4 – OUTPUT CHARACTERISTICS

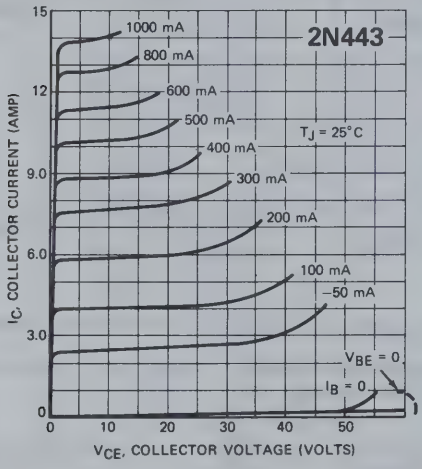


FIGURE 5 – INPUT CHARACTERISTICS

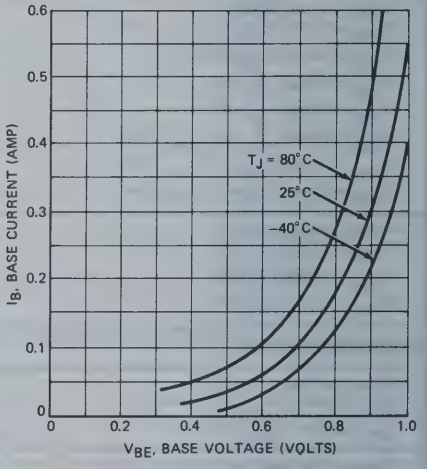


FIGURE 6 – DC CURRENT GAIN TRANSFER CHARACTERISTICS

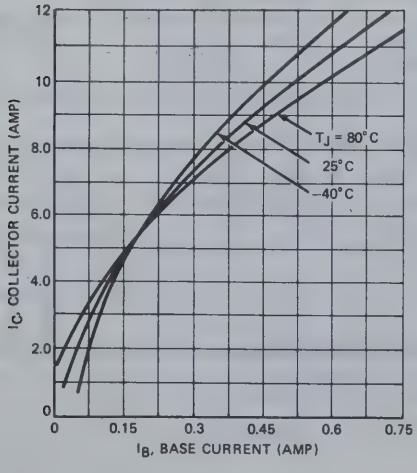
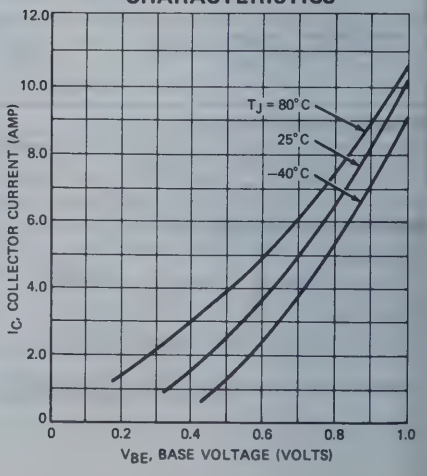


FIGURE 7 – TRANSCONDUCTANCE CHARACTERISTICS



2N456A (GERMANIUM)
2N457A
2N458A



CASE 11
(TO-3)

PNP high-current germanium power transistors for industrial and general power amplifier and switching applications.

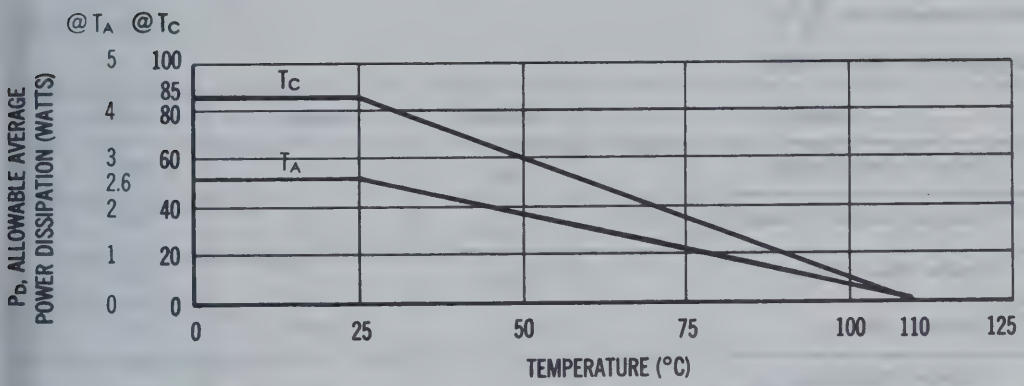
MAXIMUM RATINGS (Tc = 25°C unless otherwise noted)

Rating	Symbol	2N456A	2N457A	2N458A	Unit
Collector-Base Voltage	V_{CB}	40	60	80	Volts
Collector-Emitter Voltage	V_{CEO}	20	30	40	Volts
Emitter-Base Voltage	V_{EB}	20			Volts
Collector Current	I_C	7.0			Amp
Base Current	I_B	3.0			Amp
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +110			°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	85 1.0			Watts W/°C

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise specified)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 20 Vdc)	2N456A		—	0.5	
(V_{CB} = 30 Vdc)	2N457A		—	0.5	
(V_{CB} = 40 Vdc)	2N458A		—	0.5	
(V_{CB} = 40 Vdc)	2N456A		—	2.0	
(V_{CB} = 60 Vdc)	2N457A		—	2.0	
(V_{CB} = 80 Vdc)	2N458A		—	2.0	
(V_{CB} = 40 Vdc, T_C = +71°C)	2N456A		—	10	
(V_{CB} = 60 Vdc, T_C = +71°C)	2N457A		—	10	
(V_{CB} = 80 Vdc, T_C = +71°C)	2N458A		—	10	
Emitter-Base Cutoff Current (V_{EB} = 20 Vdc)		I_{EBO}	—	2.0	mAdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc)	2N456A	BV_{CEO}	20	—	Vdc
	2N457A		30	—	
	2N458A		40	—	
Base-Emitter Voltage (I_C = 5 Adc, V_{CE} = 1.5 Vdc)		V_{BE}	—	1.5	Vdc
Collector-Emitter Saturation Voltage (I_C = 5 Adc, I_B = 500 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
DC Current Gain		h_{FE}			—
(I_C = 1 Adc, V_{CE} = 1.5 Vdc)			40	—	
(I_C = 3 Adc, V_{CE} = 1.5 Vdc)			35	—	
(I_C = 5 Adc, V_{CE} = 1.5 Vdc)			30	90	
(I_C = 7 Adc, V_{CE} = 1.5 Vdc)			22	—	
Current Gain-Bandwidth Product (I_C = 1 Adc, V_{CE} = 2 Vdc)		f_T	200	—	kHz
Input Impedance (I_C = 5 Adc, V_{CE} = 1.5 Vdc)		h_{ie}	—	28	ohms

POWER-TEMPERATURE DERATING CURVE



2N459, A (GERMANIUM)

For Specifications, See 2N378-380 Data.

2N460, 2N461 (GERMANIUM)



CASE 31(1)
(TO-5)
Base connected to case

PNP germanium transistor for general purpose industrial applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Volts
Collector-Emitter Voltage (R_{BE} = 1 K)	V_{CER}	35	Volts
Emitter-Base Voltage	V_{EB}	10	Volts
Collector Current	I_C	400	mA
Collector Dissipation at 25° C Case Temperature Derate above 25° C at 25° C Ambient Temperature Derate above 25° C	P_D	 500 6.7 225 3.0	 mW mW/° C mW mW/° C
Junction Temperature Range	T_J	-65 to +100	° C

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Typical	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 45 Vdc)		I_{CBO}	---	---	15	μAdc
Emitter-Base Cutoff Current (V_{EB} = -10 Vdc)		I_{EBO}	---	---	10	μAdc
Collector-Emitter Voltage (I_C = 1 mAdc, R_{BE} = 1 K)		BV_{CER}	35	---	---	Vdc
Small-Signal Current Gain (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N460 2N461	h_{fb}	0.94 0.955	0.96 0.968	0.972 0.988	---
Small-Signal Current Gain (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N460 2N461	h_{fe}	17 31	---	36 200	---
Reverse Voltage Ratio (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N460 2N461	h_{rb}	--- ---	2.0 3.0	15 15	$X10^{-4}$
Input Resistance (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N460 2N461	h_{ib}	25 25	30 ---	40 40	Ohms
Output Admittance (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N460 2N461	h_{ob}	--- ---	0.8 0.5	1.5 1.5	μmho
Frequency Cutoff (V_{CE} = -5 Vdc, I_E = 1 mAdc)	2N460 2N461	$f_{\alpha b}$	--- ---	1.2 4.0	--- ---	MHz
Output Capacitance (V_{CB} = -10 Vdc, I_E = 1 mAdc, f = 1 MHz)		C_{ob}	---	20	---	pF
Noise Figure (V_{CE} = -4.5 Vdc, I_E = 0.5 mAdc, R_g = 1 K, f = 1 kHz)	2N460 2N461	NF	--- ---	5.0 4.0	--- ---	dB

2N464 thru 2N467 (GERMANIUM)



CASE 31(1)
(TO-5)
All leads isolated

PNP germanium transistor for general purpose applications in the audio-frequency range.

MAXIMUM RATINGS

Rating	Symbol	2N464	2N465	2N466	2N467	Unit
Collector-Base Voltage	V_{CB}	45	45	35	35	Volts
Collector-Emitter Voltage	V_{CER}	40	30	20	15	Volts
Emitter-Base Voltage	V_{EB}	12				Volts
DC Collector Current	I_C	500				mA
Max. Junction & Storage Temperature	T_J and T_{stg}	100				°C
Collector Dissipation, Ambient	P_D	200				mW
Derate above 25°C		2.67				mW/°C
Thermal Resistance, Junction to Ambient	θ_{JA}	0.375				°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

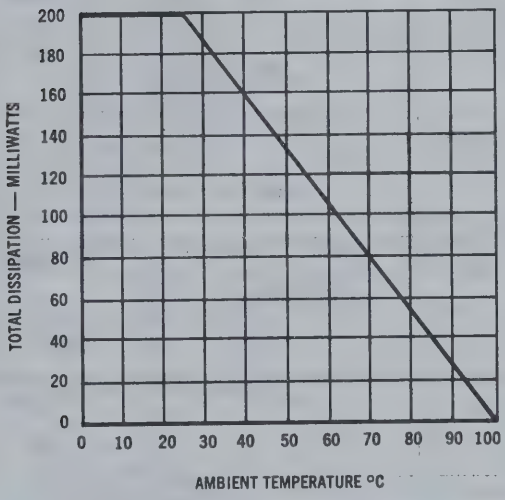
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 0.6 mAdc, R_{BE} = 10 K ohms)	2N464	BV_{CER}	40	–	–	Vdc
	2N465		30	–	–	
	2N466		20	–	–	
	2N467		15	–	–	
Collector-Base Cutoff Current (V_{CB} = 20 Vdc)		I_{CBO}	–	6.0	15	μAdc
Small Signal Current Gain Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc)	2N464	$f_{\alpha b}$	–	0.7	–	MHz
	2N465		–	0.8	–	
	2N466		–	1.0	–	
	2N467		–	1.2	–	
Small Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1.0 mAdc, f = 1 kHz)	2N464	h_{fe}	14	26	–	–
	2N465		27	45	–	
	2N466		56	90	–	
	2N467		112	180	–	

2N464 thru 2N467 (continued)

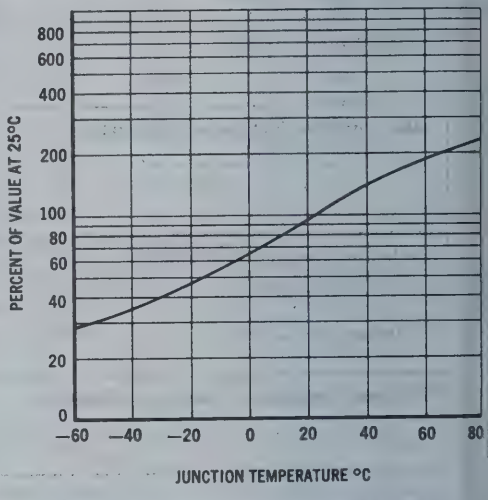
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
Small Signal Input Impedance (V_{CE} = 6 Vdc, I_E = 1.0 mAdc, f = 1 kHz)	2N464	h_{ie}	–	900	–	Ohms
	2N465		–	1400	–	
	2N466		–	3000	–	
	2N467		–	5500	–	
Small Signal Power Gain (V_{CE} = 6 Vdc, I_E = 1.0 mAdc, f = 1 kHz, matched)	2N464	G_e	–	40	–	dB
	2N465		–	42	–	
	2N466		–	44	–	
	2N467		–	45	–	
Noise Figure (V_{CE} = 2.5 Vdc, I_E = 0.5 mAdc, f = 1 kHz, R_S = 10 Kohms, Δf = 1 Hz		NF	–	–	22	dB

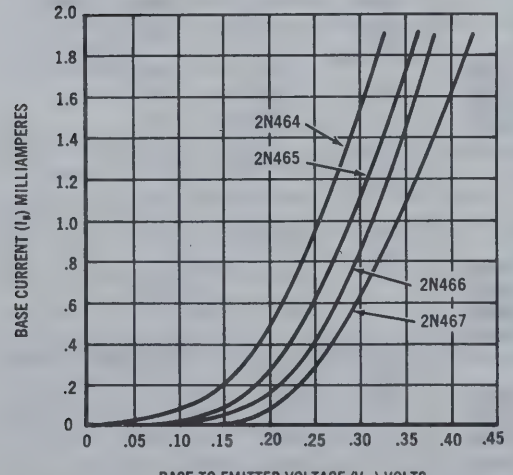
POWER-TEMPERATURE DERATING CURVE



SMALL SIGNAL CURRENT GAIN versus TEMPERATURE

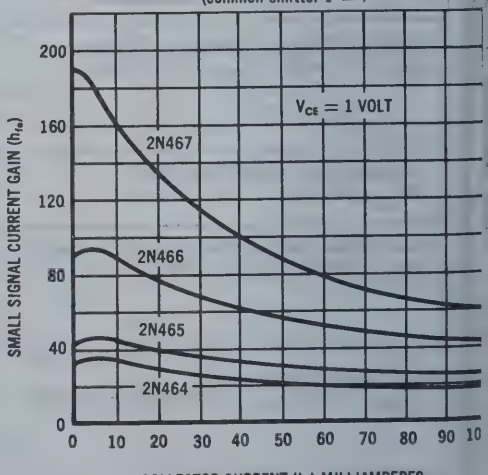


Input Current versus Emitter-Drive Voltage



Small Signal Current Gain versus Collector Current

(common emitter 1 kHz)



2N499
(JAN2N499 AVAILABLE)

2N499A
(JAN2N499A AVAILABLE)

2N502
2N502A
(JAN2N502A AVAILABLE)

2N502B
(JAN2N502B AVAILABLE)

2N1742

Germanium PNP high frequency transistors designed for driver applications, small-signal amplification, wide band video amplifiers, and VHF/UHF oscillators.



CASE 149
(TO-1)

2N499, 2N499A
JAN2N499, JAN2N499A



CASE 31
(TO-5)

2N502,A,B,
JAN2N502A,B,
2N1742

MAXIMUM RATINGS

Rating	Symbol	2N499 JAN2N499 2N499A JAN2N499A	2N502	2N502A, B JAN2N502A JAN2N502B	2N1742	Unit
Collector-Base Voltage	V_{CB}	30	20	30	20	Vdc
Emitter-Base Voltage	V_{EB}	0.5	0.5	0.5	0.5	Vdc
Collector Current	I_C	50	50	50	50	mAdc
Total Device Dissipation	P_D	60	60	75	60	mW
Operating Junction Temperature Range	T_J	100	100	100	125	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 10 Vdc, I_E = 0)	2N502, A, B		-	5.0	
	JAN2N502A, B		-	4.0	
	2N1742		-	10	
(V_{CB} = 15 Vdc, I_E = 0)	2N499, A, JAN2N499, A		-	10	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product		f_T			MHz
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N499, A, JAN2N499, A		120	-	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	JAN2N502A, B		150	600	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 4.0 MHz)	2N499, A, JAN2N499, A		-	2.5	
	2N502		-	2.0	
	2N502A, B		-	1.6	
	JAN2N502A, B		-	1.6	
Small-Signal Current Gain		h_{fe}			-
(I_C = 1.0 mAdc, V_{CE} = 9.0 Vdc, f = 1.0 kHz)	2N499, A, JAN2N499, A		20	80	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N502		9.0	-	
	2N502A		15	-	
	2N502B		20	80	
	JAN2N502A		15	200	
	JAN2N502B		25	80	
Collector-Base Time Constant		$r_b'C_c$			ps
(I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 46 MHz)	JAN2N499, A		5.0	50	
	2N499		-	250	
	2N499A		5.0	250	
	2N502		-	120	
	2N502A, B		5.0	50	
	JAN2N502A, B		5.0	25	
Noise Figure		NF			dB
(V_{CB} = 10 Vdc, I_E = 2.0 mAdc, f = 200 MHz)	2N502A, JAN2N502A		-	7.0	
	2N502B, JAN2N502B		-	7.0	
(V_{CC} = 12 Vdc, I_E = 2.5 mAdc, f = 200 MHz)	2N1742		-	5.5	
FUNCTIONAL TESTS					
Power Gain		P_G			dB
(V_{CB} = 10 Vdc, I_E = 2.0 mAdc, f = 100 MHz)	2N499, A, JAN2N499, A		7.5	-	
(V_{CB} = 10 Vdc, I_E = 2.0 mAdc, f = 200 MHz)	2N502		8.0	-	
	2N502A		10	-	
	2N502B		10	-	
	JAN2N502A, B		10	20	
(V_{CB} = 12 Vdc, I_E = 2.5 mAdc, f = 200 MHz)	2N1742		14	19	

2N508 (GERMANIUM)

FOR SPECIFICATIONS, SEE 2N322 DATA.

2N508A (GERMANIUM)



CASE 31 (1)
(TO-5)
Base connected to case

PNP Germanium Milliwatt transistor designed for low noise audio and switching applications.

- Small-Signal Current Gain –
  h_{fe} = 180 (Max) @ I_E = 1.0 mAdc
- Low Noise Figure Applications –
  NF = 5.0 dB (Max) @ I_C = 1.0 mAdc

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage (R_{BE} = 10 kohms)	V_{CER}	25	Vdc
*Collector-Emitter Voltage	V_{CES}	30	Vdc
*Collector-Base Voltage	V_{CB}	30	Vdc
*Emitter-Base Voltage	V_{EB}	10	Vdc
*Collector Current	I_C	200	mAdc
*Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	°C

*Indicates JEDEC Registered Data

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
*Collector-Emitter Breakdown Voltage (I_C = 600 μAdc, R_{BE} = 10 k ohms)	BV_{CER}	25	-	Vdc
*Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	-	7.0	μAdc
*Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	I_{EBO}	-	7.0	μAdc
ON CHARACTERISTICS				
*DC Current Gain (I_C = 20 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	100	200	-
*Base-Emitter Voltage (I_C = 20 mAdc, V_{CE} = 1.0 Vdc)	V_{BE}	0.18	0.32	Vdc
SMALL-SIGNAL CHARACTERISTICS				
*Cutoff Frequency (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	$f_{\alpha b}$	2.5	-	MHz
*Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 1.0 mAdc, f = 1.0 MHz)	C_{ob}	-	35	pF
*Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	26	31	Ohms
*Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	1×10^{-4}	17×10^{-4}	-
*Small-Signal Current Gain (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	75	180	-
*Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	0.1	0.9	μmhos
Noise Figure (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, R_S = 500 ohms, f = 1.0 kHz, Δf = 1.0 Hz)	NF	-	5.0	dB

*Indicates JEDEC Registered Data.

2N524 thru 2N527 (GERMANIUM)



CASE 31(1)
(TO-5)

Base connected to case

PNP germanium transistor for switching and amplifier applications in the audio-frequency range. Available for military and high-reliability industrial purposes.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current	I_C	500	mAdc
Storage and Operating Temperature	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation @ 25°C Ambient	P_D	225	mW
Thermal Resistance Junction to Ambient	θ_{JA}	0.333	°C/mW
Thermal Resistance (infinite heat sink)	θ_{JC}	0.15	°C/mW

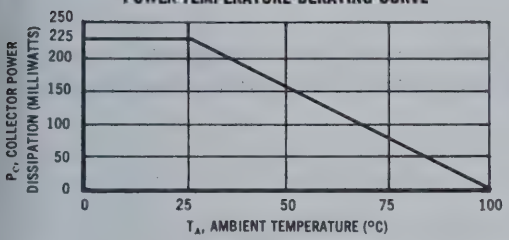
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	10	μAdc
Emitter Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)		I_{EBO}	-	10	μAdc
Collector-Emitter Breakdown Voltage (I_C = 0.6 mAdc, R_{BE} = 10K)		BV_{CER}	30	-	μVdc
Collector-Emitter Reach Through (Punch-Thru) Voltage (V_{EB} = 1 Vdc, VTVM Z ≳ 1 Megohm)		V_{RT}	30	-	μVdc
Static Forward-Current Transfer Ratio (V_{CE} = 1 Vdc, I_C = 20 mAdc)		h_{FE}			
	2N524		25	42	-
	2N525		34	65	-
	2N526		53	90	-
	2N527		72	121	-
Small-Signal Short-Circuit Forward Current Transfer Ratio Frequency Cutoff		$f_{\alpha b}$			
(V_{CB} = 5 Vdc, I_E = 1 mAdc)	2N524		0.8	5.0	MHz
	2N525		1.0	5.5	
	2N526		1.3	6.5	
	2N527		1.5	7.0	
Output Capacitance (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 MHz)		C_{ob}	5.0	40	pF
Small-Signal Open Circuit Output Admittance		h_{ob}			
(V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N524		0.10	1.3	μmho
	2N525		0.10	1.2	
	2N526		0.10	1.0	
	2N527		0.10	0.9	
Small-Signal Open Circuit Reverse Transfer Voltage Ratio		h_{rb}			
(V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N524		1.0	10	$X10^{-4}$
	2N525		1.0	11	
	2N526		1.0	12	
	2N527		1.0	14	
Small-Signal Short Circuit Input Impedance		h_{ib}			
(V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N524		26	36	ohms
	2N525		26	35	
	2N526		26	33	
	2N527		26	31	
Collector-Emitter Saturation Voltage		$V_{CE\ (sat)}$			
(I_B = 2 mAdc, I_C = 20 mAdc)	2N524				
(I_B = 1.33 mAdc, I_C = 20 mAdc)	2N525		-	130	mVdc
(I_B = 1.0 mAdc, I_C = 20 mAdc)	2N526		-	130	
(I_B = 0.67 mAdc, I_C = 20 mAdc)	2N527		-	130	
			-	130	
Base Input Voltage (V_{CE} = 1 Vdc, I_C = 20 mAdc)		V_{BE}			
	2N524		220	320	mVdc
	2N525		200	300	
	2N526		190	280	
	2N527		180	260	

ELECTRICAL CHARACTERISTICS (continued)

Characteristics		Symbol	Min	Max	Unit
Noise Figure (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz, BW = 1 Hz		NF	-	15	dB
Small-Signal Short-Circuit Forward-Current Transfer Ratio (V_{CE} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N524	h_{fe}	18	41	-
	2N525		30	64	
	2N526		44	88	
	2N527		60	120	

POWER-TEMPERATURE DERATING CURVE

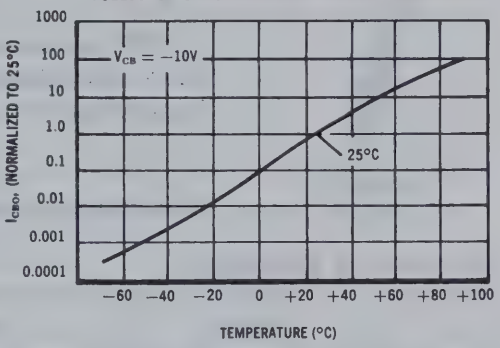


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

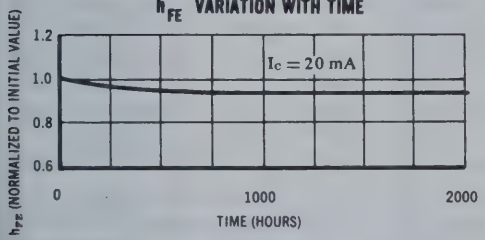
This curve has a value of 225mW at case temperatures of 25°C and is 0 mW at 100°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{100° - T_A}{0.333}$$

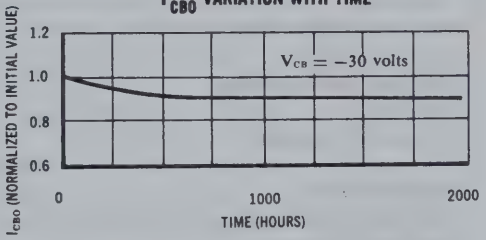
COLLECTOR CUTOFF CURRENT versus TEMPERATURE



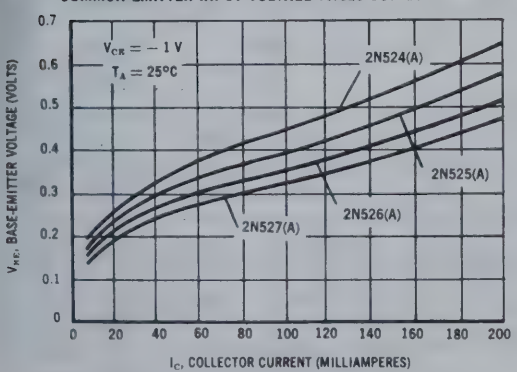
h_{FE} VARIATION WITH TIME



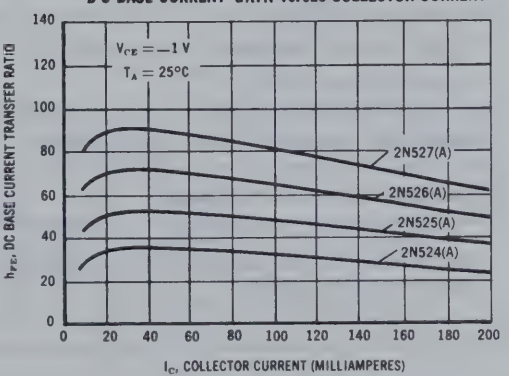
I_{CBO} VARIATION WITH TIME



COMMON EMITTER INPUT VOLTAGE versus COLLECTOR CURRENT



D-C BASE CURRENT GAIN versus COLLECTOR CURRENT



2N554 (GERMANIUM)
2N555

For Specifications, See 2N178 Data.

JAN 2N559-1 (GERMANIUM)
JAN 2N559-2
JAN 2N559-3*



PNP germanium mesa transistors designed for military and industrial high-reliability, high-speed switching applications.

CASE 22
(TO-18)
Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	50	mAdc
Base Current	I_B	50	mAdc
Emitter Current	I_E	50	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2.0	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4.0	mW $mW/^oC$
Operating Junction Temperature Range	T_J	-65 to +100	^oC
Storage Temperature Range	T_{stg}	-65 to +150	^oC

* Level 3 reliability data shown for information only. Qualification tests will be initiated upon established customer requirements.

RELIABILITY RATINGS†

Reliability Level Indicator	QUALITY LEVELS (LTPD)				RELIABILITY LEVELS Maximum failure rate (λ) during first 1000 hours with 90% confidence.						Est. Max Failure Rate in Conservatively Designed Equipment %/1000 Hrs
					Operation Life		Storage Life				
	Group A Subgroups		Group B Subgroups		$P_D = 150$ mW $I_E = 50$ mA $T_A = 25°C$		$T_A = 100°C$		$T_A = 150°C$		
	Major Defect	Minor Defect	Major Defect	Minor Defect	Major Defect	Minor Defect	Major Defect	Minor Defect	Major Defect	Minor Defect	
(1)	3.0	5.0	10	20	10	20	10	20	20	—	0.1
(2)	1.5	3.0	5	15	5	15	1.5	3	7	20	0.01
(3)*	1.0	2.0	3	7	2	5	0.2	0.5	1	3	0.001

† This table relates the statistical sampling requirements in the specification to the reliability levels for the transistor.

* Level 3 reliability data shown for information only. Qualification tests will be initiated upon established customer requirements.

TABLE I – GROUP A INSPECTION

Examination or Test	MIL-STD-750 Method	LTPD for Respective Reliability Level						Symbol	Limit				Unit
		Total ①			Major				Requirement Limit		Defect Classification		
		(1)	(2)	(3)	(1)	(2)	(3)		Min	Max	Minor	Major	
SUBGROUP 1													
Visual and Mechanical Examination	2071	10	7	5	7	5	3	—	—	—	—	—	—
SUBGROUP 2		5	3	2	3	1.5	1.0						
Emitter-Base Cutoff Current (V_{EB} = -1 Vdc)	3061 Condition D							I_{EBO}	—	5	>5 to 10	>10	μAdc
Collector-Base Cutoff Current (V_{CB} = -5 Vdc)	3036 Condition D							I_{CBO}	—	3	>3 to 5	>5	μAdc
Emitter-Base Breakdown Voltage (I_E = -200 μAdc)	3026 Condition D							BV_{EBO}	5	—	3.5 to <5	<3.5	Vdc
Collector-Emitter Breakdown Voltage (I_C = -100 μAdc)	3011 Condition C							BV_{CES}	15	—	12 to <15	<12	Vdc
SUBGROUP 3		5	3	2	3	1.5	1.0						
Collector-Emitter Saturation Voltage (I_C = -50 mAdc, I_B = -1.5 mAdc)	3071							$V_{CE(sat)}$	—	1	>1.0 to 1.2	>1.2	Vdc
(I_C = -10 mAdc, I_B = -0.4 mAdc)									—	0.3	>0.3 to 0.35	>0.35	
Base-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -0.4 mAdc)	3066 Condition A							$V_{BE(sat)}$	0.32	0.44	0.30 to <0.32 and 0.44 to 0.50	<0.30 and >0.50	Vdc
DC Current Gain (I_C = -10 mAdc, V_{CE} = -0.5 Vdc)	3076							h_{FE}	25	150	20 to <25 and >150 to 200	<20 and >200	—
SUBGROUP 4		5	3	2	3	1.5	1.0						
Rise Time (V_{CC} = -3.5 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = -0.55 mAdc, R_C = 300 ohms, C_{CE} = 150 pF, $C_{CB} = 2^{+0.5}_{-0}$ pF)	3251 Condition A							t_r	—	95	>95 to 115	>115	ns
Storage Time (V_{CC} = -3.5 Vdc, I_{B1} = -1 mAdc, I_{B2} = 0.25 mAdc, R_C = 300 ohms)	3251 Condition A							t_s	—	95	>95 to 115	>115	ns
Fall Time (V_{CC} = -3.5 Vdc, I_{B1} = -1 mAdc, I_{B2} = 0.25 mAdc, R_C = 300 ohms, $C_{CB} = 2^{+0.5}_{-0}$ pF)	3251 Condition A							t_f	—	100	>100 to 120	>120	ns

NOTES:

① Total is defined as the sum of the major and minor defectives.

TABLE II – GROUP B INSPECTION

Examination or Test	MIL-STD-750 Method	LTPD for Respective Reliability Level						Symbol	Limit				Unit
		Total (1)			Major				Requirement Limit		Defect Classification		
		(1)	(2)	(3)	(1)	(2)	(3)		Min	Max	Minor	Major	
SUBGROUP 1													
Physical Dimensions	2066	20	15	7	—	—	—	—	—	—	—	—	—
SUBGROUP 2		5	3	2	3	1.5	1						
Moisture Resistance (No initial conditioning; one cycle; only steps 1 to 6)	1021							—	—	—	—	—	—
End-Point Tests:													
Emitter-Base Cutoff Current (V_{EB} = -1 Vdc)	3061 Condition D							I_{EBO}	—	10	>10 to 20	>20	μAdc
Collector-Base Cutoff Current (V_{CB} = -5 Vdc)	3036 Condition D							I_{CBO}	—	5	> 5 to 10	>10	μAdc
DC Current Gain (I_C = -10 mAdc, V_{CE} = -0.5 Vdc)	3076							h_{FE}	20	200	15 to < 20 and >200 to 250	< 15 and >250	—
SUBGROUP 3		20	15	7	10	5	3						
Tension	2036 Condition A							—	—	—	—	—	—
Solderability	2026							—	—	—	—	—	—
Temperature Cycling (5 cycles) $T_{(high)} = 100^{+5}_{-0}$ °C 2N559 (1) $T_{(high)} = 150 \pm 5$ °C 2N559 (2), 2N559 (3)	1051 Condition B							—	—	—	—	—	—
Thermal Shock (Glass Strain)	1056 Condition A							—	—	—	—	—	—
Moisture Resistance	1021							—	—	—	—	—	—
End-Point Tests: Same as Subgroup 2													
SUBGROUP 4		20	15	7	10	5	3						
Shock (Non-operating; 5 blows: 1500 G in Orientations X_1, Y_1, Y_2, and Z_1 (total = 20 blows)	2016							—	—	—	—	—	—
Constant Acceleration (20,000 G, Orientations X_1, Y_1, Y_2, and Z_1)	2006							—	—	—	—	—	—
Vibration Fatigue (No bias applied)	2046							—	—	—	—	—	—
Vibration, Variable Frequency (1 cycle each in Orientations X_1, Y_1, and Z_1)	2056							—	—	—	—	—	—
End-Point Tests: Same as Subgroup 2													
SUBGROUP 5		20	15	7	10	5	3						
Terminal Strength - Lead Fatigue (2)	2036 Condition E							—	—	—	—	—	—
SUBGROUP 6		20	—	—	10	—	—						
High-Temperature Life (Non-operating) ($T_{stg} = 100^{+0}_{-5}$ °C 2N559 (1) ONLY	1031							—	—	—	—	—	—
End-Point Tests: Same as Subgroup 2													
SUBGROUP 7		—	20	3	—	7	1						
High-Temperature Life (Non-operating) ($T_{stg} = 150^{+0}_{-5}$ °C) 2N559 (2), 2N559 (3)	1031							—	—	—	—	—	—
End-Point Tests: Same as Subgroup 2													
SUBGROUP 8		20	15	5	10	5	2						
Steady-State Operation Life ($I_E = 50^{+0}_{-5}$ mAdc, $P_D = 150^{+0}_{-15}$ mW, $T_A = 25 \pm 3$°C)	1026							—	—	—	—	—	—
End-Point Tests: Same as Subgroup 2													

NOTES: (1) Total is defined as the sum of the major and minor defectives.
(2) Rejects from prior electrical-test samples from the same lot may be used for this test.

TABLE III – GROUP C INSPECTION*

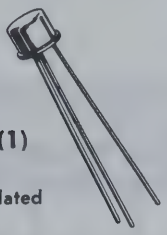
Examination or Test	MIL-STD-750 Method	LTPD for Respective Reliability Level						Symbol	Limit				Unit
		Total ①			Major				Requirement Limit		Defect Classification		
		(1)	(2)	(3)	(1)	(2)	(3)		Min	Max	Minor	Major	
SUBGROUP 1		10	7	5	5	3	2						
Output Capacitance (V_{CB} = -5 Vdc, I_E = 0, f = 100 kHz)	3236							C_{ob}	—	6	>6 to 10	>10	pF
Current-Gain — Bandwidth Product (I_E = 10 mAdc, V_C = -1 Vdc, f = 100 MHz)	3261							f_T	300	1000	250 to <300 and >1000	<250	MHz
Delay Plus Rise Time (V_{CC} = -3.5 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = -1 mAdc, R_C = 300 ohms, $C_{CB} = 2^{+0.5}_{-0}$ pF, C_{BE} = 2 ±0.5 pF	3251 Condition A							$t_d + t_r$	—	50	>50 to 75	>75	ns
SUBGROUP 2		10	7	5	5	3	2						
Collector-Emitter Cutoff Current (V_{CE} = 5 Vdc, T_A = +55°C)	3041 Condition C							I_{CES}	—	40	>40 to 50	>50	μAdc
DC Current Gain (I_C = -10 mAdc, V_{CE} = -0.5 Vdc, T_A = -55°C)	3076							h_{FE}	10	—	8 to <10	<8	—
SUBGROUP 3		20	15	7	10	5	3						
Salt Atmosphere (Corrosion)	1041							—	—	—	—	—	—
End-Point Tests: Same as Group B, Subgroup 2													
SUBGROUP 4		—	20	10	—	10	5						
High-Temperature Life (Non-operating) (T_{stg} = 100^{+0}_{-5} °C)	1031							—	—	—	—	—	—
End-Point Tests:													
Emitter-Base Breakdown Voltage (I_E = -300 μAdc)	3026 Condition D							BV_{EBO}	5	—	3.5 to <5	<3.5	Vdc
Collector-Emitter Breakdown Voltage (I_C = -100 μAdc)	3011 Condition C							BV_{CES}	12	—	8 to <12	<8	Vdc
Collector-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -0.5 mAdc)	3071							$V_{CE(sat)}$	—	0.3	>0.3 to 0.6	>0.6	Vdc
Base-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -0.4 mAdc)	3066 Condition A							$V_{BE(sat)}$	0.31	0.47	0.25 to <0.31 and >0.47 to 0.55	<0.25 and >0.55	Vdc
Delay Time (V_{CC} = -3.5 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = -0.55 mAdc, R_C = 300 ohms, C_{CE} = 150 pF, $C_{CB} = 2^{+0.5}_{-0}$ pF, C_{BE} = 2 ±0.5 pF)	3251 Condition A							t_d	10	35	<10 and >35 to 45	>45	ns
Rise Time (V_{CC} = -3.5 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_{B1} = -0.55 mAdc, R_C = 300 ohms, C_{CE} = 150 pF, $C_{CB} = 2^{+0.5}_{-0}$ pF)	3251 Condition A							t_r	15	105	<15 and >105 to 125	>125	ns
Storage Time (V_{CC} = -3.5 Vdc, I_{B1} = -1 mAdc, I_{B2} = 0.25 mAdc, R_C = 300 ohms)	3251 Condition A							t_s	15	105	<15 and >105 to 125	>125	ns

* Group C is to be performed on the first lot and every 6 months thereafter.
NOTE: ① Total is defined as the sum of the major and minor defectives.

2N618 (GERMANIUM)

For Specifications, See 2N375 Data.

2N650, A thru 2N652, A (GERMANIUM)



CASE 31(1)
(TO-5)
All leads isolated

PNP germanium transistor for switching and amplifier applications in the audio-frequency range. Available for military and high-reliability industrial purposes.

MAXIMUM RATINGS

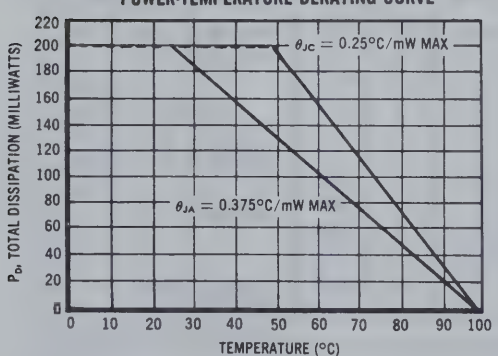
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	30	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current — Continuous	I_C	500*	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	200 2.67	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

THERMAL CHARACTERISTICS

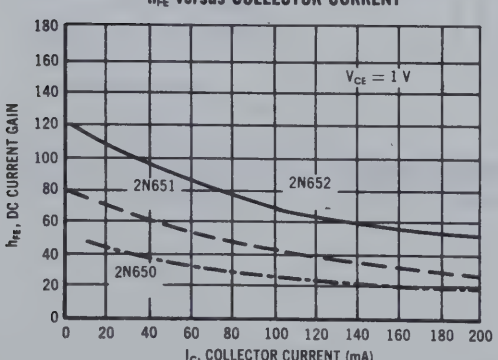
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.250	$^oC/mW$
Thermal Resistance, Junction to Ambient	θ_{JA}	0.375	$^oC/mW$

*Limited by power dissipation.

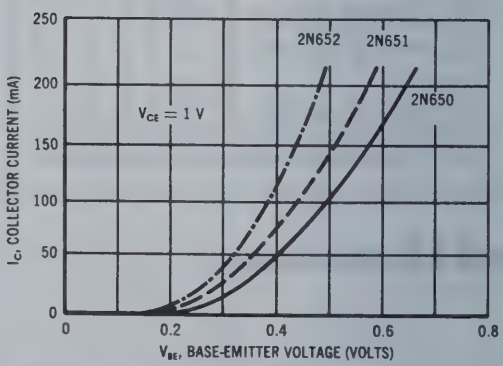
POWER-TEMPERATURE DERATING CURVE



h_{FE} versus COLLECTOR CURRENT



COLLECTOR OUTPUT CURRENT versus BASE DRIVE VOLTAGE



2N650 thru 2N652 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Punch-Thru Voltage (V_{CF} = 1.0 Vdc)		V_{pt}	45	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, R_{BE} = 10 k ohms)		I_{CER}	–	–	600	μAdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 Vdc, I_E = 0)			–	3.0	10	
(V_{CB} = 45 Vdc, I_E = 0)			–	–	50	
(V_{CB} = 10 Vdc, I_E = 0, T_A = +71°C			–	55	100	
Emitter Cutoff Current (V_{EB} = 30 Vdc, I_C = 0)		I_{EBO}	–	3.0	10	μAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N650		33	44	–	
	2N650A		33	44	90	
	2N651		45	75	–	
	2N651A		45	75	150	
	2N652		80	115	–	
	2N652A		80	115	250	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)	2N650		–	0.175	0.250	
(I_C = 50 mAdc, I_B = 1.67 mAdc)	2N651		–	0.175	0.250	
(I_C = 50 mAdc, I_B = 1.25 mAdc)	2N652		–	0.175	0.250	
(I_C = 100 mAdc, I_B = 5.0 mAdc)	2N650		–	0.250	0.500	
(I_C = 100 mAdc, I_B = 3.33 mAdc)	2N651		–	0.250	0.500	
(I_C = 100 mAdc, I_B = 2.5 mAdc)	2N652		–	0.250	0.500	
Base-Emitter Voltage		V_{BE}				Vdc
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N650		–	0.245	0.270	
	2N651		–	0.235	0.260	
	2N652		–	0.225	0.250	
SMALL-SIGNAL CHARACTERISTICS						
Common-Base Cutoff Frequency		$f_{\alpha b}$				MHz
(I_E = 1.0 mAdc, V_{CB} = 6.0 Vdc)	2N650		0.75	1.5	–	
	2N651		1.0	2.0	–	
	2N652		1.25	2.5	–	
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0)		C_{ob}	–	10	25	pF
Input Impedance		h_{ib}				Ohms
(I_E = 1.0 mAdc, V_{CB} = 6.0 Vdc, f = 1.0 kHz)	2N650		27	31	37	
	2N651		27	34	37	
	2N652		27	35	37	
Small-Signal Current Gain		h_{fe}				–
(I_E = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	2N650		30	49	70	
	2N651		50	80	120	
	2N652		100	130	225	
Output Admittance		h_{ob}				μmhos
(I_E = 1.0 mAdc, V_{CB} = 6.0 Vdc, f = 1.0 kHz)	2N650		–	0.65	1.0	
	2N650A		0.3	0.65	1.0	
	2N651		–	0.60	0.9	
	2N651A		0.3	0.60	0.9	
	2N652		–	0.55	0.8	
	2N652A		0.3	0.55	0.8	
Noise Figure (I_E = 0.5 mAdc, V_{CE} = 4.5 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz, Δf = 1.0 Hz)		NF	–	5.0	15	dB

2N653 thru 2N655 (GERMANIUM)



CASE 31(1)
(TO-5)

All leads isolated

PNP germanium transistor, for high-gain amplifie and switching service in the audio frequency range.

MAXIMUM RATINGS

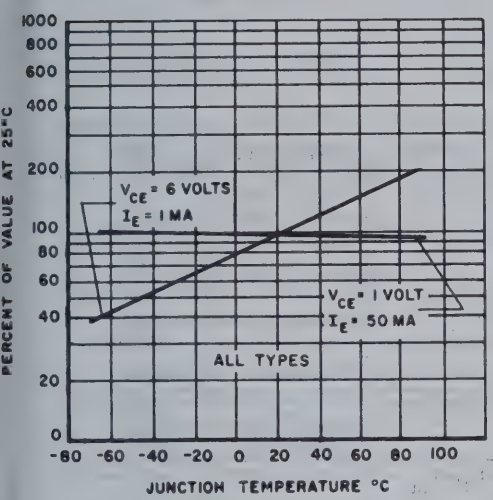
Rating	Symbol	Value	Unit
Collector to Base Voltage	V_{CB}	30	Volts
Collector to Emitter Voltage	V_{CER}	25	Volts
Emitter to Base Voltage	V_{EB}	25	Volts
Collector D. C. Current *	I_C	250*	mA
Junction Temperature Limits	T_J	-65 to +100	°C
Storage Temperature Limits	T_{stg}	-65 to +100	°C
Collector Dissipation in, Ambient Derate 2.67 mW/° C above 25° C	P_D	200	mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.375	°C/mW

*Limited by power dissipation.

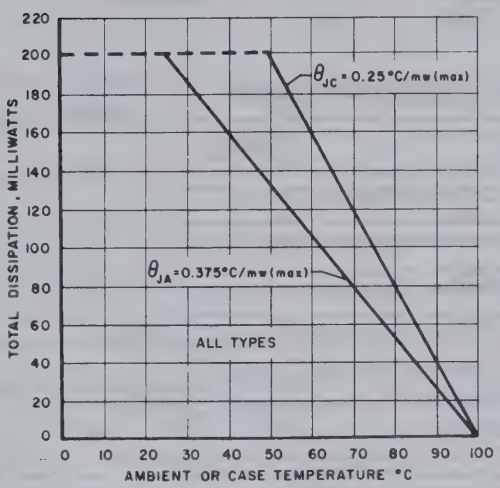
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	2N653			2N654			2N655			Uni
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Small Signal Current Gain V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kHz	h_{fe}	30	49	70	50	80	125	100	130	250	-
Small Signal Input Impedance V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kHz	h_{ie}	750	-	2900	1500	-	4700	3000	-	8500	ohm
Small Signal Current Gain Cutoff Frequency V_{CB} = 6 V, I_E = 1.0 mA	$f_{\alpha b}$		1.5			2.0			2.5		MHz
Output Capacity V_{CB} = 6 V, I_E = 0 mA, f = 1 MHz	C_{ob}		10			10			10		pF
Noise Figure V_{CE} = 4.5 V, I_E = 0.5 mA, Rs = 1, f = kHz Δf = 1 Hz	NF		10			10			10		dB
Collector Reverse Current V_{CB} = 25 V, I_E = 0	I_{CBO}		5.0	15		5.0	15		5.0	15	μA
Emitter Reverse Current V_{EB} = 25 V, I_C = 0	I_{EBO}		5.0	15		5.0	15		5.0	15	μA
Collector-Emitter Reverse Current V_{CE} = 25 V, R_{BE} = 10 k	I_{CER}			600			600			600	μA
Base-Emitter Input Voltage V_{CE} = 6 V, I_C = 1.0 mA	V_{BE}			0.3			0.3			0.3	Vdc

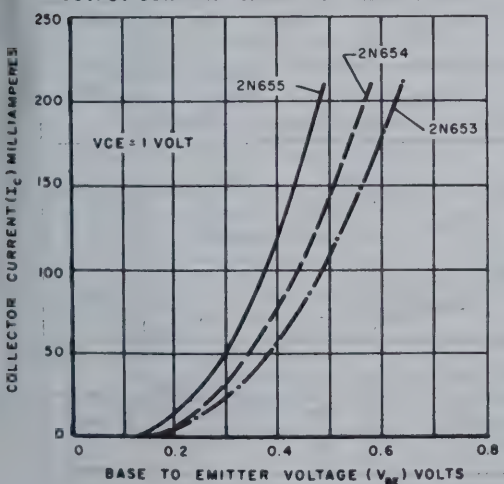
SMALL SIGNAL CURRENT GAIN (h_{fe}) versus TEMPERATURE



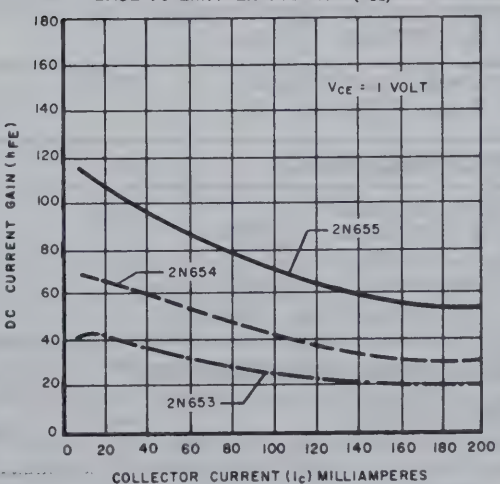
POWER-TEMPERATURE DERATING CURVE



OUTPUT CURRENT versus BASE DRIVE VOLTAGE



LARGE SIGNAL CURRENT GAIN versus COLLECTOR CURRENT



2N656 (SILICON)
2N657



CASE 31
(TO-5)

NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.

MAXIMUM RATINGS

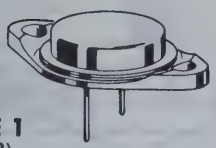
Rating	Symbol	2N656	2N657	Unit
Collector-Emitter Voltage	V_{CEO}	60	100	Vdc
Collector-Base Voltage	V_{CB}	60	100	Vdc
Emitter-Base Voltage	V_{EB}	8.0		Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 250 μAdc, I_B = 0)	2N656 2N657	BV_{CEO}	60 100	- -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N656 2N657	BV_{CBO}	60 100	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 250 μAdc, I_C = 0)		BV_{EBO}	8.0	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	10	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 200 mAdc, V_{CE} = 10 Vdc)		h_{FE}*	30	90	-
Collector-Emitter Saturation Voltage* (I_C = 200 mAdc, I_B = 40 mAdc)		$V_{CE(sat)}$*	-	4.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Input Impedance* (I_B = 8.0 mAdc, V_{CE} = 10 Vdc)		h_{ie}*	-	0.5	k ohm

* Pulse Test: Pulse Length = 300 μs, Duty Cycle ≤ 2.0%.

2N665 (GERMANIUM)



CASE 1
(TO-3)

PNP germanium power transistor for driver and power output amplifier and power switching applications in military and industrial equipment.

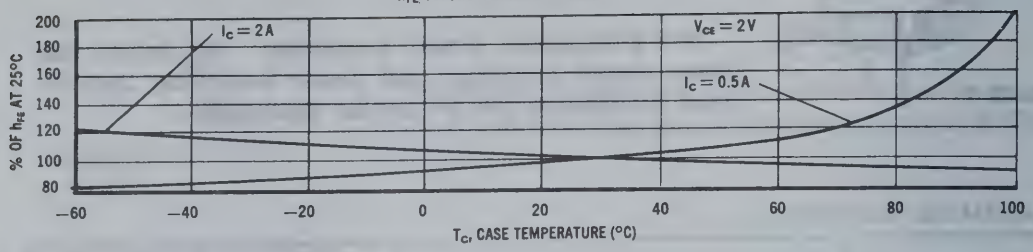
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
DC Collector Current	I_C	3.0	Amp
DC Emitter Current	I_E	5.0	Amp
Collector Junction Temperature	T_J	-65 to +95	^oC
Collector Dissipation Derate above 25^oC	P_D	35 0.5	Watts W/^oC

ELECTRICAL CHARACTERISTICS

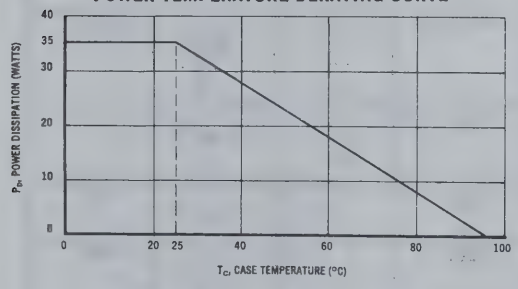
Characteristic	Symbol	Min	Max	Unit
Emitter Cutoff Current (V_{EBO} = -40 Vdc, I_C = 0)	I_{EBO}	—	2.0	mAdc
Collector Cutoff Current (V_{CBO} = -2 Vdc, I_E = 0) (V_{CBO} = -60 Vdc, I_E = 0) (V_{CBO} = -80 Vdc, I_E = 0)	I_{CBO}	— — —	0.05 2.0 10	mAdc
DC Current Gain (V_{CE} = -2 Vdc, I_C = -0.5 Adc) (V_{CE} = -2 Vdc, I_C = -2 Adc)	h_{FE}	40 20	80 —	—
Emitter-Base Voltage (V_{CE} = -2 Vdc, I_C = -2 Adc)	V_{EB}	—	1.5	Vdc
Floating Potential (V_{CB} = -80 Vdc, voltmeter input resistance = 10 megohms min, t ≈ 1 sec)	V_{EBF}	—	1.0	Vdc
Collector-Emitter Saturation Voltage (I_C = -3 Adc, I_B = -220 mAdc)	$V_{CE(sat)}$	—	-0.9	Vdc
Collector-Emitter Voltage (I_C = -300 mAdc, I_B = 0)	V_{CEO}	40	—	Vdc
Small-Signal Short-Circuit Forward-Current Transfer-Ratio Cutoff Frequency (V_{CE} = -14 Vdc, I_C = -2 Adc)	$f_{\alpha e}$	20	—	kHz
Emitter Cutoff Current (V_{EBO} = -30 Vdc, I_C = 0, T_C = +71^oC min)	I_{EBO}	—	2.0	mAdc
Collector Cutoff Current (V_{CBO} = -30 Vdc, I_E = 0, T_C = +71^oC min)	I_{CBO}	—	2.0	mAdc

h_{FE} versus TEMPERATURE

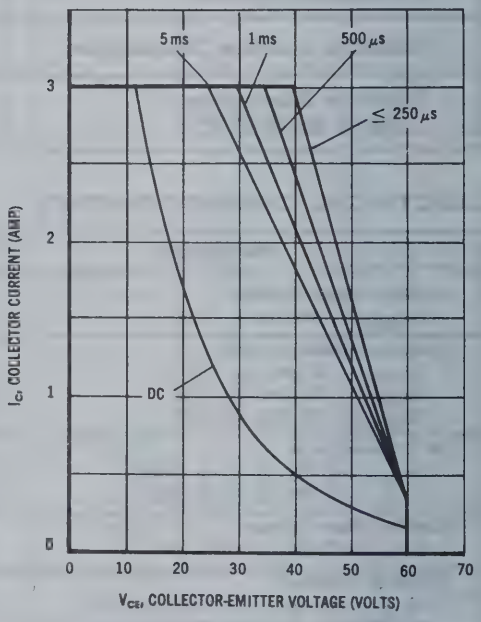


The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

POWER-TEMPERATURE DERATING CURVE



SAFE OPERATING AREA



2N669 (GERMANIUM)

For Specifications, See 2N176 Data.

2N681 thru 2N689 (SILICON)



CASE 64
(TO-48)

Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 25 amperes at junction temperatures to 125°C.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating		Symbol	Value	Unit
Peak Reverse Blocking Voltage* †		$V_{ROM(rep)}$*†		Volts
	2N681		25	
	2N682		50	
	2N683		100	
	2N684		150	
	2N685		200	
	2N686		250	
	2N687		300	
	2N688		400	
	2N689		500	
Peak Reverse Blocking Voltage* (Transient) (non-recurrent t = 5 ms max.)		$V_{ROM(non-rep)}$*		Volts
	2N681		35	
	2N682		75	
	2N683		150	
	2N684		225	
	2N685		300	
	2N686		350	
	2N687		400	
	2N688		500	
	2N689		600	
Forward Current RMS (all conduction angles)		I_f	25	Amp
Peak Forward Surge Current (One cycle, 60 Hz, T_J = -65 to +125°C)		$I_{FM(surge)}$	200	Amp
Circuit Fusing Considerations (T_J = -65 to +125°C, t ≦ 8.3 ms)		I^2t	165	A^2s
Peak Gate Power-Forward		P_{GFM}	5.0	Watts
Average Gate Power-Forward		$P_{GF(AV)}$	0.5	Watt
Peak Gate Current-Forward		I_{GFM}	2.0	Amp
Peak Gate Voltage-Forward		V_{GFM}	10	Volts
Reverse		V_{GRM}	5.0	
Operating Junction Temperature Range		T_J	-65 to +125	°C
Storage Temperature Range		T_{stg}	-65 to +150	°C
Stud Torque		—	30	in. lb.

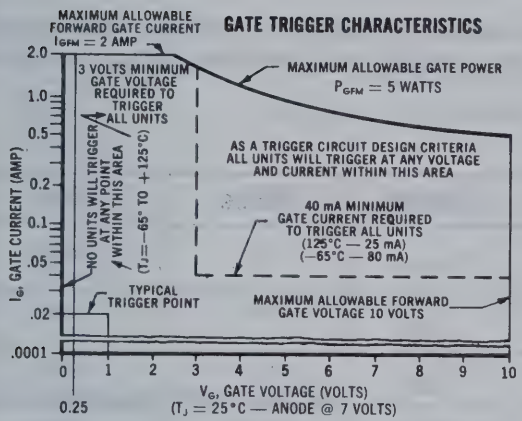
† V_{ROM} for all types can be applied on a continuous dc basis without incurring change.

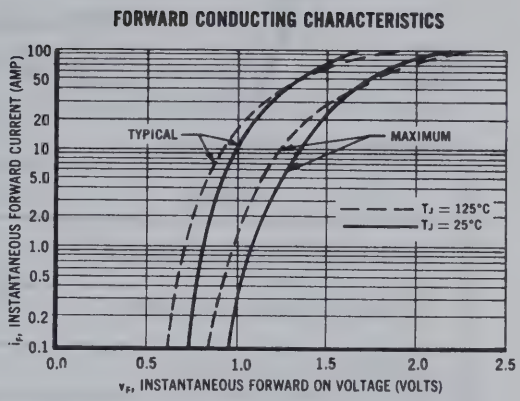
* $V_{ROM(rep)}$ ratings apply for zero or negative gate voltage.

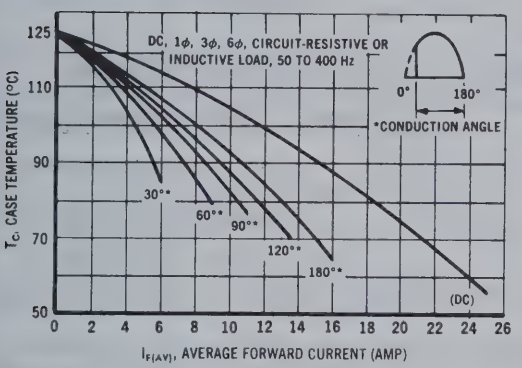
2N681 thru 2N689 (continued)

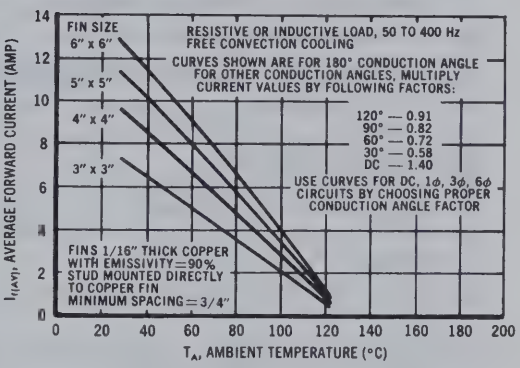
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage (T_J = 125°C)	2N681	V_{FOM}	25	—	—	Volts
	2N682		50	—	—	
	2N683		100	—	—	
	2N684		150	—	—	
	2N685		200	—	—	
	2N686		250	—	—	
	2N687		300	—	—	
	2N688		400	—	—	
	2N689		500	—	—	
Peak Forward or Reverse Blocking Current (T_J = 125°C)	2N681 - 2N684	I_{FOM} I_{ROM}	—	—	10.0	mA
	2N685		—	—	10.0	
	2N686		—	—	10.0	
	2N687		—	—	10.0	
	2N688		—	—	8.0	
	2N689		—	—	6.0	
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		I_{GT}	—	10	25	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		V_{GT}	0.25	—	3.0	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_{HO}	—	20	—	mA
Forward On Voltage (I_F = 20 Adc)		V_F	—	1.1	1.5	Volts
Turn-On Time (I_F = 10A, I_G = 200 mA)		t_{on}	—	1.0	—	μs
Turn-Off Time (I_F = 10 A; I_R = 10 A, dv/dt = 30 V/μs min, T_J = 125°C) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)		t_{off}	—	30	—	μs
Forward Voltage Application Rate (Gate open, T_J = 125°C)		dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case)		θ_{JC}	—	1.0	2.0	°C/W


GATE TRIGGER CHARACTERISTICS
MAXIMUM ALLOWABLE FORWARD GATE CURRENT
I_{GFM} = 2 AMP
MAXIMUM ALLOWABLE GATE POWER
P_{GFM} = 5 WATTS
3 VOLTS MINIMUM GATE VOLTAGE REQUIRED TO TRIGGER ALL UNITS
NO UNITS WILL TRIGGER AT ANY POINT WITHIN THIS AREA
(T_J = −65° TO +125°C)
AS A TRIGGER CIRCUIT DESIGN CRITERIA ALL UNITS WILL TRIGGER AT ANY VOLTAGE AND CURRENT WITHIN THIS AREA
40 mA MINIMUM GATE CURRENT REQUIRED TO TRIGGER ALL UNITS
(125°C — 25 mA)
(−65°C — 80 mA)
TYPICAL TRIGGER POINT
MAXIMUM ALLOWABLE FORWARD GATE VOLTAGE 10 VOLTS
I_G, GATE CURRENT (AMP)
2.0
1.0
0.5
0.2
0.1
.05
.02
.0001
0
1
2
3
4
5
6
7
8
9
10
0.25
V_G, GATE VOLTAGE (VOLTS)
(T_J = 25°C — ANODE @ 7 VOLTS)


FORWARD CONDUCTING CHARACTERISTICS
i_F, INSTANTANEOUS FORWARD CURRENT (AMP)
100
50
20
10
5.0
2.0
1.0
0.5
0.2
0.1
TYPICAL
MAXIMUM
T_J = 125°C
T_J = 25°C
0.0
0.5
1.0
1.5
2.0
2.5
v_F, INSTANTANEOUS FORWARD ON VOLTAGE (VOLTS)


CURRENT DERATING
T_C, CASE TEMPERATURE (°C)
125
110
90
70
50
DC, 1ϕ, 3ϕ, 6ϕ, CIRCUIT-RESISTIVE OR INDUCTIVE LOAD, 50 TO 400 Hz
0°
180°
*CONDUCTION ANGLE
30°*
60°*
90°*
120°*
180°*
(DC)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
$I_{F(AV)}$, AVERAGE FORWARD CURRENT (AMP)


SUGGESTED FIN SIZES
$I_{(AV)}$, AVERAGE FORWARD CURRENT (AMP)
14
12
10
8
6
4
2
0
FIN SIZE
6" x 6"
5" x 5"
4" x 4"
3" x 3"
RESISTIVE OR INDUCTIVE LOAD, 50 TO 400 Hz
FREE CONVECTION COOLING
CURVES SHOWN ARE FOR 180° CONDUCTION ANGLE
FOR OTHER CONDUCTION ANGLES, MULTIPLY
CURRENT VALUES BY FOLLOWING FACTORS:
120° — 0.91
90° — 0.82
60° — 0.72
30° — 0.58
DC — 1.40
USE CURVES FOR DC, 1ϕ, 3ϕ, 6ϕ
CIRCUITS BY CHOOSING PROPER
CONDUCTION ANGLE FACTOR
FINS 1/16" THICK COPPER
WITH EMISSIVITY=90%
STUD MOUNTED DIRECTLY
TO COPPER FIN
MINIMUM SPACING=3/4"
0
20
40
60
80
100
120
140
160
180
200
T_A, AMBIENT TEMPERATURE (°C)

2N696 (SILICON)
2N697



CASE 31
(TO-5)

NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 13.3	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 13.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 100 mAdc, R_{BE} = 10 ohms)		BV_{CER}*	40		Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	60		Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0		Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	- -	1.0 100	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N696 2N697	h_{FE}*	20 40	60 120	-
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$*	-	1.5	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$*	-	1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N696 2N697	f_T	40 50	- -	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)		C_{ob}	-	35	pF

* Pulse Test: Pulse Length ≤ 12 ms, Duty Cycle ≤ 2.0%.

2N699 (SILICON)



CASE 79
(TO-39)

NPN silicon annular transistor designed for medium-current switching and amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CB}	120	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation $T_A = 25°C$	P_D	0.6	Watt
Derate above 25°C		4.0	mW/°C
Total Device Dissipation $T_C = 25°C$	P_D	2.0	Watts
Derate above 25°C		13.3	mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	75	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	250	°C/W

2N699 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 100 mAdc, $R_{BE} \leq$ 10 ohms)	BV_{CER}*	80	-	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	-	2.0	μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)		-	200	
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}*	40	120	-
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$*	-	5.0	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$*	-	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	20	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	20	30	ohms
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	10	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	2.5	X 10^{-4}
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	3.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	35	100	-
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		45	-	
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	0.1	0.5	μmhos
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	1.0	

* Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%.

2N700, A (GERMANIUM)



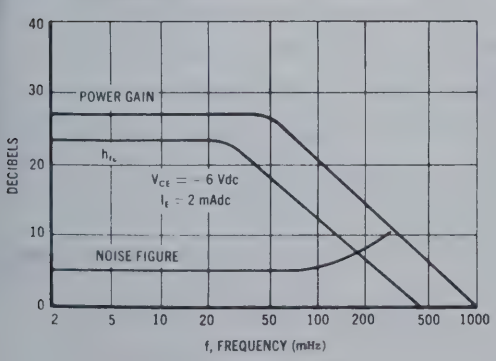
CASE 21
(TO-17)

PNP germanium mesa transistors for oscillator, frequency multiplier, wide-band mixer and wide-band amplifier applications.

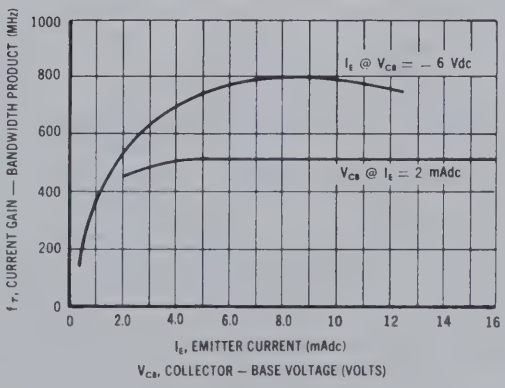
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage 2N700 2N700A	V_{CEO}	 20 25	Vdc
Emitter-Base Voltage	V_{EB}	0.2	Vdc
Collector DC Current	I_C	50	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Total Device Dissipation at 25°C Ambient (Derate 1 mW/°C above 25°C)	P_D	75	mW

POWER GAIN, CURRENT GAIN, & NOISE FIGURE versus FREQUENCY



CURRENT-GAIN-BANDWIDTH PRODUCT versus CURRENT AND VOLTAGE



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Sym	Test Conditions	Types	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 100 μAdc, I_E = 0	All Types	25	32	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	I_C = 100 μAdc, I_B = 0	2N700 2N700A	20 25	— —	— —	Vdc
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E = 100 μAdc, I_C = 0	All Types	0.2	0.5	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 6 Vdc, I_E = 0 V_{CB} = 6 Vdc, I_E = 0, T_A = 85°C	All Types 2N700 2N700A	— — —	0.4 60 —	2 150 50	μAdc
Small Signal Forward Current Transfer Ratio	h_{fe}	I_E = 2 mAdc, V_{CE} = 6 Vdc, f = 1 kHz I_E = 5 mAdc, V_{CE} = 6 Vdc, f = 1 kHz I_E = 2 mAdc, V_{CE} = 6 Vdc, f = 200 MHz	All Types 2N700A 2N700 2N700A	4 — 2.5 5	10 — 7 —	— 50 — —	— — dB dB
Input Impedance	h_{ib}	I_E = 2 mAdc, V_{CB} = 6 Vdc, f = 1 kHz	All Types	—	17	30	Ohms
Base Resistance	r'_b	I_E = 2 mAdc, V_{CB} = 6 Vdc, f = 300 MHz	All Types	—	55	100	Ohms
Collector-Base Output Capacitance (case grounded)	C_{ob}	V_{CB} = 6 Vdc, I_E = 0, f = 100 kHz	2N700 2N700A	— —	1.1 —	1.5 1.4	pF
Power Gain	G_e	I_E = 2 mAdc, V_{CB} = 6 Vdc, f = 70 MHz (neutralized)	2N700 2N700A	20 22	23 —	— —	dB
Noise Figure	NF		All Types	—	6	10	dB
Power Gain	G_e	I_E = 2 mAdc, V_{CB} = 6 Vdc, f = 30 MHz (neutralized)	2N700A	26	—	—	

2N702 (SILICON)
2N703

NPN silicon annular transistors designed for low-level, high-speed switching applications.



CASE 22
(TO-18)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	300	mW
Derate above 25°C		2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	600	mW
Derate above 25°C		4.0	mW/°C
Operating and Storage Junction Temperature Range	T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)		BV_{CEO}	25	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 5.0 μAdc, I_E = 0)		BV_{CBO}	25	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)		I_{CEO}	-	-	10	μAdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	-	-	0.5	μAdc
(V_{CB} = 10 Vdc, I_E = 0, T_A = +150°C)			-	-	50	
ON CHARACTERISTICS						
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N702	h_{FE}*	20	-	60	-
	2N703		40	-	100	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	2N702		12	-	-	
	2N703		20	-	-	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$*	-	-	0.5	Vdc
Base-Emitter On Voltage* (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$*	0.7	-	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain – Bandwidth Product (I_E = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	70	150		MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	3.0	6.0	pF

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

2N705 (GERMANIUM)

CASE 22
(TO-18)



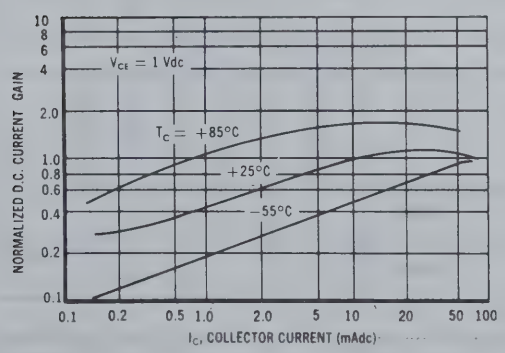
PNP germanium mesa transistor for high-speed switching applications.

Collector connected to case

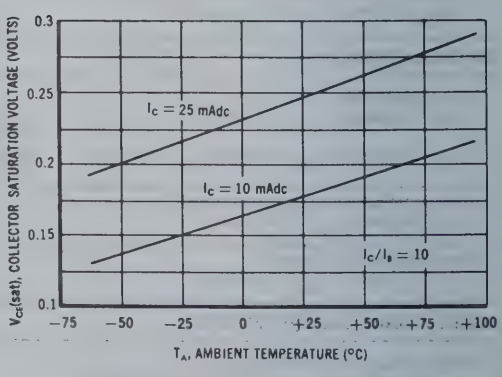
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CES}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current	I_C	50	mAdc
Emitter Current	I_E	50	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65°C to +100	°C
Collector Dissipation @ T_C = 25°C Derate above 25°C	P_C	300 4.0	mW mW/°C
Collector Dissipation in Free Air	P_C	150	mW

NORMALIZED D.C. CURRENT GAIN
versus COLLECTOR CURRENT



COLLECTOR SATURATION VOLTAGE
versus AMBIENT TEMPERATURE

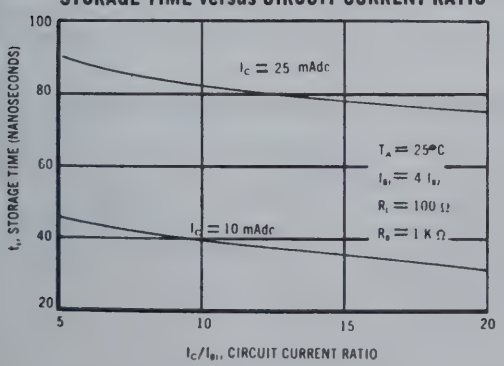


2N705 (continued)

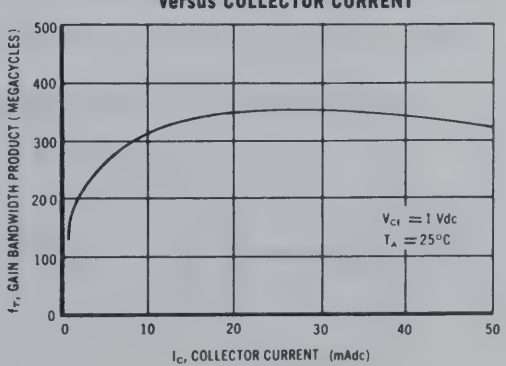
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_{CE} = 100 μAdc, V_{BE} = 0)	BV_{CES}	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)	I_{CBO}	—	0.2	3	μAdc
DC Forward Current Transfer Ratio (V_{CE} = .3 Vdc, I_C = 10 mAdc)	h_{FE}	25	40	—	—
Collector Saturation Voltage (I_B = .4 mAdc, I_C = 10 mAdc)	$V_{CE(sat)}$	—	0.18	0.3	Vdc
(I_B = 5 mAdc, I_C = 50 mAdc)		—	0.45	—	
Base-Emitter Voltage (I_B = .4 mAdc, I_C = 10 mAdc)	V_{BE}	0.34	0.39	0.44	Vdc
Small Signal Forward Current Transfer Ratio (V_{CE} = 1.0 Vdc, I_C = 10 mAdc, f = 100 MHz)	h_{fe}	—	9	—	
Collector Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	5.0	—	pF
Input Capacitance (V_{BE} = 2 Vdc)	C_{ib}	—	3.5	—	pF
Common Base Alpha Cutoff Frequency (V_{CB} = 5 Vdc, I_C = 10 mAdc)	$f_{\alpha b}$	—	300	—	MHz
Delay + Rise Time (I_C = 10 mAdc, I_B = 1 mAdc)	$t_d + t_r$	—	55	75	ns
Storage Time (I_{B1} = 1.0 mAdc, I_{B2} = .25 mAdc)	t_s	—	65	100	ns
Fall Time (I_{B1} = 1.0 mAdc, I_{B2} = .25 mAdc)	t_f	—	70	100	ns

STORAGE TIME versus CIRCUIT CURRENT RATIO



CURRENT GAIN — BANDWIDTH PRODUCT (f_T) versus COLLECTOR CURRENT



2N706, A, B (SILICON)
2N753



CASE 22
(TO-18)
Collector connected to case

NPN silicon annular switching transistors for high-speed switching applications.

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Collector-Base Voltage		V_{CB}	25	Volts
Collector-Emitter Voltage *		V_{CER}*	20	Volts
Emitter-Base Voltage	2N706 2N706A 2N706B 2N753	V_{EB}	3 5 5 5	Volts
Junction Temperature		T_J	175	°C
Storage Temperature		T_{stg}	-65 to +175	°C
Total Device Dissipation at 25° C Case Temperature (Derate 6.67 mW/°C above 25°C)		P_D	1.0	Watt
Total Device Dissipation at 25° C Ambient Temperature (Derate 2 mW/°C above 25°C)		P_D	0.3	Watt
Total Device Dissipation at 100°C Case Temperature (Derate 6.67 mW/°C above 100°C)		P_D	0.5	Watt

**Refers to collector breakdown voltage in the high current region when $R_{be} = 10\Omega$*

2N706,A,B,2N753 (continued)

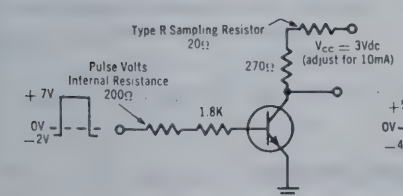
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 15Vdc, I_E = 0)	All Types		-	0.005	0.5	
(V_{CB} = 15Vdc, I_E = 0, T_A = 150 °C)	All Types		-	3	30	
(V_{CB} = 25Vdc, I_E = 0)	2N706A, 2N706B, 2N753		-	-	10	
Collector-Emitter Cutoff Current		I_{CER}				μAdc
(V_{CE} = 20Vdc, R_{be} = 100k)	2N706A, 2N706B, 2N753		-	-	10	
Emitter Cutoff Current		I_{EBO}				μAdc
(V_{EB} = 3Vdc, I_C = 0)	2N706		-	-	10	
(V_{EB} = 5Vdc, I_C = 0)	2N706A, 2N706B, 2N753		-	-	10	
Collector-Emitter Breakdown Voltage*		BV_{CEO}*				Vdc
(I_C = 10mAdc, I_B = 0)			15		-	
Collector-Emitter Breakdown Voltage*		BV_{CER}*				Vdc
(R = 10 ohms, I_C = 10mAdc)			20		-	
Forward-Current Transfer Ratio*		h_{FE}*				
(I_C = 10mAdc, V_{CE} = 1Vdc)	2N706		20	40	-	
	2N706A, 2N706B, 2N753		20	40	60	
			40	-	120	
Base-Emitter Voltage*		V_{BE}(sat)*				Vdc
(I_C = 10mAdc, I_B = 1mAdc)	2N706		-	0.75	0.9	
	2N706A, 2N706B, 2N753		0.7	0.75	0.9	
Collector Saturation Voltage*		V_{CE}(sat)*				Vdc
(I_C = 10mAdc, I_B = 1mAdc)	2N706, 2N706A		-	0.3	0.6	
	2N706B		-	0.3	0.4	
	2N753		-	0.18	0.6	
(I_C = 50mAdc, I_B = 5mAdc)	2N753		-	0.3	-	
Collector Capacitance		C_{ob}				pF
(V_{CB} = 5Vdc, I_E = 0	2N706A, 2N706B, 2N753		-	4.5	5	
(V_{CB} = 10Vdc, I_E = 0)	2N706		-	5	6	
Small-Signal Forward Current Transfer Ratio		h_{fe}				-
(V_{CE} = 15Vdc, I_E = 10mAdc, f = 100MHz)			2	4	-	
Current Gain-Bandwidth Product		f_T				MHz
(V_{CE} = 15Vdc, I_E = 10mAdc, f = 100 MHz)			-	400	-	
Base Resistance		r_b'				ohms
(V_{CE} = 15Vdc, I_E = 10mAdc, f = 300 MHz)			-	39	50	
Charge Storage Time Constant		τ_s**				ns
	2N706		-	16	60	
	2N706A		-	16	25	
	2N753		-	19	35	
Storage Time	2N706B	t_s	-	19	25	ns
Turn-On Time		ton**	-	30	40	ns
Turn-Off Time		toff**	-	50	75	ns

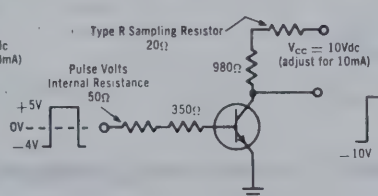
* Pulse Test: PW ≤ 12 ms, Duty Cycle ≤ 2%

** Switching Times Measured with Tektronix Type R Plug-In (50Ω Internal Impedance) and Circuits Shown Below.

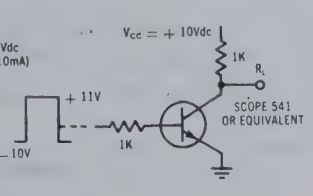
SWITCHING TIME TEST CIRCUIT



STORAGE TIME TEST CIRCUIT



MEASUREMENT CIRCUIT



2N707, A (SILICON)



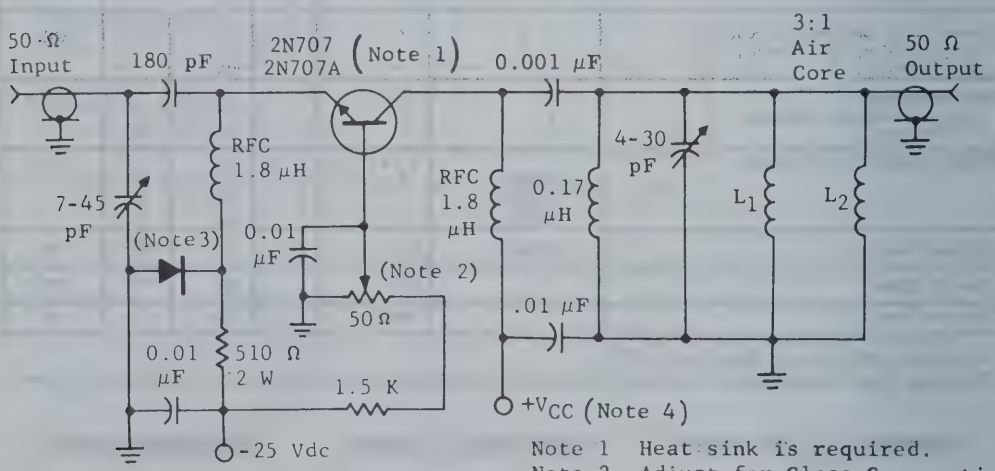
NPN silicon epitaxial mesa transistors for VHF oscillator and class C amplifier applications.

CASE 22
(TO-18)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N707	2N707A	Unit
Collector-Emitter Voltage	V_{CEO}	-	40	Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ ohms)	V_{CER}	28	-	Vdc
Collector-Base Voltage	V_{CB}	56	70	Vdc
Emitter-Base Voltage	V_{EB}	4	5	Vdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.3 2	0.5 3.33	Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 6.67	1.2 8	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		^oC



L_1 5 turns #14 wire wound on 1/2" diameter.

L_2 2 turns #14 wire wound on L_1.

Note 1 Heat sink is required.
Note 2 Adjust for Class C operation.
Note 3 Very High conductance silicon diode.
Note 4 Adjust V_{CC} for proper V_{CE}

FIGURE 1 – 100 MHz, CLASS C, COMMON BASE AMPLIFIER

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise specified)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 20 mAdc, I_B = 0)	2N707A	BV_{CEO}*	40	-	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, R_{BE} = 10 ohms)	2N707	BV_{CER}	28	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N707 2N707A	BV_{CBO}	56 70	- -	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N707A	BV_{EBO}	5	-	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	2N707	I_{CBO}	-	0.005	5.0	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	2N707		-	3.0	-	
(V_{CB} = 30 Vdc, I_E = 0)	2N707A		-	0.01	1.0	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N707A		-	5.0	100	
Emitter Cutoff Current (V_{BE} = 4 Vdc, I_C = 0)	2N707	I_{EBO}	-	-	10	μAdc
(V_{BE} = 5 Vdc, I_C = 0)	2N707A		-	-	100	
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N707 2N707A	h_{FE}	9 9	12 -	- 50	-
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	-	0.18	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	-	0.75	0.9	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_E = 15 mAdc, V_{CE} = 10 Vdc)		f_T	70	350	-	MHz
Maximum Frequency of Oscillation		f_{max}	-	600	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	2N707	C_{ob}	-	4.0	10.0	pF
(V_{CB} = 5 Vdc, I_E = 0)	2N707A		-	4.0	6.0	
Collector-Base Time Constant (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 4 MHz)		$r'_b C_c$	-	80	-	ps
FUNCTIONAL TEST						
Power Output (Figure 1) (V_{CE} = 20 Vdc, P_{in} = 50 mW)	All Types	P_{out}	200	300	-	mW
(V_{CE} = 40 Vdc, P_{in} = 175 mW)	2N707A		400	-	-	
100-MHz Oscillator Efficiency (V_{CE} = 28 Vdc, I_C = 40 mAdc)		η	-	38	-	%

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N708 (SILICON)

NPN silicon annular transistor for high-speed switching applications.



CASE 22
(TO-18)
Collector
connected to case

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	360 2.0	mW mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ $T_C = 100^oC$ Derate above 25^oC Derate above 100^oC	P_D	1.2 680 6.9 6.9	Watts mW mW/^oC mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	^oC

*Indicates JEDEC Registered Data.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	15	-	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, $R_{BE} \leq$ 10 ohms)	BV_{CER}	20	-	-	Vdc
*Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	40	-	-	Vdc
*Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	-	Vdc
†Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0.25 Vdc, T_A = +125°C)	I_{CEX}	-	-	10	μAdc
*Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	0.005 -	0.025 15	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	-	0.08	μAdc
ON CHARACTERISTICS					
*DC Current Gain (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (Note 1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (Note 1)	h_{FE}	15 30 15	- - -	- 120 -	-
*Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = -55°C to +125°C)	$V_{CE(sat)}$	- -	0.2 -	0.4 0.4	Vdc
*Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = -55°C)	$V_{BE(sat)}$	0.72 -	- -	0.80 0.90	Vdc
DYNAMIC CHARACTERISTICS					
††Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	450	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{ob}	-	3.0	6.0	pF
*Extrinsic Base Resistance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 300 MHz)	r_b'	-	-	50	ohms
*Storage Time ($I_C = I_{B1} = I_{B2}$ = 10 mAdc)	t_s	-	15	25	ns

*Indicates JEDEC Registered Data.
†JEDEC Registration Defined as V_{CB} = 20 Vdc.
††JEDEC Registration Defined as h_{fe}.
Note 1: Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle ≤ 2.0%.

2N711, A, B (GERMANIUM)

CASE 22
(TO-18)



PNP germanium mesa transistors for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N711	2N711A	2N711B	Unit
Collector-Base Voltage	V_{CB}	12	15	18	Vdc
Collector-Emitter Voltage	V_{CES}	12	14	15	Vdc
Collector-Emitter Voltage	V_{CEO}	—	7	7	Vdc
Emitter-Base Voltage	V_{EB}	1	1.5	2	Vdc
Collector Current (Continuous)	I_C	50	100	100	mAdc
Emitter Current (Continuous)	I_E	50	100	100	mAdc
Junction Temperature	T_J	← 100 →			°C
Storage Temperature	T_{stg}	← -65 to +100 →			°C
Device Dissipation @ T_C = 25°C	P_D	← 300 →			mW
Derate above 25°C		← 4 →			mW/°C
Device Dissipation @ T_A = 25°C	P_D	← 150 →			mW
Derate above 25°C		← 2 →			mW/°C

2N711,A,B (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Sym	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 100 μAdc, I_E = 0)	2N711		12	—	—	
	2N711A		15	—	—	
(I_C = 20 μAdc, I_E = 0)	2N711B		18	—	—	
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 100 μAdc)	2N711		12	—	—	
	2N711A		14	—	—	
(I_C = 20 μAdc)	2N711B		15	—	—	
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 5 mAdc, I_B = 0)	2N711A, 2N711B		7	—	—	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 0.1 mAdc, I_C = 0)	2N711		1.0	—	—	
	2N711A		1.5	—	—	
	2N711B		2.0	—	—	
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 5 Vdc, I_E = 0)	2N711		—	0.2	3.0	
	2N711A		—	—	1.5	
(V_{CB} = 10 Vdc, I_E = 0)	2N711B		—	—	1.5	
Emitter-Base Cutoff Current		I_{EBO}				μAdc
(V_{EB} = 1 Vdc)	2N711A		—	—	100	
	2N711B		—	—	20	
DC Current Gain		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc)	2N711		20	30	—	
	2N711A		25	—	150	
	2N711B		30	—	150	
(I_C = 50 mAdc, V_{CE} = 0.7 Vdc)	2N711A, 2N711B		40	—	—	
Collector Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 0.5 mAdc)	2N711		—	0.2	0.5	
	2N711A		—	—	0.30	
(I_C = 10 mAdc, I_B = 0.4 mAdc)	2N711B		—	—	0.25	
(I_C = 50 mAdc, I_B = 2 mAdc)	2N711A		—	—	0.55	
	2N711B		—	—	0.45	
Small-Signal Current Gain		h_{fe}				—
(I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 100 MHz)	2N711A, 2N711B		1.5	—	—	
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc, f = 100 MHz)	2N711A		1.1	—	—	
	2N711B		1.2	—	—	
Base-Emitter Voltage		V_{BE}				Vdc
(I_C = 10 mAdc, I_B = 0.4 mAdc)	2N711, 2N711A		0.30	0.38	0.44	
	2N711B		0.30	—	0.44	
(I_C = 50 mAdc, I_B = 2 mAdc)	2N711A		0.40	—	0.65	
	2N711B		0.40	—	0.65	
Collector Output Capacitance		C_{ob}				pF
(V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)	2N711A, 2N711B		—	—	6	
(V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	2N711		—	5.0	—	
Fall Time		t_f				ns
Figure 1:	2N711A		—	—	150	
	2N711B		—	—	110	
Figure 2:	2N711A		—	—	110	
	2N711B		—	—	100	
	2N711		—	90	150	
Minority Carrier Storage Time		t_s				ns
Figure 1:	2N711A		—	—	150	
	2N711B		—	—	140	
Figure 2:	2N711A		—	—	120	
	2N711B		—	—	100	
	2N711		—	90	200	
Delay Plus Rise Time		$t_d + t_r$				ns
Figure 1:	2N711A, 2N711B		—	—	100	
Figure 2:	2N711A, 2N711B		—	—	75	
	2N711		—	70	100	

SWITCHING CIRCUITS

FIGURE 1

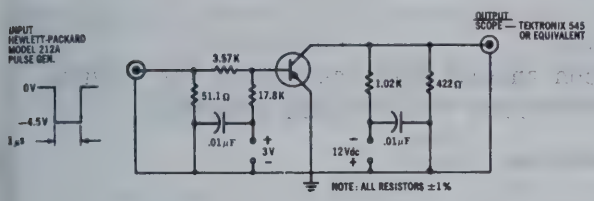
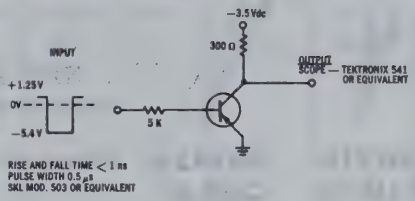
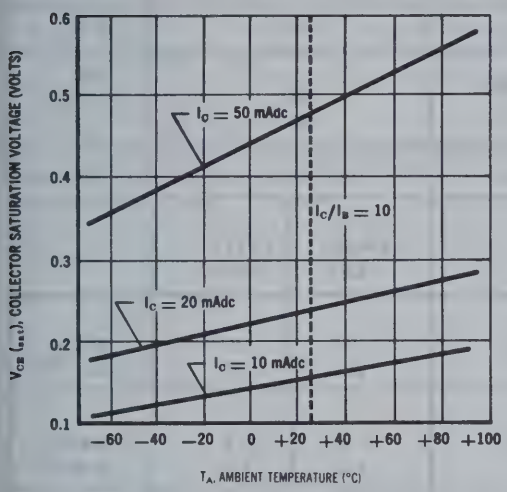


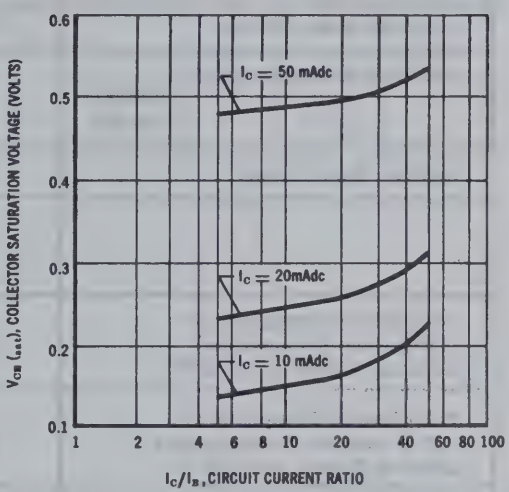
FIGURE 2



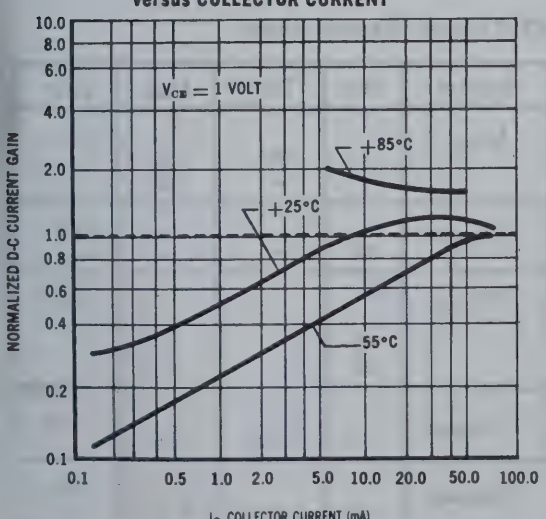
COLLECTOR SATURATION VOLTAGE versus AMBIENT TEMPERATURE



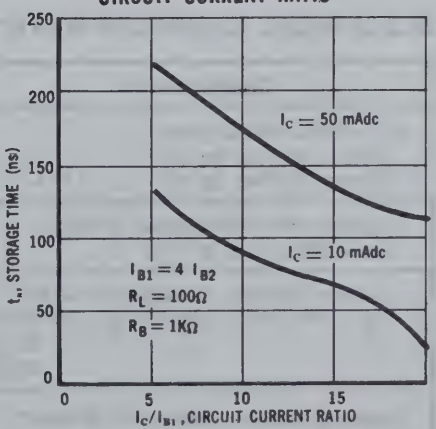
COLLECTOR SATURATION VOLTAGE STORAGE TIME versus CIRCUIT CURRENT RATIO



NORMALIZED DC CURRENT GAIN versus COLLECTOR CURRENT



STORAGE TIME versus CIRCUIT CURRENT RATIO



2N718 (SILICON)
2N1420



NPN silicon annular Star transistors for medium-current switching and amplifier applications.

2N718 CASE 22 (TO-18)
2N1420 CASE 31 (TO-5)
Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Emitter Voltage 2N718 2N1420	V_{CER}	 40 30		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
		2N1420 TO-5	2N718 TO-18	
Total Device Dissipation at 25°C Case Temperature Derating Factor Above 25°C	P_D	3 20	1.5 10	Watts mW/°C
Total Device Dissipation at 25°C Ambient Temperatures Derating Factor Above 25°C	P_D	0.6 4.0	0.4 2.66	Watts mW/°C
Junction Temperature	T_J	+ 175		°C
Storage Temperature range	T_{stg}	-65 to + 200		°C

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 — —	.001 —	1.0 100	μAdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed; $R_B \leq$ 10 Ohms) 2N718 2N1420	BV_{CER}	 40 30	 — —	 — —	Vdc
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$*	—	0.3	1.5	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$*	—	—	1.3	Vdc

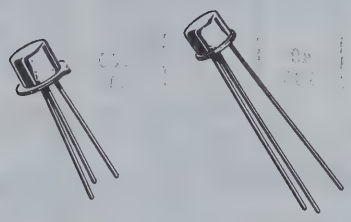
*Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
DC Forward Current Transfer Ratio* (I_C = 1 mAdc, V_{CE} = 10 Vdc)	h_{FE} *				–
2N718		–	20	–	
2N1420		–	35	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)					
2N718		40	–	120	
2N1420		100	–	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)					
2N718		–	20	–	
2N1420		–	35	–	
Small Signal Forward Current Transfer Ratio (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	h_{fe}	2.5	15	–	–
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{ob}	–	5	35	pF

*Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

2N718A (SILICON)
2N956
2N1613
2N1711



CASE 22 (TO-18)
2N718A
2N956

CASE 31 (TO-5)
2N1613
2N1711

Collector connected to case

NPN silicon annular Star transistors for high-speed switching and DC to UHF amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	2N718A 2N956	2N1613 2N1711	Unit
Collector-Emitter Voltage	V_{CER}	50		Vdc
Collector-Base Voltage	V_{CB}	75		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Total Device Dissipation @ T_A = 25°C	P_D	500	800	mW
Derate above 25°C		2.86	4.57	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.8	3.0	Watts
Derate above 25°C		10.3	17.1	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

2N718A, 2N956, 2N1613, 2N1711 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed; $R_{BE} \leq$ 10 ohms)		BV_{CER}	50	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	75	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	-	0.001	0.01	μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)			-	-	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N718A, 2N1613	I_{EBO}	-	-	0.010	μAdc
	2N956, 2N1711		-	-	0.005	
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.01 mAdc, V_{CE} = 10 Vdc)	2N956, 2N1711	h_{FE}	20	-	-	-
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N718A, 2N1613		20	-	-	
	2N956, 2N1711		35	-	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N718A, 2N1613		35	-	-	
	2N956, 2N1711		75	-	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N718A, 2N1613		20	-	-	
	2N956, 2N1711		35	-	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*	2N718A, 2N1613		40	-	120	
	2N956, 2N1711		100	-	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)*	2N718A, 2N1613		20	-	-	
	2N956, 2N1711		40	-	-	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$*	-	0.24	1.5	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$*	-	1.0	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N718A, 2N1613	f_T	60	300	-	MHz
	2N956, 2N1711		70	300		
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	4.0	25	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	20	80	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	24	-	34	ohms
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)			4.0	-	8.0	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N718A, 2N1613	h_{rb}	-	-	3.0	X 10^{-4}
	2N956, 2N1711		-	-	5.0	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N718A, 2N1613		-	-	3.0	
	2N956, 2N1711		-	-	5.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N718A, 2N1613	h_{fe}	30	-	100	-
	2N956, 2N1711		50	-	200	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A, 2N1613		35	-	150	
	2N956, 2N1711		70	-	300	
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	0.1	-	0.5	μmho
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)			0.1	-	1.0	
Noise Figure (I_C = 300 μAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A, 2N1613	NF	-	-	12	dB
	2N956, 2N1711		-	-	8.0	

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N720A (SILICON)



NPN silicon annular transistor designed for small-signal amplifier and general purpose switching applications.

CASE 22
(TO-18)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CB}	120	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	97	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	80	-	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, R_{BE} = 10 ohms)	$BV_{CER(sus)}$*	100	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	120	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0)	I_{CBO}	-	10	nAdc
(V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)		-	15	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	-	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	-	-
(I_C = 10 mAdc, V_{CE} = 10 Vdc)*		35	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)		20	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*		40	120	
Collector-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$*	-	1.2	Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		-	5.0	
Base-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$*	-	0.9	Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		-	1.3	
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	-	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	20	30	Ohms
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		4.0	8.0	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	1.25	X 10^{-4}
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	1.50	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	30	100	-
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		45	-	
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	0.5	μmhos
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	0.5	

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N721 (SILICON)



CASE 22
(TO-18)

PNP silicon annular transistor for high-frequency general-purpose amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Emitter Voltage	V_{CER}	50	Vdc
Collector - Base Voltage	V_{CB}	50	Vdc
Emitter - Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ T_A=25°C (Derate above 25°C)	P_D	0.40 2.67	Watts mW/°C
Total Device Dissipation @ T_C=25°C T_C=100°C (Derate above 25°C)	P_D	1.5 0.75 10	Watts mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	35	-	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, $R_{BE} \leq$ 100 ohms)	$BV_{CER(sus)}$*	50	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	50	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	1.0	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)		-	100	
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}*	20	45	-
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc)		15	-	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	-	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	-	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	45	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0)	C_{ib}	-	100	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	25	35	ohms
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	10	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	8.0	$X10^{-4}$
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	8.0	
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	15	50	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		20	-	
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	1.0	μmhos
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	5.0	

* Pulse Test: Pulse Width = 300 μs; Duty Cycle = 1.0%

2N722
2N1132
2N1132A
2N2303

PNP SILICON SWITCHING TRANSISTORS

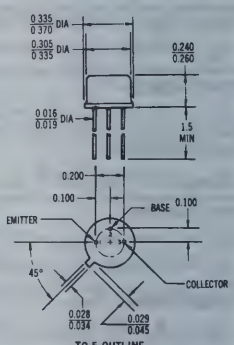
PNP SILICON ANNULAR TRANSISTORS

. . . designed for medium-current switching and amplifier applications.

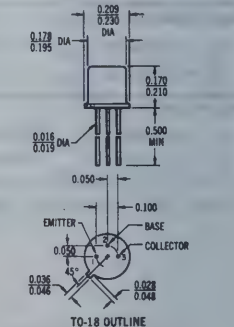


MAXIMUM RATINGS

Rating	Symbol	2N722	2N1132	2N1132A	2N2303	Unit
Collector-Emitter Voltage	V_{CEO}	35	35	40	35	Vdc
Collector-Emitter Voltage ($R_{BE} \leq$ 10 Ohms)	V_{CER}	50	50	50	50	Vdc
Collector-Base Voltage	V_{CB}	50	50	60	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	5.0	5.0	Vdc
Collector Current	I_C	-	-	600	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	600 4.0	600 4.0	600 4.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 10	2.0 13.3	2.0 13.3	2.0 13.3	Watts mW/°C
Operating Junction Temperature Range	T_J	← -65 to +175 →				°C
Storage Temperature Range	T_{stg}	← -65 to +300 →				°C



TO-5 OUTLINE
(Collector internally connected to case)



TO-18 OUTLINE
(Collector internally connected to case)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 100 mAdc, I_B = 0)	2N722, 2N1132, 2N2303	BV_{CEO}*	35	-	Vdc
	2N1132A		40	-	
Collector-Emitter Breakdown Voltage* (I_C = 100 mAdc, R_{BE} ≤ 10 Ohms)		BV_{CER}*	50	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N722, 2N1132, 2N2303	BV_{CBO}	50	-	Vdc
	2N1132A		60	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N722, 2N1132, 2N2303	BV_{EBO}	5.0	-	Vdc
(I_E = 1.0 mAdc, I_C = 0)	2N1132A		5.0	-	
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	2N722, 2N1132, 2N2303	I_{CBO}	-	1.0	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N722, 2N1132, 2N2303		-	100	
(V_{CB} = 50 Vdc, I_E = 0)	2N1132A		-	0.5	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	2N1132A		-	50	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N1132A	I_{EBO}	-	100	μAdc
(V_{BE} = 2.0 Vdc, I_C = 0)	2N2303		-	100	
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	2N722, 2N1132, 2N1132A	h_{FE}	25	-	-
	2N2303		75	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N722, 2N1132, 2N1132A		30	90	
	2N2303		75	200	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	-	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	-	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	2N722, 2N1132, 2N2303	C_{ob}	-	45	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N1132A		-	30	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	80	pF
Input Resistance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	35	Ohms
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)			-	10	
Voltage Feedback Ratio (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{rb}	-	8.0	X 10^{-4}
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			-	8.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N722, 2N1132	h_{fe}	25	100	-
	2N1132A		25	75	
	2N2303		75	300	
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N722, 2N1132, 2N1132A		30	-	
	2N2303		75	-	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	-	1.0	μmhos
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			-	5.0	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N726 (SILICON)
2N727

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general purpose audio amplifier applications.

- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 20 Vdc (Min) @ I_C = 10 mAdc
- Low Output Capacitance —
  C_{ob} = 5.0 pF (Max) @ V_{CB} = 5.0 Vdc

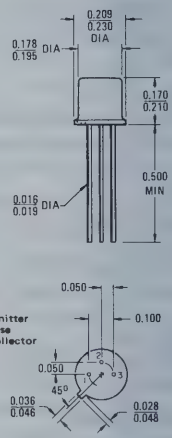
PNP SILICON AMPLIFIER TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 6.67	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data



Collector Connected to Case
CASE 22 (1)
(TO-18)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	20	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)		I_{CEO}	–	5.0	μAdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)		I_{CBO}	–	1.0	μAdc
(V_{CB} = 25 Vdc, I_E = 0, T_A = 150°C)			–	25	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N726	h_{FE}	15	45	–
	2N727		30	120	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)	2N726		6.0	–	
	2N727		12	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	140	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	5.0	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N726	h_{fe}	15	90	–
	2N727		30	240	

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N731 (SILICON)



CASE 22
(TO-18)

Collector electrically connected to case

NPN silicon transistor designed primarily for large-signal, medium-power audio-frequency applications in industrial service.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (R_{BE} = ≦ 10 ohms)	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 3.33	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 10	Watts mW/°C
Operating Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 100 mAdc, R_{BE} = 10 ohms)	BV_{CER}*	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	1.0 100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	120	-
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$*	-	1.5	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$*	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	25	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	35	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	-	80	pF

* Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

2N735 (SILICON)
2N736
2N739
2N740



NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.

Collector electrically connected to case

CASE 22
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	2N735 2N736	2N739 2N740	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	80	125	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25°C$	P_D	500		mW
Derate above 25°C		2.86		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

Lead Temperature, 1/16" ± 1/32" from case for 10 s.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N735, 2N736 2N739, 2N740	BV_{CEO}*	60 80	- -	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N735, 2N736 2N739, 2N740	BV_{CBO}	80 125	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	-	1.0	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc)	2N735, 2N739 2N736, 2N740	h_{FE}	30 60	100 200	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 2.0 mAdc)		V_{BE}	0.35	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	10	pF
Input Impedance (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N735, 2N739 2N736, 2N740	h_{ie}	- -	1500 1800	Ohm
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 Hz)	2N735, 2N739 2N736, 2N740	h_{fe}	40 80	100 200	-

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N741, A (GERMANIUM)



CASE 22
(TO-18)

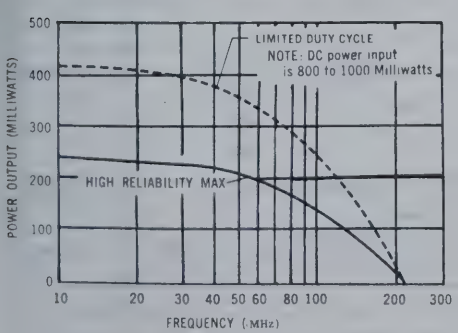
PNP germanium mesa transistors for oscillator, frequency multiplier and amplifier applications.

Collector connected to case

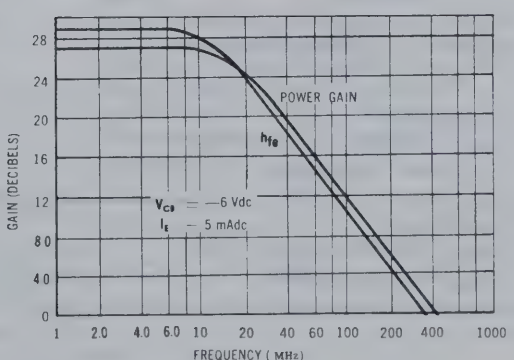
MAXIMUM RATINGS

Rating	Symbol	2N741	2N741A	Unit
Collector-Emitter Voltage	V_{CE}	15	20	Vdc
Collector-Base Voltage	V_{CB}	15	20	Vdc
Emitter-Base Voltage	V_{EB}	1.0		Vdc
Collector Current	I_C	100		mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2		mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4		mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		^oC

POWER OUTPUT versus FREQUENCY, CLASS C AMPLIFIER



POWER GAIN AND COMMON EMITTER CURRENT GAIN versus FREQUENCY



2N741,A (continued)

ELECTRICAL CHARACTERISTICS (at 25°C unless otherwise specified)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N741	BV_{CBO}	15	-	-	Vdc
	2N741A		20	-	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	1.0	-	-	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	2N741	I_{CES}	-	-	100	μAdc
(V_{CE} = 20 Vdc, V_{BE} = 0)	2N741A		-	-	100	
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	0.2	3	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 5 mAdc, V_{CE} = 6 Vdc)		h_{FE}	10	25	-	-
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 100 MHz)	2N741	f_T	-	360	-	MHz
	2N741A		300	360	-	
Output Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	6	10	pF
Collector Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 100 kHz)		C_c	-	3	-	pF
Small-Signal Current Gain (I_C = 5 mAdc, V_{CE} = 6 Vdc, f = 1 kHz)		h_{fe}	20	-	-	-
Output Admittance (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 1 kHz)		h_{ob}	-	45	-	μmhos
Input Impedance (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 1 kHz)		h_{ib}	-	8	15	Ohms
Base Resistance (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 300 MHz)	2N741	r'_b	-	75	-	Ohms
	2N741A		-	65	-	
Noise Figure (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 30 MHz)		NF	-	7	-	dB
Power Gain, Matched, Neutralized (V_{CB} = 6 Vdc, I_E = 5 mAdc, f = 30 MHz)		G_{pe}	16	22	-	dB
Power Output (I_C = 60 mAdc, V_{CB} = 6 Vdc,		P_{out}	-	200	-	mW
G_{pe} = 8 dB, f = 30 MHz)			-	250	-	
Power Output (I_C = 60 mAdc, V_{CB} = 6 Vdc, G_{pe} = 5 dB, f = 70 MHz)		P_{out}	-	200	-	mW

2N743 (SILICON)



CASE 22
(TO-18)

NPN silicon annular transistor designed for high-speed, low-current, saturated switching operations.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

SWITCHING TEST CIRCUITS

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

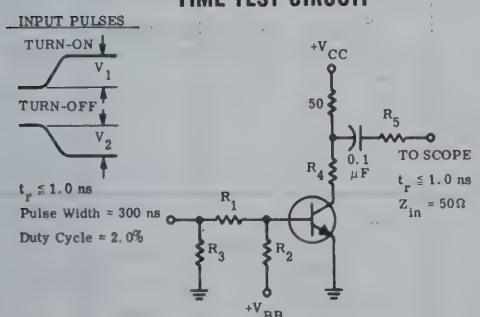
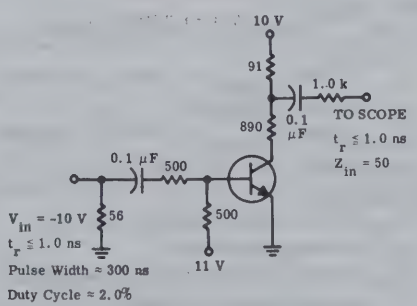


FIGURE 2 — CHARGE-STORAGE TIME TEST CIRCUIT



	CIRCUIT CONDITIONS								
	(VOLTS)					(OHMS)			
	t_{on}		t_{off}						
Condition	V_1	V_{BB}	V_2	V_{BB}	V_{CC}	$R_1 = R_2$	R_3	R_4	R_5
1	15	-3.0	-15	+12	3.0	3.3 k	50	220	-
2	20	-4.5	-20	+15.3*	6.0	330	56	-	1.0 k

* V_{BB} is pulsed for 1.5 s at less than 10% Duty Cycle to maintain $T_C < 30°C$.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	-	Vdc
Collector-Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	I_{CES}	-	1.0	μAdc
(V_{CE} = 20 Vdc, V_{BE} = 0, T_A = 170°C)		-	100	
Collector Cutoff Current (V_{CE} = 10 Vdc, $V_{EB(off)}$ = 0.35 Vdc, T_A = 100°C)	I_{CEX}	-	30	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	1.0	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	-	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 0.25 Vdc)	h_{FE}	10	-	-
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc)		20	60	
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = -55°C)		10	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		10	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 170°C)	$V_{CE(sat)}$	-	0.35	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc, T_A = 170°C)		-	1.0	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = -55°C)		-	1.1	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = -55°C)		-	1.1	
(I_C = 100 mAdc, I_B = 10 mAdc)		-	1.5	
(I_C = 100 mAdc, I_B = 10 mAdc, T_A = -55°C)		-	1.6	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	282	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	5.0	pF
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, Condition 1)	t_{on}	-	16	ns
(V_{CC} = 6.0 Vdc, $V_{BE(off)}$ = 2.4 Vdc, I_C = 100 mAdc, I_{B1} = 40 mAdc, Figure 1, Condition 2)		-	12	
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc, Condition 1)	t_{off}	-	24	ns
(V_{CC} = 6.0 Vdc, I_C = 100 mAdc, I_{B1} ≈ 40 mAdc, I_{B2} ≈ 20 mAdc, Figure 1, Condition 2)		-	40	
Storage Time (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc, V_{CC} = 10 Vdc, Figure 2)	t_s	-	14	ns

2N744 (SILICON)



CASE 22
(TO-18)

NPN silicon annular transistor for high-speed switching applications.

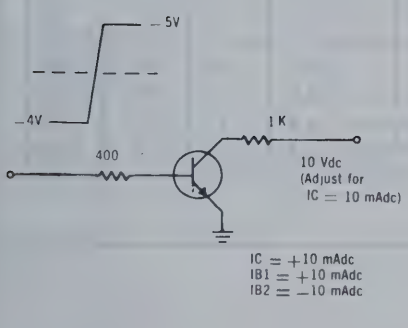
Collector connected to case

MAXIMUM RATINGS

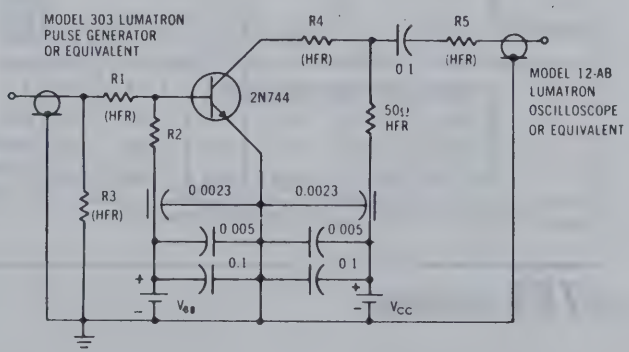
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	20	Vdc
Collector-Emitter Voltage*	V_{CEO}	12*	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector DC Current	I_C	200	mAdc
Total Device Dissipation at 25°C Case Temperature (Derate 6.67 mW/°C above 25°C)	P_D	1.0	Watt
Total Device Dissipation at 25°C Ambient Temperature Derate above 25°C	P_D	0.3 2.0	Watt mW/°C
Junction Temperature	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

*Refers to the voltage at which the magnitude of h_{FE} approaches one when the emitter-base diode is open-circuited.

SWITCHING TIME TEST CIRCUIT



CHARGE STORAGE TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CE} = 20 Vdc, I_E = 0) (V_{CE} = 20 Vdc, I_B = 0, T_A = 170°C)	I_{CES}	 – –	 .005 –	 1.0 100	μAdc
Collector Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0.35 Vdc, T_A = 100°C)	I_{CEX}	–	–	30	μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	–	–	10	μAdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)*	BV_{CEO}	12	30	–	Vdc
Forward Current Transfer Ratio (I_C = 1.0 mAdc, V_{CE} = 0.25 Vdc) (I_C = 10 mAdc, V_{CE} = 0.35 Vdc) (I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = -55°C) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)*	h_{FE}	 20 40 20 20	 – – – –	 – 120 – –	–
Small Signal Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	2.8	4.5	–	–
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 10 mAdc, I_B = 1 mAdc, T_A = -55°C) (I_C = 100 mAdc, I_B = 10 mAdc)* (I_C = 100 mAdc, I_B = 10 mAdc, T_A = -55°C)*	V_{BE}	 0.7 – – –	 – – – –	 0.85 1.1 1.5 1.6	Vdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc, T_A = 170°C) (I_C = 100 mAdc, I_B = 10 mAdc, T_A = 170°C)*	$V_{CE(sat)}$	 – –	 – –	 0.35 1.0	Vdc
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0)	C_{ob}	–	3.0	5.0	pF
Turn-on Time (Condition 1) (Condition 2) (Condition 3) (Condition 4)	t_{on}	 – – – –	 26 10 7 6	 – 16 – 12	ns
Turn-off Time (Condition 1) (Condition 2) (Condition 3) (Condition 4)	t_{off}	 – – – –	 30 17 18 23	 – 24 – 45	ns
Charge Storage Time Constant (I_C = 10 mAdc, I_{B1} = $-I_{B2}$ = 10 mAdc)	τ_s	–	–	18	ns

* Pulse Test: Pulse width ≤ 300 μs, duty cycle ≤ 2%

CONDITION	I_C mA	I_{B1} mA	I_{B2} mA	$V_{BE(off)}$ Vdc	V_{CC} Vdc	$R_1 = R_2$ Ω	R_3 Ω	R_4 Ω	R_5 Ω	t_{on} V_{BB} V	t_{on} V_{IN} V	t_{off} V_{BB} V	t_{off} V_{IN} V
1	3	1	-0.5	-0.9	3.4	6.8 K	50	1 K	0	-1.8	10.2	8.4	-10.2
2	10	3	-1.5	-1.5	3.0	3.3 K	50	220	0	-3.0	15.0	12.0	-15 0
3	50	15	-7.5	-1.8	4.0	680	50	18	1 K	-3.5	15.3	*11.7	-15.3
4	100	40	-20.0	-2.4	6.0	330	56	0	1 K	-4.5	20.0	*15.3	-20.0

*V_{BB} is pulsed for 1.5 s @ less than 10% duty cycle

2N753 (SILICON)

For Specifications, See 2N706 Data.

2N827 (GERMANIUM)



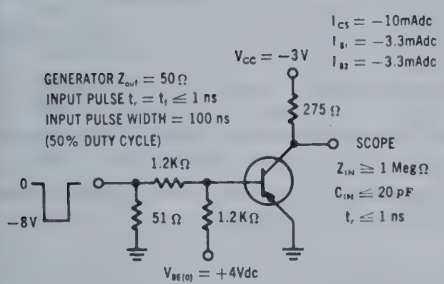
CASE 22
(TO-18)

PNP germanium mesa transistor for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	20	Vdc
Collector-Emitter Voltage	V_{CES}	20	Vdc
Collector-Emitter Voltage	V_{CEX}	10	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current (Continuous)	I_C	100	mAdc
Junction Temperature	T_J	+100	°C
Storage Temperature	T_{stg}	-65 to + 100	°C
Device Dissipation @ 25°C Ambient Temperature (Derate 2mW/°C above 25°C)	P_D	150	mW



SWITCHING TIME TEST CIRCUIT

ELECTRICAL CHARACTERISTICS (At = 25°C unless otherwise specified)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	22	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{EB} = 0)	BV_{CES}	20	22	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4	5	---	Vdc
Collector Latch-up Voltage	LV_{CEX}	10	---	---	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 15 Vdc, V_{EB} = 0)	I_{CES}	---	0.5	5	μAdc
Collector-Base Cutoff Current (V_{CB} = 15 Vdc)	I_{CBO}	---	0.5	5	μAdc
DC Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	h_{FE}	100	150	---	---
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.3 mAdc)	$V_{CE(sat)}$	---	0.16	0.25	Vdc
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 3.3 mAdc)	V_{BE}	---	0.39	0.5	Vdc
Small-Signal Forward Current Transfer Ratio (I_C = 10 mA, V_{CE} = 1 V, f = 100 MHz)	h_{fe}	2.5	3.5	---	---
Collector Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}	---	4	9	pF
Delay Time	t_d	---	10	15	ns
Rise Time	t_r	---	10	20	ns
Storage Time	t_s	---	15	30	ns
Fall Time	t_f	---	15	30	ns

2N828 (GERMANIUM)



CASE 22
(TO-18)

PNP germanium epitaxial mesa transistor for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector-Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

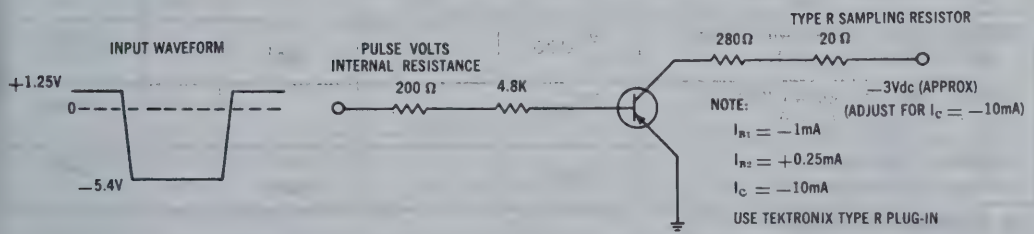


FIGURE 2 — CHARGE STORAGE TIME TEST CIRCUIT

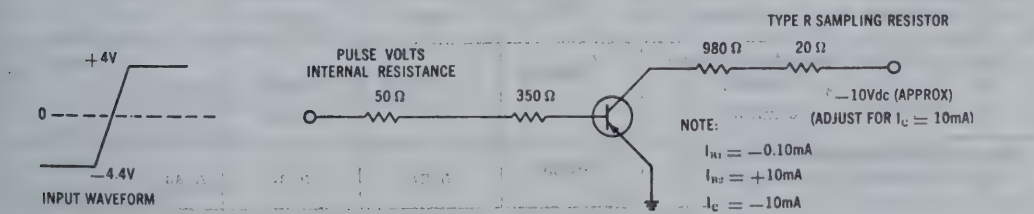


FIGURE 3 — RISE TIME FACTOR

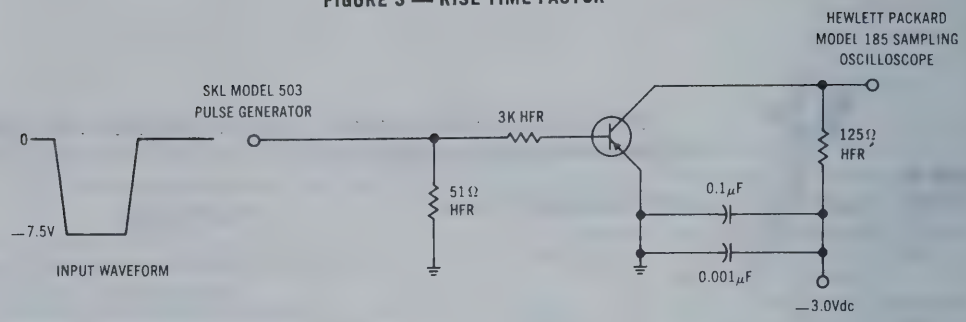
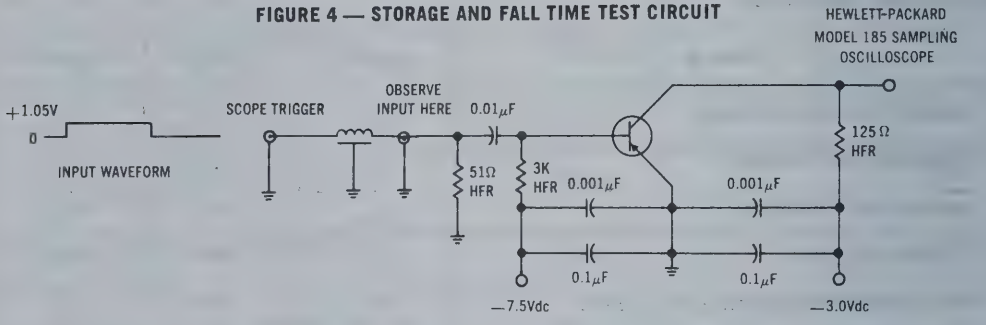


FIGURE 4 — STORAGE AND FALL TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	-	10	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	15	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100μAdc, I_E = 0)	BV_{CBO}	15	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2.5	-	-	Vdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)	I_{CBO}	-	0.4	3	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	h_{FE}	25	40	-	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	-	0.12	0.2	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)		-	0.18	0.25	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	0.34	0.39	0.44	Vdc

2N828 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	f_T	300	400	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{ob}	-	3.5	-	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	h_{fe}	3	4	-	-
Delay Plus Rise Time (Figure 1)	$t_d + t_r$	-	50	70	ns
Storage Time (Figure 1)	t_s	-	33	50	ns
Fall Time (Figure 1)	t_f	-	35	50	ns
Charge Storage Time Constant (Figure 2)	τ_s	-	14	25	ns
Rise Time (Figure 3)	t_r	-	7	-	ns
Storage Time (Figure 4)	t_s	-	5	-	ns
Fall Time (Figure 4)	t_f	-	3	-	ns

2N828A (GERMANIUM)
2N829



Collector connected to case

CASE 22
(TO-18)

PNP germanium epitaxial mesa transistors for high-speed switching applications

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector to Base Voltage	V_{CB}	15	Vdc
Collector to Emitter Voltage	V_{CES}	15	Vdc
Emitter to Base Voltage	V_{EB}	2.5	Vdc
Collector Current (Continuous)	I_C	200	mAdc
Total Device Dissipation at 25°C case Temperature (Derate 4.0mw/°C above 25°C)	P_D	300	mW
Total Device Dissipation at 25°C Ambient Temperature (Derate 2.0mw/°C)	P_D	150	mW
Junction Temperature	T_J	+100	°C
Storage Temperature	T_{stg}	-65 to +100	°C

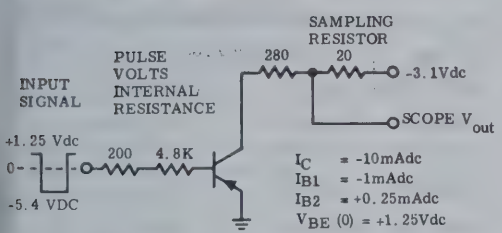
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector to Base Breakdown Voltage $I_E = 0$, $I_C = 100\mu$Adc		BV_{CBO}	15	25	--	Vdc
Collector to Emitter Breakdown Voltage $V_{EB} = 0$, $I_C = 100\mu$Adc		BV_{CES}	15	25	--	Vdc
Emitter to Base Breakdown Voltage $I_C = 0$, $I_E = 100\mu$Adc		BV_{EBO}	2.5	--	--	Vdc
Collector Cutoff Current $I_E = 0$, $V_{CB} = 6$Vdc		I_{CBO}	--	4	3	μAdc
Forward Current Transfer Ratio $I_C = 10$mAdc, $V_{CE} = 0.3$Vdc	2N828A 2N829	h_{FE}	 25 50	 40 80	--	--
Forward Current Transfer Ratio $I_C = 150$mAdc, $V_{CE} = 1$Vdc	2N828A 2N829	h_{fe}	 25 50	 40 80	--	--
Collector Saturation Voltage $I_C = 10$mAdc, $I_B = 1.0$ mAdc $I_C = 10$mAdc, $I_B = 0.5$mAdc	 2N828A 2N829	$V_{CE(sat)}$	--	 0.11 0.11	 0.20 0.20	Vdc
Collector Saturation Voltage $I_C = 50$mAdc, $I_B = 5.0$mAdc		$V_{CE(sat)}$	--	--	0.25	Vdc
Collector Saturation Voltage $I_C = 150$mAdc, $I_B = 15$mAdc $I_C = 150$mAdc, $I_B = 7.5$mAdc	 2N828A 2N829	$V_{CE(sat)}$	--	 0.35 0.38	 0.50 0.50	Vdc
Base to Emitter Voltage $I_C = 10$mAdc, $I_B = 1$mAdc $I_C = 10$mAdc, $I_B = 0.5$mAdc	 2N828A 2N829	V_{BE}	 0.34 .30	 0.40 0.38	 0.44 0.44	Vdc
Base to Emitter Voltage $I_C = 150$mAdc, $I_B = 15$mAdc $I_C = 150$mAdc, $I_B = 7.5$mAdc	 2N828A 2N829	V_{BE}	--	 0.70 0.65	 0.85 0.85	Vdc
Collector Capacitance $I_E = 0$, $V_{CB} = 6$Vdc, f = 100 kHz)		C_{ob}	--	2.2	4	pF

ELECTRICAL CHARACTERISTICS (continued)

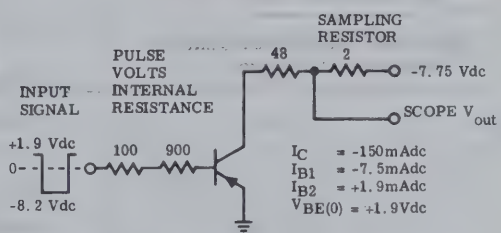
Characteristic	Symbol	Min	Typ	Max	Unit
Input Capacitance (V_{BE} = 1Vdc, I_E = 0, f = 100 kHz)	C_{ib}	--	2.2	3.5	pF
Small Signal Forward Current Transfer Ratio I_C = 10mAdc, V_{CE} = -1Vdc, f = 100 MHz	h_{fe}	3.0	4.0	--	--
Current Gain Bandwidth Product V_{CE} = 1Vdc, I_C = -10mAdc, f = 100 MHz	f_T	300	400	--	MHz
Delay Plus Rise Time (Fig. 1) I_C = 10mAdc	td+tr	--	35	50	ns
Storage Time (Fig. 1) I_C = 10mAdc	ts	--	30	50	ns
Fall Time (Fig. 1) I_C = 10mAdc	tf	--	30	50	ns
Total Control Charge (Fig. 3) I_C = 10mAdc	Q_T	--	50	80	pC
Delay Plus Rise Time (Fig. 2) I_C = 150mAdc	t_d+t_r	--	25	50	ns
Turn Off Time (Fig. 2) I_C = 150mAdc	t_{off}	--	60	100	ns
Total Control Charge (Fig. 4) I_C = 150mAdc	Q_T	--	120	175	pC

FIGURE 1 — 10mA SWITCHING TIME TEST CIRCUIT



SCOPE INPUT IMPEDANCE = 1Megohm
SCOPE INPUT CAPACITANCE = 20 pF
GENERATOR OUTPUT IMPEDANCE = 50 ohms
INPUT PULSE $t_r = t_f$ = 2ns

FIGURE 2 — 150mA SWITCHING TIME TEST CIRCUIT



SCOPE INPUT IMPEDANCE = 1Megohm
SCOPE INPUT CAPACITANCE = 20 pF
GENERATOR OUTPUT IMPEDANCE = 50 ohms
INPUT PULSE $t_r = t_f$ = 2ns

FIGURE 3 — 10mA TOTAL CONTROL CHARGE TEST CIRCUIT

*ADJUST V_{BB} FOR -5.4 VOLT PULSE AT POINT A

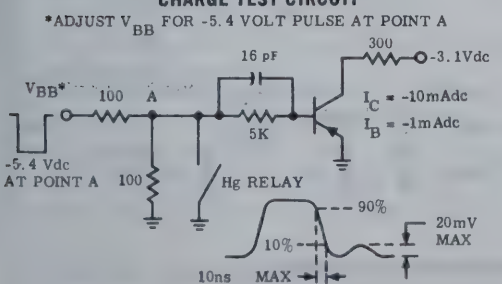
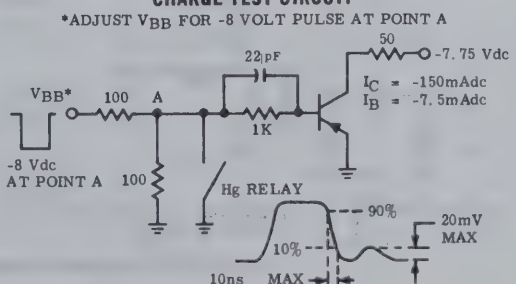


FIGURE 4 — 150mA TOTAL CONTROL CHARGE TEST CIRCUIT

*ADJUST V_{BB} FOR -8 VOLT PULSE AT POINT A



2N834 (SILICON)
2N835



CASE 22
(TO-18)

Collector connected to case

NPN silicon epitaxial transistors for high-speed switching applications.

MAXIMUM RATINGS

Rating	Symbol	2N834	2N835	Unit
Collector-Emitter Voltage	V_{CES}	30	20	Vdc
Collector-Base Voltage	V_{CB}	40	25	Vdc
Emitter-Base Voltage	V_{EB}	5	3	Vdc
Collector Current-Continuous Peak	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.3 2		Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 6.67		Watt $mW/^oC$
Total Device Dissipation @ $T_C = 100^oC$ Derate above 100^oC	P_D	0.5 6.67		Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		^oC

FIGURE 1 — TURN-ON AND TURN-OFF TIME MEASUREMENT CIRCUIT

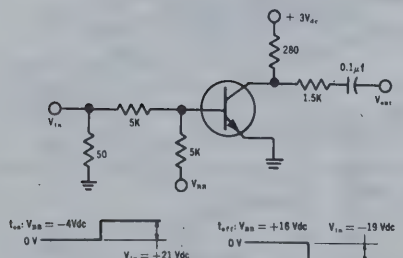
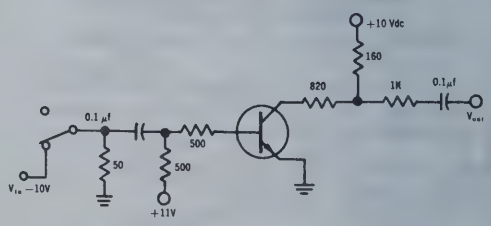


FIGURE 2 — CHARGE STORAGE TIME CONSTANT MEASUREMENT CIRCUIT



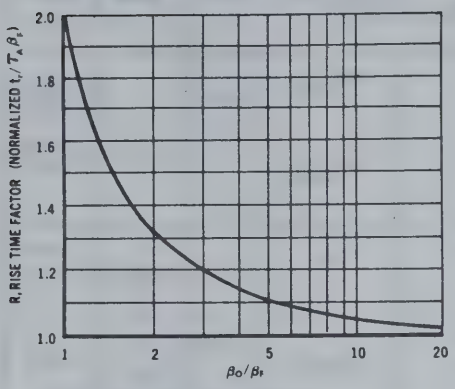
NOTE: ALL SWITCHING TIMES MEASURED WITH LUMATRON MODEL 420 SWITCHING TIME TEST SET OR EQUIVALENT.

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

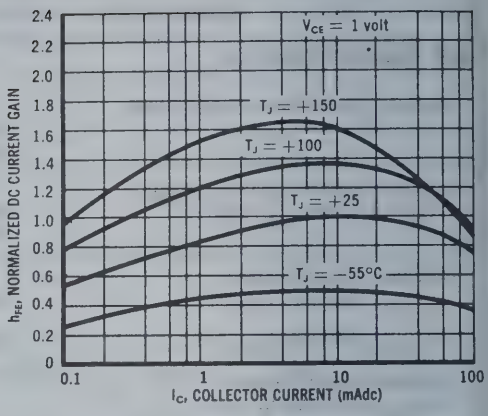
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N834	BV_{CBO}	40	-	Vdc
	2N835		25	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	2N834	BV_{EBO}	5	-	Vdc
	2N835		3	-	
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	2N834	I_{CES}	-	10	μAdc
(V_{CE} = 20 Vdc, V_{BE} = 0)	2N835		-	10	
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	0.5	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)			-	30	
ON CHARACTERISTICS					
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N834	h_{FE}*	25	-	-
	2N835		20	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	2N834	$(V_{CE(sat)}$	-	0.25	Vdc
	2N835		-	0.30	
(I_C = 50 mAdc, I_B = 5 mAdc)*	2N834		-	0.4	
	2N835		-	-	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$*	-	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N834	f_T	350	-	MHz
(I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	2N835		300	-	
High-Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N834	$\lvert h_{fe} \rvert$	3.5	-	-
(I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	2N835		3.0	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	4.0	pF
Charge-Storage Time Constant (Figure 2) (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	2N834	t_s	-	25	ns
	2N835		-	35	
Turn-On Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	2N834	t_{on}	-	33	ns
	2N835		-	20	
Turn-Off Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	2N834	t_{off}	-	75	ns
	2N835		-	35	

*Pulse Test: Pulse Width ≤ 12 ms, Duty Cycle ≤ 2%

RISE TIME FACTOR



NORMALIZED CURRENT GAIN CHARACTERISTICS



2N838 (GERMANIUM)



CASE 22
(TO-18)

PNP germanium epitaxial mesa transistor for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Emitter Voltage	V_{CEX}	15	Vdc
Emitter-Base Boltage	V_{EB}	2.5	Vdc
Collector Current (Continuous)	I_C	100	mAdc
Junction Temperature	T_J	+100	°C
Storage Temperature	T_{stg}	-65 to+ 100	°C
Device Dissipation @ 25°C Ambient Temperature (Derate 2mW/°C above 25°C)	P_D	150	mW

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

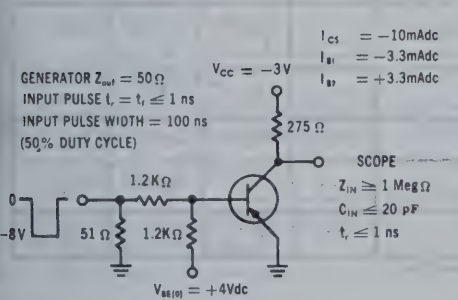
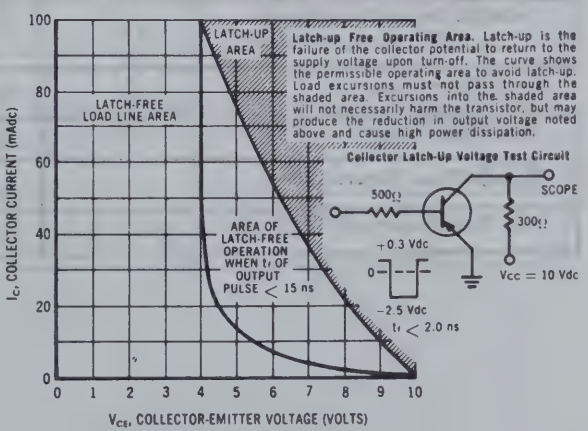


FIGURE 2 — AREA OF PERMISSIBLE LOAD LOCI



ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C =100 μAdc, I_E =0)	BV_{CBO}	30	35	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{EB} = 0)	BV_{CES}	30	35	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2.5	4.5	---	Vdc
Collector Latch-up Voltage (see Figure 2)	LV_{CEX}	15	---	---	Vdc
Collector-Emitter Cutoff Current (V_{CE} =15 Vdc, V_{EB} =0)	I_{CES}	---	1	10	μAdc
Collector-Base Cutoff Current (V_{CB} = 15 V, I_E = 0)	I_{CBO}	---	1	10	μAdc
DC Forward Current Transfer Ratio (I_C = 10mAdc, V_{CE} = 0.3 Vdc)	h_{FE}	30	70	---	---
Collector-Emitter Saturation Voltage (I_C =10 mAdc, I_B = 3.3 mAdc)	$V_{CE(sat)}$	---	0.1	0.18	Vdc
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 3.3 mAdc)	V_{BE}	---	0.39	0.5	Vdc
Small-Signal Forward Current Transfer Ratio (I_C = 10 mA, V_{CE} = 1V, f = 100 MHz)	h_{fe}	3	4.5	---	---
Collector Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}	---	2	4	pF
Delay Time (Figure 1)	t_d	---	10	15	ns
Rise Time (Figure 1)	t_r	---	7	15	ns
Storage Time (Figure 1)	t_s	---	10	20	ns
Fall Time (Figure 1)	t_f	---	10	20	ns

2N840 (SILICON)
2N841



NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.

CASE 22
(TO-18)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Emitter Voltage	V_{CES}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	2.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.86	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	45	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	45	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	2.0	-	Vdc
Collector Cutoff Current (V_{CE} = 45 Vdc, V_{BE} = 0, R_{BE} = 5.0 k ohms)		I_{CER}	-	20	μAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	-	1.0	μAdc
(V_{CB} = 45 Vdc, I_E = 0, T_A = 150°C)			-	50	
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)		I_{EBO}	-	50	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N840	h_{FE}	30	100	-
	2N841		60	400	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 2.2 mAdc)		$V_{CE(sat)}$	-	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	2N840	f_T	1.5	-	MHz
	2N841		2.0	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	15	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N840	h_{fe}	40	90	-
	2N841		80	330	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz, T_A = -55°C)	2N840		15	-	
	2N841		25	-	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{oe}	-	1.2	μmhos
Input Resistance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	-	80	Ohms
Output Conductance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	-	1.2	μmhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		$Re(h_{ie})$	-	500	Ohms

2N869 (SILICON)
2N995



CASE 22
(TO-18)

PNP silicon annular transistors for high-frequency general-purpose amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Types	Value	Unit
Base Voltage	V_{CB}	2N869 2N995	25 20	Volts Volts
Collector-Emitter Voltage	V_{CEO}	2N869 2N995	18 15	Volts Volts
Emitter-Base Voltage	V_{EB}	2N869 2N995	5 4	Volts Volts
Total Device Dissipation at 25°C Case Temperature at 100°C Case Temperature (Derate 6.86 mW/°C above 25°C)	P_D	Both Types	 1.2 0.68	 Watts Watt
Total Device Dissipation at 25°C Ambient Temperature (Derate 2.06 mW/°C above 25°C)	P_D	Both Types	0.36	Watt
Storage Temperature	T_{stg}	Both Types	-65 to +200	°C
Junction Temperature	T_J	Both Types	+200	°C

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0) 2N869	BV_{CBO}	25	---	---	Volts
2N995		20	---	---	
Collector-Emitter Sustaining Voltage * (I_C = 10 mAdc, I_B = 0) 2N869	$V_{CEO(sust)}$*	18	---	---	Volts
2N995		15	---	---	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0) 2N869	BV_{EBO}	5	---	---	Volts
2N995		4	---	---	
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) 2N869	I_{CBO}	---	---	.010	μ Adc
2N995		---	---	.005	
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C) Both Types		---	---	25	
Emitter Current (V_{EB} = 4.0 Vdc, I_C = 0) 2N995	I_{EBO}	---	---	10	μ Adc
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) 2N869	$V_{CE\ (sat)}$	---	0.17	1.0	Volt
(I_C = 20 mAdc, I_B = 2.0 mAdc) 2N995		---	---	0.2	
Base Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) 2N869	$V_{BE\ (sat)}$	---	0.78	1.0	Volt
(I_C = 20 mAdc, I_B = 2.0 mAdc) 2N995		---	---	0.95	
DC Forward-Current Transfer Ratio *	h_{FE}*				---
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc) 2N869		20	---	120	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) 2N995		25	---	---	
(I_C = 20 mAdc, V_{CE} = 1.0 Vdc) 2N995		35	---	140	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc) 2N995		25	---	---	
Open-Circuit Output Capacitance (V_{CB} = 10 V, I_E = 0) 2N869	C_{ob}	---	3	9	pF
2N995		---	3	10	
Open-Circuit Input Capacitance (V_{BE} = 0.5 V, I_C = 0) Both Types	C_{ib}	---	7	11	pF
Small-Signal Forward-Current Transfer Ratio	h_{fe}				---
(I_C = 10 mA, V_{CE} = 15 V, f = 100 MHz) 2N869		1.0	3.0	---	
(I_C = 10 mA, V_{CE} = 10 V, f = 100 MHz) 2N995		1.0	3.0	---	

*Pulse Note: Pulse Width = 300 μs, Duty Cycle = 1%

2N869A (SILICON)



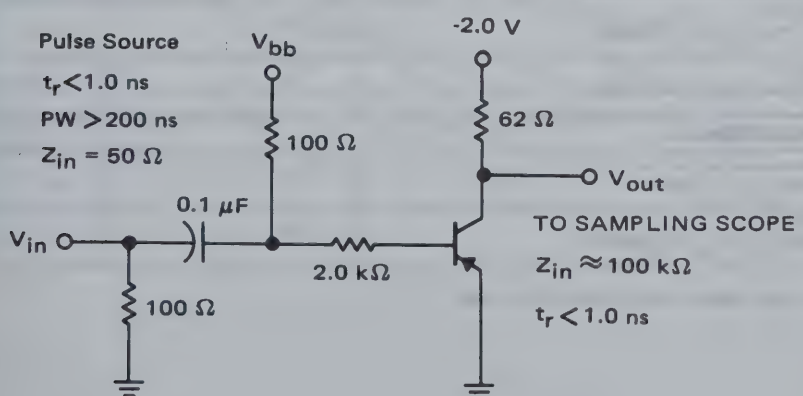
CASE 22
(TO-18)

PNP silicon annular low-power transistor designed for medium-speed, saturated switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.1	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.86	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	18	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	-	10	nAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	-	25	μAdc
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_B	-	10	nAdc
ON CHARACTERISTICS				
DC Current Gain*	h_{FE}*			-
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)		30	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		40	120	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc)		40	120	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C)		17	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		25	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		-	0.15	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		-	0.2	
(I_C = 100 mAdc, I_B = 10 mAdc)		-	0.5	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.78	0.98	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		0.85	1.2	
(I_C = 100 mAdc, I_B = 10 mAdc)		-	1.7	
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	400	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 150 kHz)	C_{ib}	-	6.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 30 mAdc, I_{B1} = 1.5 mAdc)	t_{on}	-	50	ns
Turn-Off Time (I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc)	t_{off}	-	80	ns

* Pulse Test: Pulse Length = 300 μs, Duty Cycle = 1.0%.

2N910 (SILICON)
2N911



NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.

CASE 22
(TO-18)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Emitter Voltage	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.8 0.975 10.3	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

2N910, 2N911 (Continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	60	-	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, $R_{BE} \leq$ 10 ohms)		$BV_{CER(sus)}$*	80	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	100	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)		I_{CBO}	-	25	nAdc
(V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)			-	15	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	25	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N910	h_{FE}	35	-	-
	2N911		20	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N910*		75	-	
	2N911*		35	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N910*		30	-	
	2N911*		15	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	0.4	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)			-	1.2	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	0.6	0.8	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)			-	0.9	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N910	f_T	60	-	MHz
	2N911		50	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	85	pF
Input Impedance (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N910	h_{ie}	-	1800	Ohms
	2N911		-	1000	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N910	h_{fe}	76	200	-
	2N911		36	90	
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N911		40	100	
Output Admittance (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N910	h_{oe}	-	100	μmhos
	2N911		-	50	
Input Resistance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	20	30	Ohms
(I_C = 5.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)			4.0	8.0	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N910	h_{rb}	-	3.0	X 10-4
	2N911		-	1.25	
(I_C = 5.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N911		-	1.75	
Output Conductance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz).		h_{ob}	-	0.5	μmho
(I_C = 5.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)			-	1.0	
Noise Figure (I_C = 0.3 mAdc, V_{CB} = 10 Vdc, R_G = 510 ohms,	2N910	NF	-	12	dB
f = 1.0 kHz, B. W. = 200 Hz)	2N911		-	15	

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

2N914 (SILICON)



CASE 22
(TO-18)

Collector connected to case

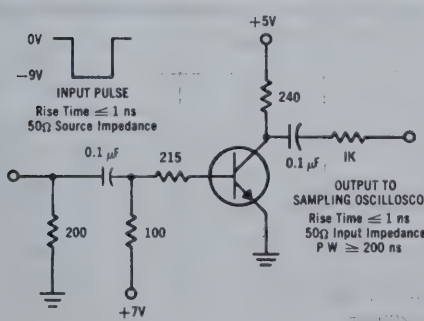
NPN silicon annular transistor for high-speed switching applications.

MAXIMUM RATINGS

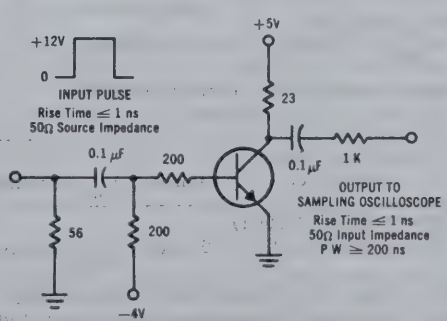
Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	15	Vdc
*Collector-Emitter Voltage ($R_{BE} \leq 10$ ohms)	V_{CER}	20	Vdc
*Collector-Base Voltage	V_{CB}	40	Vdc
*Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current (Note 1)	I_C	150	mAdc
*Total Device Dissipation @ $T_A = 25^oC$	P_D	360	mW
Derate above 25^oC		2.06	$mW/^oC$
*Total Device Dissipation @ $T_C = 25^oC$	P_D	1.2	Watts
Derate above 25^oC		6.9	$mW/^oC$
*Total Device Dissipation @ $T_C = 100^oC$	P_D	0.68	Watt
*Operating Junction Temperature Range	T_J	200	^oC
*Storage Temperature Range	T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.
Note 1: Limited by Power Dissipation

CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



t_{on} and t_{off} TEST CIRCUIT



2N914 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
*Collector-Emitter Sustaining Voltage (Note 1) (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$	15	-	Vdc
*Collector-Emitter Sustaining Voltage (Note 1) (I_C = 30 mAdc, $R_{BE} \leq$ 10 ohms)	$BV_{CER(sus)}$	20	-	Vdc
*Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
*Emitter-Base Breakdown Voltage (I_E = 10μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
*Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 125°C)	I_{CEX}	-	10	μAdc
*Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	0.025	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		-	15	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (Note 1) *(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	120	-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		12	-	
*(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)		10	-	
Collector-Emitter Saturation Voltage *(I_C = 200 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	-	0.70	Vdc
(I_C = 10 mAdc, I_B = 1.0 thru 20 mAdc, T_A = -55 to +125°C)		-	0.25	
*Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.70	0.80	Vdc
DYNAMIC CHARACTERISTICS				
†Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	-	9.0	pF
*Charge Storage Time Constant (Note 2) (I_C = I_{B1} = I_{B2} = 20 mAdc)	τ_s	-	20	ns
Turn-On Time (Note 2) (I_C = 200 mAdc, I_{B1} = 40 mAdc, I_{B2} = 20 mAdc)	t_{on}	-	40	ns
Turn-Off Time (Note 2) (I_C = 200 mAdc, I_{B1} = 40 mAdc, I_{B2} = 20 mAdc)	t_{off}	-	40	ns

Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤1.0%.
Note 2: Measured on Sampling Scope: Pulse Width ≥ 200 ns.
*Indicates JEDEC Registered Data.
†JEDEC Registration Defined as h_{fe}.

2N915 (SILICON)



CASE 22
(TO-18)

NPN silicon annular transistor for high-frequency amplifier, oscillator and switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	70	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	1.2 6.9	W mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	.36 2.06	W mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to + 200	°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current $I_E = 0$ $V_{CB} = 60V$	I_{CBO}		10	nA
Collector Cutoff Current @ 150°C $I_E = 0$ $V_{CB} = 60V$	I_{CBO}		30	μ A
Collector Breakdown Voltage $I_C = 100\ \mu$ A $I_E = 0$	BV_{CBO}	70		Volts
Collector to Emitter Sustaining Voltage $I_C = 10mA$ $I_B = 0$	$*V_{CEO}$	50		Volts
Emitter Breakdown Voltage $I_C = 0$ $I_E = 100\ \mu A$	BV_{EBO}	5.0		Volts
Base Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{BE(sat)}$		0.9	Volts
Collector Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{CE(sat)}$		1.0	Volts
DC Pulse Current Gain $I_C = 10mA$ $V_{CE} = 5.0V$	h_{FE}	50	200	
Output Capacitance $I_E = 0$ $V_{CB} = 10V$	C_{ob}		3.5	pF
Emitter Transition Capacitance $I_C = 0$ $V_{EB} = 0.5V$	C_{TE}		10	pF
High Frequency Current Gain f = 100 MHz $I_C = 10mA$ $V_{CE} = 15V$	h_{fe}	2.5		
Small Signal Current Gain f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{fe}	40 50	200 250	
Input Resistance f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{ie}		6000 2000	ohms ohms
Output Conductance f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{oe}		75 125	μmho μmho

*Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 1.0%

2N916 (SILICON)



Collector connected to case

CASE 22
(TO-18)

NPN silicon annular transistor for high-frequency amplifier, oscillator and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	1.2 6.9	W mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	.36 2.06	W mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +300	°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current $I_E = 0$ $V_{CB} = 30V$	I_{CBO}		10	nAdc
Collector Cutoff Current @150° C $I_E = 0$ $V_{CB} = 30V$	I_{CBO}		10	μAdc
Collector Breakdown Voltage $I_C = 10\mu A$ $I_E = 0$	BV_{CBO}	45		Volts
Collector to Emitter Sustaining Voltage $I_C = 30mA$ $I_B = 0$	$*V_{CEO}$	25		Volts
Emitter Breakdown Voltage $I_C = 0$ $I_E = 10\mu A$	BV_{EBO}	5.0		Volts
Base Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{BE(sat)}$		0.9	Volts
Collector Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{CE(sat)}$		0.5	Volts
DC Pulse Current Gain $I_C = 10mA$ $V_{CE} = 1.0V$	$*h_{FE}$	50	200	—
Output Capacitance $I_E = 0$ $V_{CB} = 5.0V$	C_{ob}		6.0	pF
Emitter Transition Capacitance $I_C = 0$ $V_{EB} = 0.5V$	C_{TE}		10	pF
High Frequency Current Gain f = 100 MHz $I_C = 10mA$ $V_{CE} = 15V$	h_{fe}	3.0		—
Small Signal Current Gain f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{fe}	40 50	200 250	
Input Resistance f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{ie}		6000 2000	ohms ohms
Output Conductance f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{oe}		75 125	μmho μmho

*Pulse Test: Pulse Width = 300 μs, Duty Cycle=1.0%

2N918 (SILICON)



CASE 20
(TO-72)

NPN silicon annular transistors with high reliability designed for use in VHF and UHF amplifier, mixer and oscillator applications. JAN/JANTX also available.

Active elements isolated from case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_C = 25°C	P_D	300	mW
Derating Factor Above 25°C		1.71	mW/°C
Total Device Dissipation @ T_A = 25°C	P_D	200	mW
Derating Factor Above 25°C		1.14	mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

TABLE I : GROUP A INSPECTION (T_A = 25°C ± 3°C unless otherwise noted)

Examination or Test		Mil-Std-750 Method	Symbol	Limits Min	Limits Max	Unit	*LTPD
SUBGROUP 1							
Visual and Mechanical Examination		2071	-	-	-	-	10
SUBGROUP 2							
Collector-Base Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	All Types	3036 Condition D	I_{CBO}	-	10	nAdc	5
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	All Types	3001 Condition D	BV_{CBO}	30	-	Vdc	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	All Types	3026 Condition D	BV_{EBO}	3.0	-	Vdc	
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	All Types	3011 Condition D	BV_{CEO}	15	-	Vdc	
DC Current Gain (V_{CE} = 10 Vdc, I_C = 10 mAdc)	JAN2N918	3076	h_{FE}	20	-	-	
(V_{CE} = 1.0 Vdc, I_C = 3.0 mAdc)	JAN2N918 ‡			20 ‡	200		
(V_{CE} = 10 Vdc, I_C = 500 μAdc)	JAN2N918			10	-		
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	All Types	3066 Condition A	V_{BE}	-	1.0	Vdc	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	All Types	3071	$V_{CE(sat)}$	-	0.4	Vdc	

*Applies to Meg-A-Life II and Mil Units Only
‡Minimum value only applies to Standard Unit

TABLE I : GROUP A INSPECTION (T_A = 25°C ± 3°C unless otherwise noted) (continued)

Examination or Test		Mil-Std-750 Method	Symbol	Limits Min	Limits Max	Unit	*LTPD
SUBGROUP 3							
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f ≥ 0.1 MHz & ≤ 1.0 MHz)	All Types	3236	C_{ob}	-	1.7	pF	
(V_{CB} = 0, I_E = 0, f ≥ 0.1 MHz & ≤ 1.0 MHz)	All Types			-	3.0		
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f ≥ 0.1 MHz & ≤ 1.0 MHz)	All Types	3240 (Note 1)	C_{ib}	-	2.0	pF	
SUBGROUP 4							
Small-Signal Current Gain (V_{CE} = 10 Vdc, I_C = 4.0 mAdc, f = 100 MHz)	All Types	3306	$\|h_{fe}\|$	6.0	-	-	
Small-Signal Amplifier Gain (V_{CC} = 12 Vdc, I_C = 6.0 mAdc, f = 200 MHz)	All Types	(Figure 2)	G_{pe}	15	-	dB	10
Collector-Base Time Constant (V_{CB} = 10 Vdc, I_E = -4.0 mAdc, f = 79.8 MHz)	JAN2N918		$r_b'C_c$	-	25	ps	
Noise Figure (V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc, R_G = 400 ohms, f = 60 MHz)	All Types	(Note 2)	NF	-	6.0	dB	
Oscillator Power Output (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	All Types	(Note 3)	P_{out}	30	-	mW	
Collector-Efficiency Test (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	All Types	(Note 3)	η	25	-	%	
SUBGROUP 5 (Note 4)		(Note 4)					
High Temperature Operation							
Collector-Base Cutoff Current (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	All Types	3036 Condition D	I_{CBO}	-	1.0	μAdc	
Low Temperature Operation							
DC Current Gain (V_{CE} = 1.0 Vdc, I_C = 3.0 mAdc, T_A = -55°C)	JAN2N918	3076 (Note 4)	h_{FE}	10	-	-	

*Applies to Meg-A-Life II and Mil Units Only

NOTES:

1. This test shall be in accordance with Method 3240 of MIL-STD-750 except that the output capacitor is omitted.
2. Noise Figure shall be measured using a HP 342A NF Meter in accordance with HP 342A pertinent test procedure or by use of a suitable equivalent test-equipment circuit and procedure.
3. Sample units shall be allowed to return to and be stabilized at room ambient temperature prior to being subjected to the Low-Temperature Operation test.
4. Test Measurement shall be made after thermal equilibrium has been reached at the temperature specified.
5. All applicable end-point test measurements shall be made within four hours after the particular sample units have been subjected to the required physical-mechanical or environmental test(s). This requirement is not applicable to measurements specified to be made during (subjection of sample units) a physical-mechanical or environmental test, and shall not be applicable where otherwise specified for life test(s).
6. There shall be no evidence of flaking, pitting, or other visible signs of corrosion on sample units, upon examination without magnifications, after subjection to test.
7. Per MIL-STD-202, Method 112, Test Condition C, Procedure 111a and Test Condition A for Gross Leaks.

TABLE II : GROUP B INSPECTION

(Fourth lead is "floating" unless otherwise specified.)

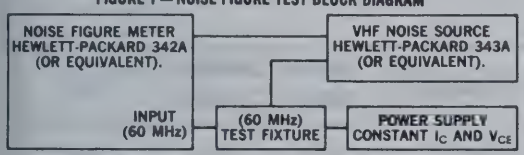
Examination or Test	Mil-Std-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 1						
Physical Dimensions	2066	-	-	-	-	20
SUBGROUP 3						
Solderability	2026	-	-	-	-	10
Temperature Cycling	1051 Condition C	-	-	-	-	
Thermal Shock (Glass Strain)	1056 Condition A	-	-	-	-	
Seal (Leak Rate)	(Note 7)	-	-	-	-	
Moisture Resistance (No Initial Conditioning)	1021	-	-	-	-	
End-Point Tests: (Note 5)						
Collector-Base Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	1036 Condition D	I_{CBO}	-	10	nAdc	
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE}	20	200	-	
SUBGROUP 3						
Shock (1500 G, 0.5 ms, 5 blows each, Orientations X_1, Y_1, Y_2, Z_1; Total = 20 blows)	2016 Non-operating	-	-	-	-	10
Vibration, Variable Frequency	2056	-	-	-	-	
Vibration Fatigue (20 G)	2046 Non-operating	-	-	-	-	
Constant Acceleration (Centrifuge) (20,000 G, Orientations X_1, Y_1, Y_2, Z_1)	2006	-	-	-	-	
End-Point Tests:						
Same as Subgroup 2 (Note 5)						
SUBGROUP 4						
Lead Fatigue	2036 Condition E	-	-	-	-	15
End-Point Tests:						
Seal (Notes 5 and 7)			-	5×10^{-7}	atm cm^3/s	
SUBGROUP 5						
Salt Atmosphere (Corrosion) (Note 6)	1041	-	-	-	-	20
End-Point Tests:						
Same as Subgroup 2						
SUBGROUP 6						
High Temperature Life (Non-Operating) (T_{stg} = +200°C, min)	1031 Non-operating	-	-	-	-	λ = 15
End-Point Tests: (Note 5)						
Collector-Base Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	3036 Condition D	I_{CBO}	-	20	nAdc	
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE}		± 25% of Group A Limits	-	
SUBGROUP 7						
Steady State Operation Life (P_T = 200 mW, I_C = 20 mAdc, T_A = 25°C ± 3°C)	1026	-	-	-	-	λ = 15
End-Point Tests: (Note 5)						
Same as Subgroup 6						

TABLE III: CONDITIONING and SCREENING

Procedure	Symbol	Mil-Std-750 Method	Conditions	Limits
BURN-IN at rated Power for 96 hours	–	–	V_{CE} = 10 Vdc, T_A = 25°C	–
ELECTRICAL SCREENS After Burn-In				
DC Current Gain	Δh_{FE}	3076	I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc, Pulsed*	±20% Within Group A Limits
Changes in h_{FE} before and after Burn-In, measured at stated conditions.				
Collector-Base Cutoff Current	I_{CBO}	3036 Condition D	V_{CB} = 15 Vdc	Group A Limits
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	3071	I_C = 10 mA, I_B = 1.0 mA; Pulsed*	Group A Limits
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	3066 Condition A	I_C = 10 mA, I_B = 1.0 mA; Pulsed*	Group A Limits

* Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

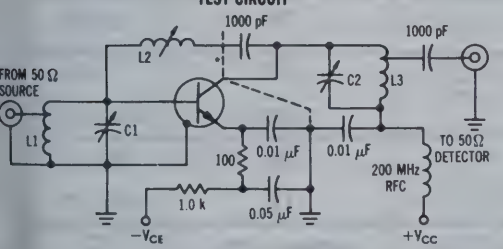
FIGURE 1 — NOISE FIGURE TEST BLOCK DIAGRAM



The test fixture shall consist of a 60 MHz tuned amplifier and suitable biasing circuits. It should be constructed utilizing good very-high-frequency design techniques.

The effective source susceptance should be tuned for each device being tested to obtain minimum noise figure. Note that because the HP 343A has a 50-ohm output resistance, a suitable impedance transformer must be used to obtain an effective source conductance of 2.5 mmho at the transistor with minimum losses.

FIGURE 2 — NEUTRALIZED 200 MHz POWER AMPLIFIER GAIN TEST CIRCUIT



NEUTRALIZATION PROCEDURE:

A — Connect 200 MHz signal generator (with 50 ohm output impedance) to input terminals of amplifier, and connect 50 ohm RF voltmeter to output terminals of amplifier.

B — Apply V_{EE} and V_{CC} to obtain specified test conditions.

C — Adjust output of signal generator to approximately 10 millivolts and tune C1 and C2 for maximum output.

D — Interchange connections to signal generator and RF voltmeter and with sufficient signal applied at output terminals, tune L2 for minimum indication on RF-voltmeter.

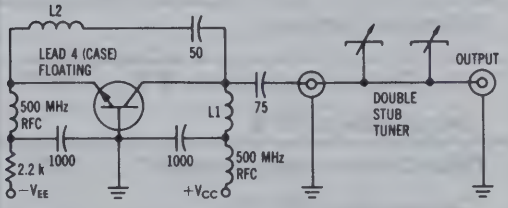
E — Repeat this sequence until optimum settings are obtained for all variables.

CIRCUIT COMPONENT INFORMATION:

C1: 3-12 pF
C2: 1.5-7.5 pF
L1: 3 1/2 turns #16 AWG 5/16" ID, 7/16" length, turns ratio — 2 to 1
L2: 0.4-0.65 μH Miller #4303 (or equal)
L3: 8 turns #16 AWG 1/8" ID, 7/8" length, turns ratio — 8 to 1

*External interlead shield to isolate collector lead from emitter and base leads.

FIGURE 3 — 500 MHz OSCILLATOR TEST CIRCUIT



OSCILLATOR ADJUSTMENT PROCEDURE:

Measurements of P_{out} shall be made in this circuit or a suitable equivalent. The circuit adjustment procedure is as follows:

A — Set V_{CC} and V_{EE} to obtain specified test conditions.

B — Adjust stub tuner to obtain maximum output at specified frequency of oscillation.

C — Check I_C and reset if necessary.

D — Read P_{out}.

Note: Collector efficiency (η), may be determined as follows:

$$\eta \text{ in } \% = \frac{P_{out} \times 100}{120}$$

Where P_{out} is in milliwatts.

CIRCUIT COMPONENT INFORMATION:

L1: 2 turns #16 AWG, 3/8" OD, 1 1/4" length
L2: 9 turns #22 AWG, 3/16" OD, 1/2" length

Capacitance values are in pF.

Double Stub Tuner consists of the following commercially available components.

2 GR Type 874 TEE
1 GR Type 874-D20 Adjustable Stub
1 GR Type 874-LA Adjustable Line
1 GR Type 874-WN3 Short-Circuit Termination
(or equivalents)

2N929, A (SILICON)
2N930, A



NPN silicon annular transistors for low-level, low-noise amplifier applications.

CASE 22
(TO-18)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N929 2N930	2N929A 2N930A	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CB}	45	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	Vdc
Collector Current	I_C	30		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 3.33		W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 12		Watt mW/°C
Operating Junction Temperature Range	T_J	-65to + 175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

2N929, A, 2N930, A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	45	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N929A, 2N930A	BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	2N929, 2N930 2N929A, 2N930A	BV_{EBO}	5.0 6.0	- -	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)		I_{CEO}	-	2.0	nAdc
Collector Cutoff Current (V_{CE} = 45 Vdc, V_{BE} = 0)	2N929, 2N930 2N929A, 2N930A	I_{CES}	- -	10 2.0	nAdc
(V_{CE} = 45 Vdc, V_{BE} = 0, T_A = 170°C)	2N929, 2N930 2N929A, 2N930A		- -	10 2.0	μAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	2N929, 2N930 2N929A, 2N930A	I_{CBO}	- -	10 2.0	nAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N929, 2N930 2N929A, 2N930A	I_{EBO}	- -	10 2.0	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)	2N929A 2N930A	h_{FE}	25 60	- -	-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N929, 2N929A 2N930, 2N930A		40 100	120 300	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	2N929 2N929A 2N930 2N930A		10 15 20 30	- - - -	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	2N929, 2N929A 2N930, 2N930A		60 150	- -	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N929, 2N929A 2N930, 2N930A		- -	350 600	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 0.5 mAdc)	2N929, 2N930 2N929A, 2N930A	$V_{CE(sat)}$*	- -	1.0 0.5	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 0.5 mAdc)	2N929, 2N930 2N929A, 2N930A	$V_{BE(sat)}$*	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)	2N929, 2N930 2N929A, 2N930A	f_T	30 45	- -	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	2N929, 2N930 2N929A, 2N930A	C_{ob}	- -	8.0 6.0	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	32	ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{rb}	-	600	X 10-6
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N929, 2N929A 2N930, 2N930A	h_{fe}	60 150	350 600	-
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	-	1.0	μmho
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz)	2N929, 2N929A 2N930, 2N930A	NF	- -	4.0 3.0	dB

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N956

For Specifications, See 2N718A Data.

2N960 (GERMANIUM)
2N961
2N962
2N964
2N965
2N966



CASE 22
(TO-18)

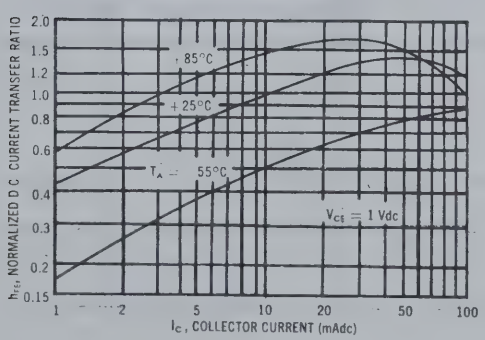
PNP germanium epitaxial mesa transistors for high-speed switching applications.

Collector connected to case

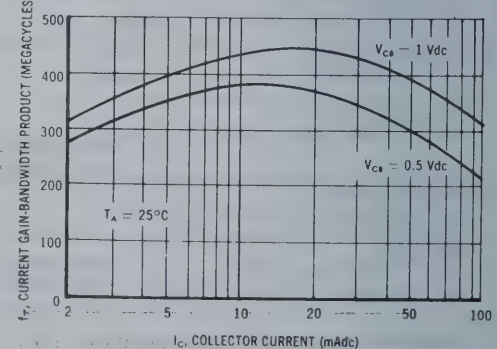
MAXIMUM RATINGS

Characteristic	Symbol	2N960 2N964	2N961 2N965	2N962 2N966	Unit
Collector-Emitter Voltage	V_{CE}	15	12	12	Vdc
Collector-Base Voltage	V_{CB}	15	12	12	Vdc
Emitter-Base Voltage	V_{EB}	2.5	2.0	1.25	Vdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2			mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4			mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100			^oC

NORMALIZED D C CURRENT TRANSFER RATIO
versus COLLECTOR CURRENT

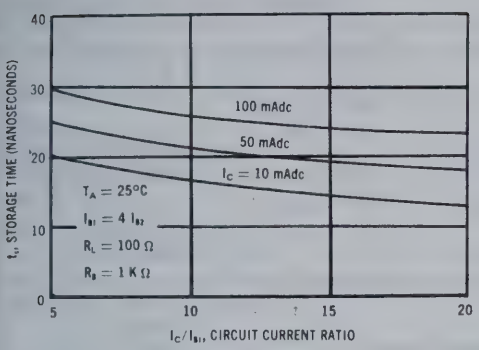


CURRENT GAIN-BANDWIDTH PRODUCT (f_T)
versus COLLECTOR CURRENT

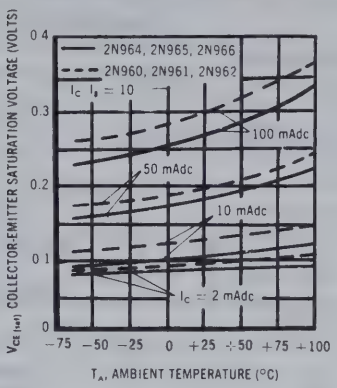


2N960 SERIES (continued)

STORAGE TIME versus CIRCUIT RATIO



COLLECTOR-EMITTER SATURATION VOLTAGE versus AMBIENT TEMPERATURE



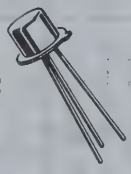
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N960, 2N964	BV_{CBO}	15	25	-	Vdc
	2N961, 2N962, 2N965, 2N966		12	20	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N960, 2N964	BV_{EBO}	2.5	-	-	Vdc
	2N961, 2N965		2.0	-	-	
	2N962, 2N966		1.25	-	-	
Collector-Latch-up Voltage V_{CC} = 11.5 Vdc		LV_{CEX}	11.5	-	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 15 Vdc)	2N960, 2N964	I_{CES}	-	-	100	μAdc
(V_{CE} = 12 Vdc)	2N961, 2N962, 2N965, 2N966		-	-	100	
Collector-Base Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	0.4	3	μAdc
DC Current Gain		h_{FE}				-
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	2N960, 2N961, 2N962		20	40	-	
	2N964, 2N965, 2N966		40	70	-	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N960, 2N961, 2N962		20	55	-	
	2N964, 2N965, 2N966		40	90	-	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N960, 2N961, 2N962		20	50	-	
	2N964, 2N965, 2N966		40	85	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	2N964, 2N965, 2N966		-	0.11	0.18	
	2N960, 2N961, 2N962		-	0.13	0.20	
(I_C = 50 mAdc, I_B = 5 mAdc)	2N964, 2N965, 2N966		-	0.18	0.35	
	2N960, 2N961, 2N962		-	0.20	0.40	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N964, 2N965, 2N966		-	0.27	0.60	
	2N960, 2N961, 2N962		-	0.30	0.70	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	All Types		0.30	0.40	0.50	
(I_C = 50 mAdc, I_B = 5 mAdc)	All Types		0.40	0.55	0.75	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N960, 2N961, 2N964, 2N965		0.40	0.65	1.00	
	2N962, 2N966		0.40	0.75	1.25	
Current-Gain – Bandwidth Product (I_E = 20 mAdc, V_{CB} = 1.0 Vdc, f = 100 MHz)		f_T	300	460	-	MHz

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max.	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	-	2.2	4	pF
Emitter Transition Capacitance (V_{EB} = 1 Vdc)		C_{Te}	-	2.0	3.5	pF
Turn-On Time (I_C = 10 mAdc, I_{B1} = 5 mAdc, $V_{BE(off)}$ = 1.25 Vdc)	All Types	t_{on}	-	35	50	ns
(I_C = 100 mAdc, I_{B1} = 5 mAdc, $V_{BE(off)}$ = 1.25 Vdc)			-	30	50	
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 1 mAdc, I_{B2} = 0.25 mAdc)		t_{off}				ns
	2N960, 2N961, 2N964, 2N965		-	60	85	
	2N962, 2N966		-	80	100	
(I_C = 100 mAdc, I_{B1} = 5 mAdc, I_{B2} = 1.25 mAdc)						
	2N960, 2N961, 2N964, 2N965		-	50	85	
	2N962, 2N966		-	60	100	
Rise Time Constant		τ_{RE}	-	0.6	-	ns
Hole Storage Factor		K'_s	-	16	-	ns
Fall Time Constant		τ_{FE}	-	0.5	-	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1 mAdc)	2N960, 2N961, 2N964, 2N965	Q_T	-	50	80	pC
	2N962, 2N966		-	60	90	
(I_C = 100 mAdc, I_B = 5 mAdc)	2N960, 2N961, 2N964, 2N965		-	80	125	
	2N962, 2N966		-	100	150	

2N963 (GERMANIUM)
2N967



CASE 22
(TO-18)

PNP germanium epitaxial mesa transistors for high-speed switching applications.

Collector connected to case

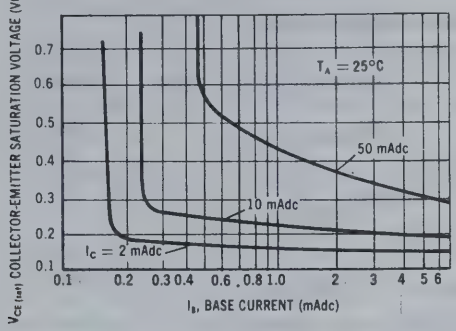
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Total Device Dissipation @ T_A = 25°C	P_D	150	mW
Derate above 25°C		2	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	300	mW
Derate above 25°C		4	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	100	°C

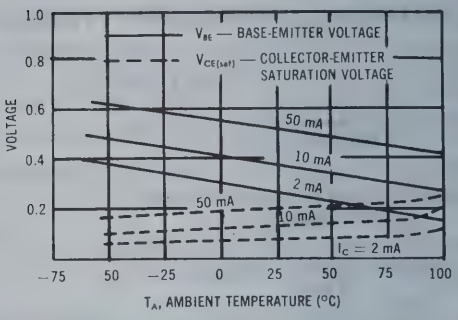
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	12	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	2	-	Vdc
Collector-Latch-up Voltage (V_{CC} = 10 Vdc)		LV_{CEX}	10	-	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, V_{BE} = 0)		I_{CES}	-	100	μAdc
Collector Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0.3 Vdc, T_A = 55°C)		I_{CEX}	-	20	μAdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	5	μAdc
Emitter Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)		I_{EBO}	-	1	mAdc
Base Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0.3 Vdc, T_A = 55°C)		I_{BL}	-	20	μAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	2N963 2N967	h_{FE}	20 40	- -	-
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc		$V_{CE(sat)}$	-	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	0.3	0.5	Vdc
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)		f_T	300	-	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	-	5	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	4	pF
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1 mAdc, $V_{BE(off)}$ = 1.25 Vdc)		t_{on}	-	60	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 1 mAdc, I_{B2} = 1.25 mAdc)		t_{off}	-	120	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1 mAdc)		Q_T	-	120	pC

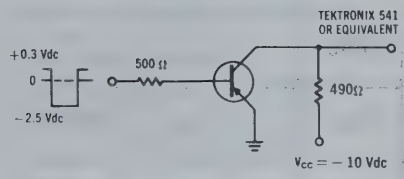
COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT



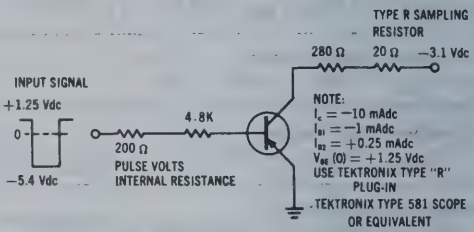
VOLTAGE versus TEMPERATURE CHARACTERISTICS



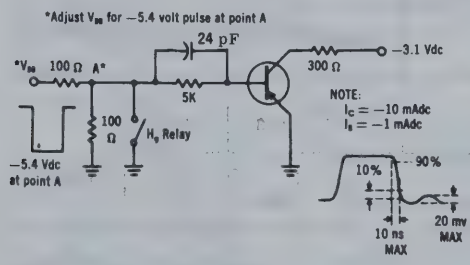
COLLECTOR LATCH-UP VOLTAGE TEST CIRCUIT



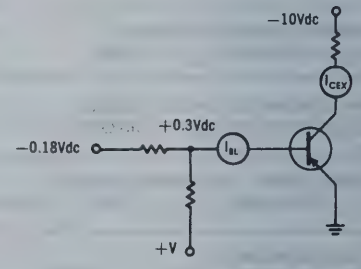
10-mA (I_C) SWITCHING TIME TEST CIRCUIT



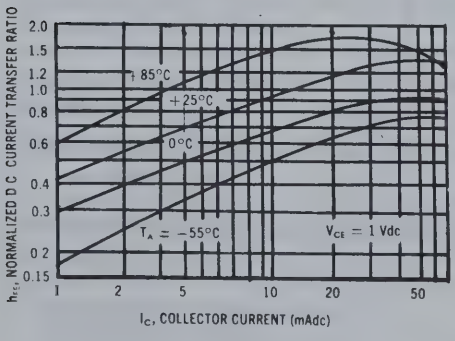
BASE AND COLLECTOR CUTOFF CURRENT TEST CIRCUIT



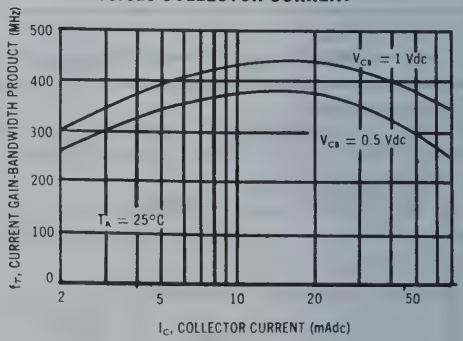
10-mA (I_C) TOTAL CONTROL CHARGE TEST CIRCUIT



NORMALIZED DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT



CURRENT GAIN-BANDWIDTH PRODUCT (f_T) versus COLLECTOR CURRENT



2N964 (GERMANIUM)

For Specifications, See 2N960 Data.

2N964A (GERMANIUM)



CASE 22
(TO-18)

PNP germanium epitaxial mesa transistor for high-speed switching applications.

Collector connected to case

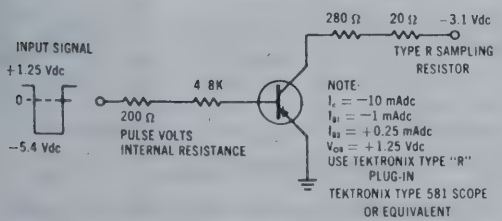
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	7	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

THERMAL CHARACTERISTICS

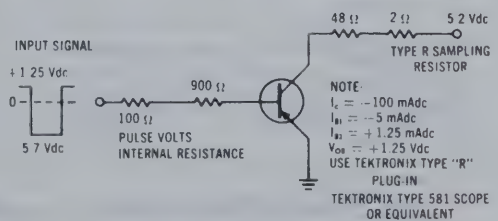
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.25	$^oC/mW$
Thermal Resistance, Case to Ambient	θ_{CA}	0.5	$^oC/mW$

FIGURE 1



10-mA (I_C) SWITCHING TIME TEST CIRCUIT

FIGURE 2



100-mA (I_C) SWITCHING TIME TEST CIRCUIT

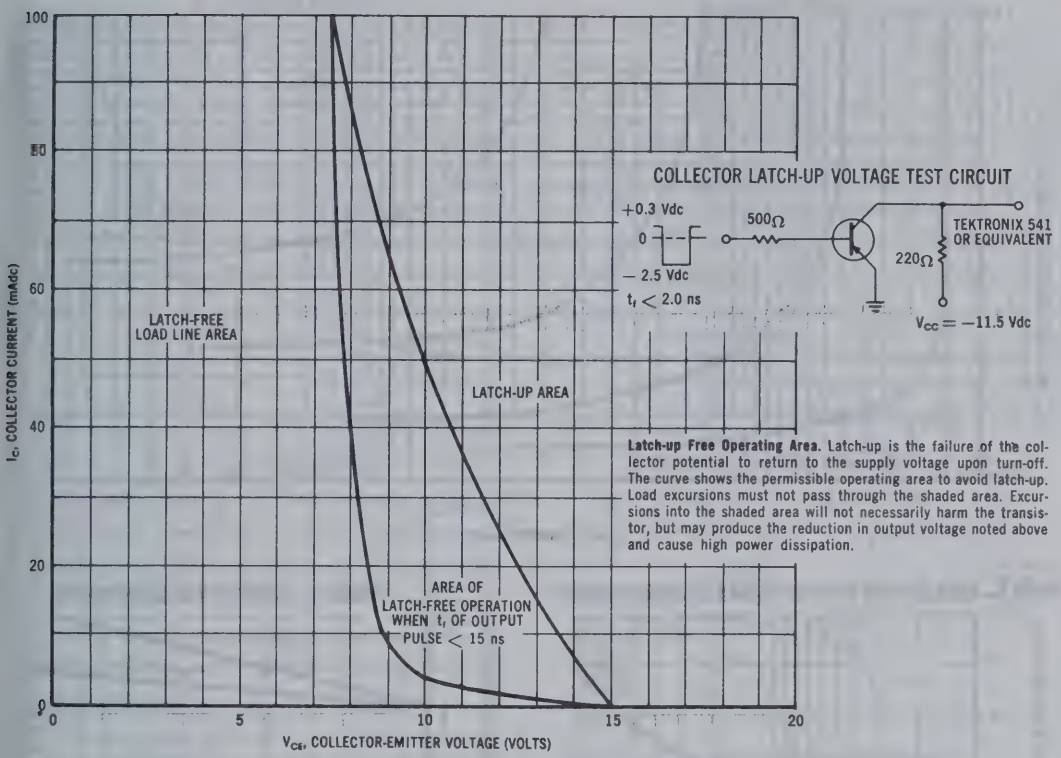
2N964A (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Fig.	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	7	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	15	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	2.5	- -	-	Vdc
Collector Latch-up Voltage	3	LV_{CEX}	11.5	-	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	-	-	100	μAdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	0.4	3	μAdc
Base Leakage Current (V_{CE} = 6 Vdc, $V_{BE(off)}$ = 0.5 Vdc)	4	I_{BL}	-	-	4	μAdc
(V_{CE} = 6 Vdc, $V_{BE(off)}$ = 0.5 Vdc, T_J = 85°C)			-	50	140	
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	8	h_{FE}	40	80	-	
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc, T_J = -55°C)			20	45	-	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)			48	105	-	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)			40	95	-	
(I_C = 100 mAdc, V_{CE} = 1 Vdc, T_J = 85°C)			35	85	-	
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	5	$V_{CE(sat)}$	-	0.1	0.18	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)			-	0.16	0.28	
(I_C = 100 mAdc, I_B = 10 mAdc)			-	0.22	0.4	
Base-Emitter Saturation Voltage	6	$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			0.3	0.38	0.44	
(I_C = 50 mAdc, I_B = 5 mAdc)			0.4	0.48	0.58	
(I_C = 100 mAdc, I_B = 10 mAdc)			0.4	0.6	0.72	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_E = 20 mAdc, V_{CB} = 1 Vdc, f = 100 MHz)		f_T	300	460	-	MHz
High-Frequency Current Gain (I_C = 20 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)		h_{fe}	3.0	4.6	-	-
Output Capacitance (V_{CB} = 1 Vdc, I_E = 0, f = 1 MHz)	11	C_{ob}	-	2.7	5	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)			-	2.2	4	
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kHz)	11	C_{ib}	-	2	3.5	pF
Delay Time Plus Rise Time (I_C = 10 mAdc)	1	$t_d + t_r$	-	35	50	ns
(I_C = 100 mAdc)	2		-	30	50	
Storage Time Plus Fall Time (I_C = 10 mAdc)	1	$t_s + t_f$	-	60	85	ns
(I_C = 100 mAdc)	2		-	50	85	
Active Region Time Constant (I_C = 10 mAdc)	9	τ_A	-	0.6	1.5	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1 mAdc)	10	Q_T	-	50	75	pC

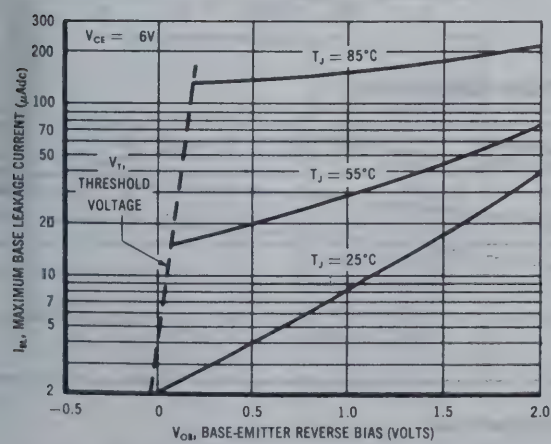
2N964A LIMIT CURVES

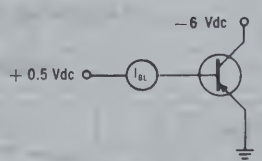
FIGURE 3—AREA OF PERMISSIBLE LOAD LOCI



Latch-up Free Operating Area. Latch-up is the failure of the collector potential to return to the supply voltage upon turn-off. The curve shows the permissible operating area to avoid latch-up. Load excursions must not pass through the shaded area. Excursions into the shaded area will not necessarily harm the transistor, but may produce the reduction in output voltage noted above and cause high power dissipation.

FIGURE 4—COMMON EMITTER DC LEAKAGE CHARACTERISTICS





BASE LEAKAGE CURRENT TEST CIRCUIT

Base Leakage Current. I_{BL} is defined as base leakage current with both junctions reverse biased. I_c is always less than I_{BL} for $V_{OB} > V_T$. (V_{OB} is off condition base bias, V_T is base voltage at threshold of conduction.)

NOTE: Limit Curves are based on periodic engineering evaluation. Production Tests are made at points indicated in the Electrical Characteristics Table.

2N964A LIMIT CURVES

FIGURE 5—COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT



FIGURE 6—BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

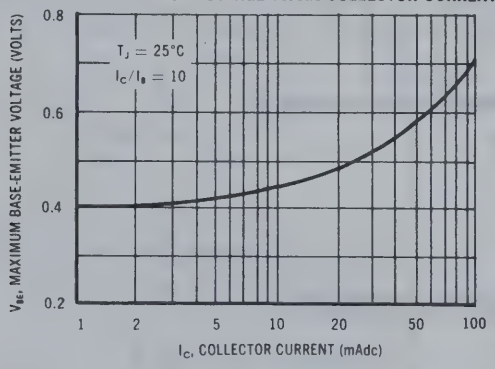


FIGURE 7—TEMPERATURE CO-EFFICIENTS

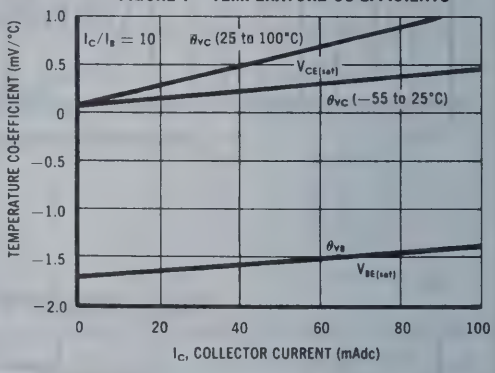
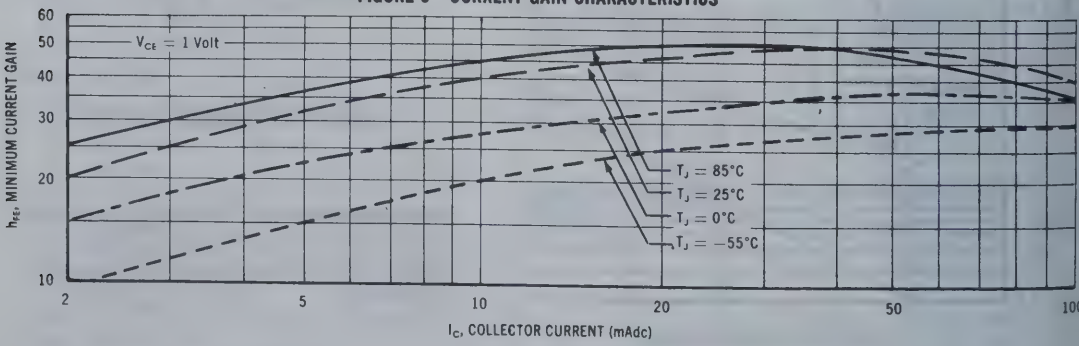


FIGURE 8—CURRENT GAIN CHARACTERISTICS

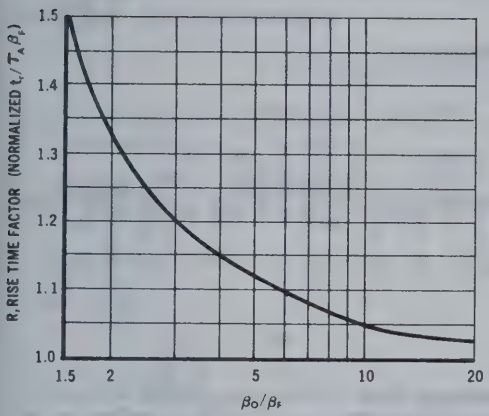


NOTE: Limit Curves are based on periodic engineering evaluation. Production Tests are made at points indicated in the Electrical Characteristics Table.

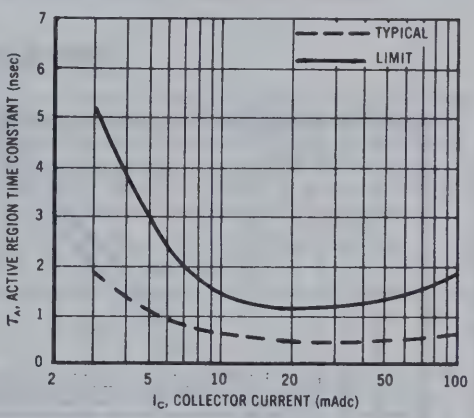
2N964A LIMIT CURVES

FIGURE 9—SWITCHING TIME CURVES FOR RESISTOR COUPLED CIRCUITS

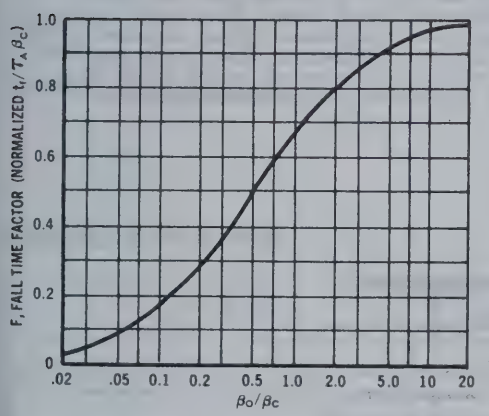
9a—RISE TIME FACTOR



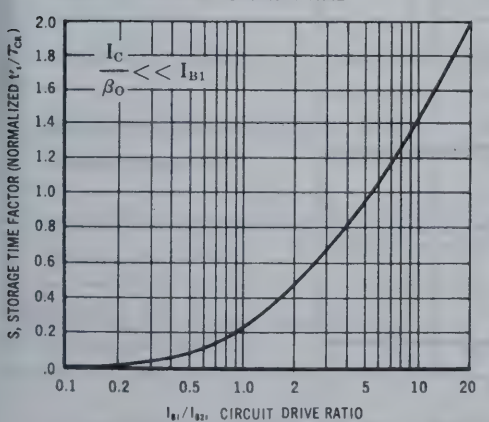
9b—ACTIVE REGION TIME CONSTANT



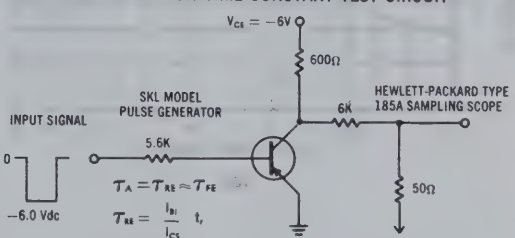
9c— FALL TIME FACTOR



9d—STORAGE TIME



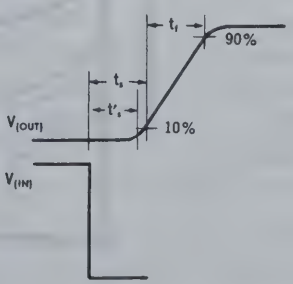
ACTIVE REGION TIME CONSTANT TEST CIRCUIT



SWITCHING TIME EQUATIONS

RISE-TIME $= t_r = \tau_A\beta_F R$
FALL-TIME $= t_f = \tau_A\beta_C F$
STORAGE TIME $= t'_s = \tau_{CR} S$
t_r = 10 to 90% rise-time
t_f = 10 to 90% fall-time
$t_s = t'_s + \frac{1}{2} t_f$
τ_{CR} = the effective collector recovery time and is virtually uninfluenced by current levels. 20 ns typical and 60 ns maximum for this transistor.

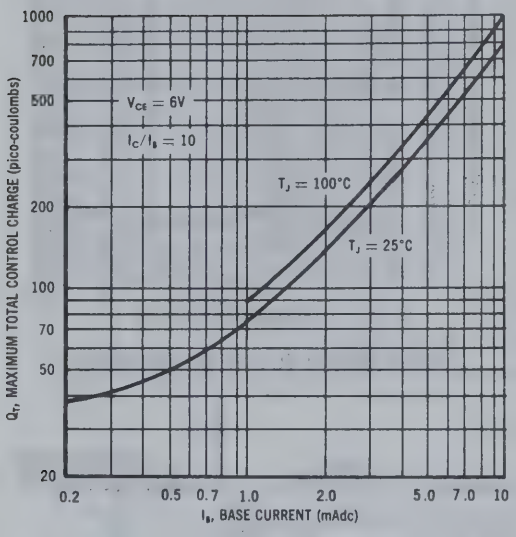
τ_A = active region time constant
$\tau_A = \tau_{RE} \approx \tau_{FE}$ (Figure 9b)
$\beta_O = h_{FE}$ at edge of saturation ($\beta_O \approx h_{FE}$ on Figure 8)
$\beta_F = I_C$ in saturation/I_{B1} (base "on" current)
$\beta_C = I_C$ in saturation/I_{B2} (base "off" current)
R see Figure 9a
F see Figure 9c
S see Figure 9d



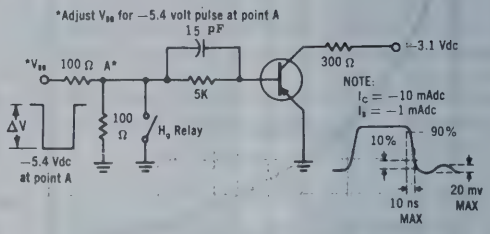
NOTE: Limit Curves are based on periodic engineering evaluation. Production Tests are made at points indicated in the Electrical Characteristics Table.

2N964A LIMIT CURVES

FIGURE 10—TOTAL CONTROL CHARGE



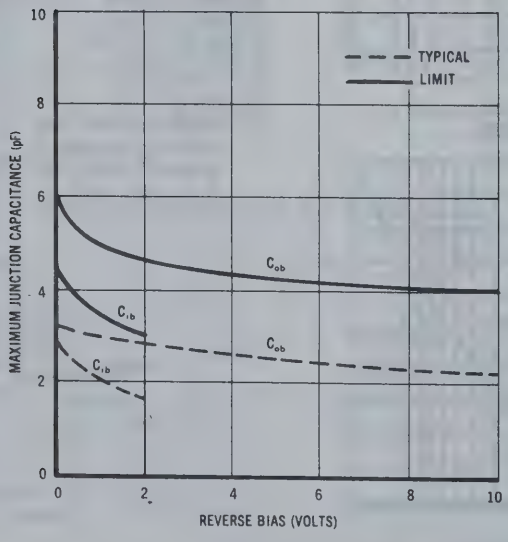
10a



10b

Total Control Charge. When a transistor is held in a conductive state by a current, I_{B1}, a charge Q_S is developed in the active region. A charge Q_T of opposite polarity, equal in magnitude, can be stored on an external capacitor C to neutralize the internal charge and considerably reduce the turn-off time of the transistor. Figure 10b shows the test circuit and turn-off waveform. Given Q_T from Figure 10a, the external C for worst case turn-off in any circuit is: $C = Q_T/\Delta V$, where ΔV is defined in Figure 10b.

FIGURE 11— JUNCTION CAPACITANCE VARIATIONS



NOTE: Limit Curves are based on periodic engineering evaluation. Production Tests are made at points indicated in the Electrical Characteristics Table.

2N965 (GERMANIUM)
2N966

For Specifications, See 2N960 Data.

2N967 (GERMANIUM)

For Specifications, See 2N963 Data.

2N968 thru 2N975 (GERMANIUM)



CASE 22
(TO-18)

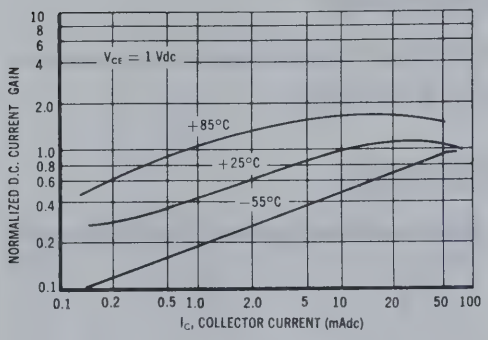
Collector connected to case

PNP germanium mesa transistors for high-speed switching applications.

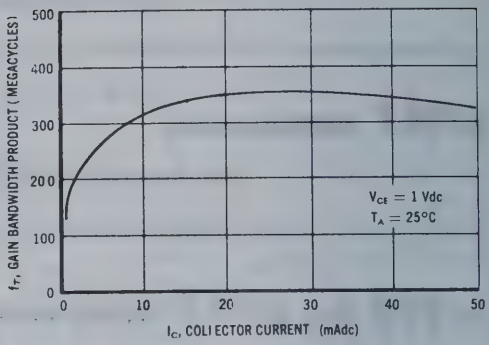
MAXIMUM RATINGS

Rating	Symbol	2N968 2N972	2N969 2N973	2N970 2N974	2N971 2N975	Unit
Collector-Emitter Voltage	V_{CES}	15	12	12	7	Vdc
Collector-Base Voltage	V_{CB}	15	12	12	7	Vdc
Emitter-Base Voltage	V_{EB}	2.5	2.0	1.25	1.25	Vdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2				mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4				mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100				^oC

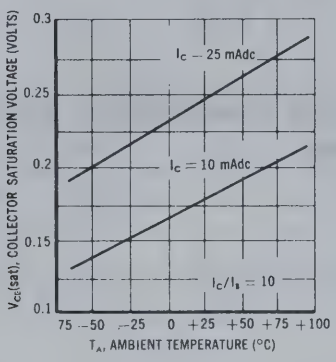
NORMALIZED D.C. CURRENT GAIN versus COLLECTOR CURRENT



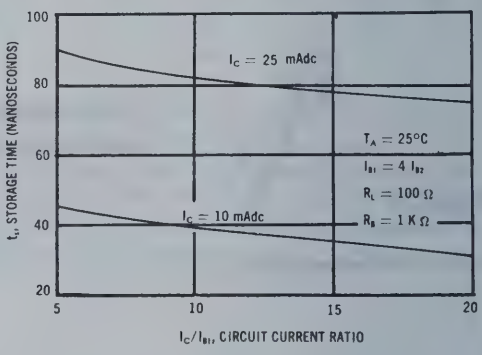
CURRENT GAIN-BANDWIDTH PRODUCT (f_T) versus COLLECTOR CURRENT



COLLECTOR SATURATION VOLTAGE versus AMBIENT TEMPERATURE



STORAGE TIME versus CIRCUIT CURRENT RATIO



ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N968, 2N972	BV_{CBO}	15	25	-	Vdc
	2N969, 2N970, 2N973, 2N974		12	20	-	
	2N971, 2N975		7	15	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N968, 2N972	BV_{EBO}	2.5	-	-	Vdc
	2N969, 2N973		2.0	-	-	
	2N970, 2N974		1.25	-	-	
	2N971, 2N975		1.25	-	-	
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	2N968, 2N972	I_{CES}	-	-	100	μAdc
(V_{CE} = 12 Vdc, V_{BE} = 0)	2N969, 2N970, 2N973, 2N974		-	-	100	
(V_{CE} = 7 Vdc, V_{BE} = 0)	2N971, 2N975		-	-	100	
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}				μAdc
	2N968, 2N969, 2N970,		-	-	3	
	2N972, 2N973, 2N974		-	-	3	
	2N971, 2N975		-	-	10	

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc)	2N968, 2N969, 2N970, 2N971		17	35	-	
	2N972, 2N973, 2N974, 2N975		40	75	-	
(I_C = 25 mAdc, V_{CE} = 0.7 Vdc)	2N968, 2N969, 2N970, 2N971		20	40	-	
	2N972, 2N973, 2N974, 2N975		40	85	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			-	0.19	0.25	
(I_C = 25 mAdc, I_B = 1.5 mAdc)			-	0.25	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	2N968, 2N969, 2N972, 2N973		0.30	0.39	0.55	
	2N970, 2N971, 2N974, 2N975		0.30	0.43	0.65	
(I_C = 25 mAdc, I_B = 1.5 mAdc)	2N968, 2N969, 2N972, 2N973		-	0.45	0.80	
	2N970, 2N971, 2N974, 2N975		-	0.60	1.0	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_E = 10 mAdc, V_{CB} = 1 Vdc, f = MHz)		f_T	250	320	-	MHz
Collector Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	-	4.0	9.0	pF
Emitter Transition Capacitance (V_{EB} = 1 Vdc, I_C = 0)		C_{Te}	-	3.5	-	pF
Turn-On Time ($V_{BE(off)}$ = 1.25 Vdc, I_C = 10 mAdc, I_{B1} = 1 mA)		t_{on}				ns
	2N968, 2N969, 2N972, 2N973		-	50	75	
	2N970, 2N971, 2N974, 2N975		-	65	100	
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 1 mAdc, I_{B2} = 0.25 mAdc)		t_{off}				ns
	2N968, 2N969		-	70	150	
	2N972, 2N973		-	75	175	
	2N970, 2N971, 2N974, 2N975		-	100	275	
Total Control Charge		Q_T				pC
(I_C = 10 mAdc, I_B = 1 mAdc)	2N968, 2N969, 2N972, 2N973		-	75	100	
	2N970, 2N971, 2N974, 2N975		-	80	150	
(I_C = 25 mAdc, I_B = 1.5 mAdc)	2N968, 2N969, 2N972, 2N973		-	90	175	
	2N970, 2N971, 2N974, 2N975		-	175	300	

2N978 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose amplifier applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 20 Vdc (Min) @ I_C = 100 mAdc

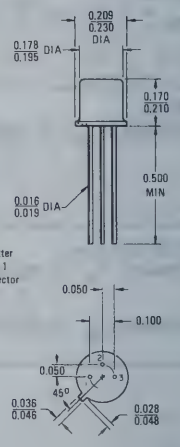
PNP SILICON AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltate	V_{EB}	5.0	Vdc
Collector Current	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.33 2.64	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.25 10	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to + 200	°C

*Indicates JEDEC Registered Data.



Collector Connected to Case
CASE 22 (1)
(TO-18)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	5.0	μAdc
(V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)		–	200	
Emitter Cutoff Current (V_{EB} = 1.0 Vdc, I_C = 0)	I_{EBO}	–	200	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	15	–	–
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		15	60	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	45	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	h_{fe}	2.0	–	–

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

2N985 (GERMANIUM)



PNP germanium epitaxial mesa transistor for high-speed switching applications.

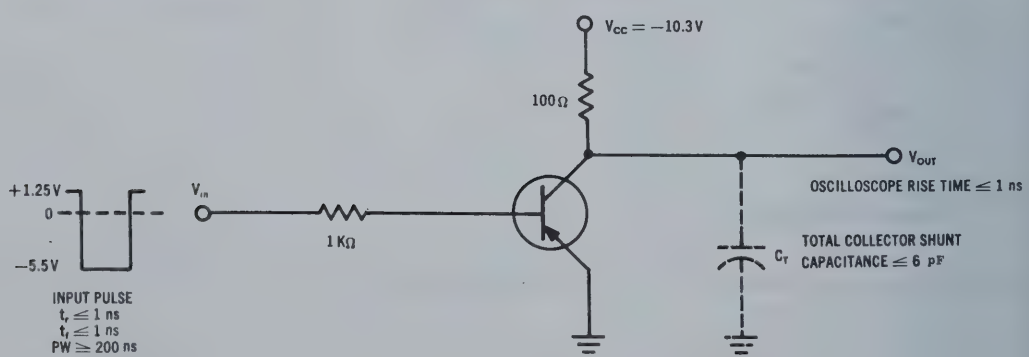
CASE 22
(TO-18)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	7	Vdc
Emitter-Base Voltage	V_{EB}	3	Vdc
Collector Current	I_C	200	mAdc
Junction Temperature	T_J	100	^oC
Storage Temperature	T_{stg}	-65 to +100	^oC
Device Dissipation @ $T_C = 25^oC$ Derate above 25°C	P_D	300 4	mW $mW/^oC$
Device Dissipation @ $T_A = 25^oC$ Derate above 25°C	P_D	150 2	mW $mW/^oC$

SWITCHING TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5 mAdc, I_B = 0)	BV_{CEO}	7	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, R_{BE} = 0)	BV_{CES}	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3	—	Vdc
Collector Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)	I_{CBO}	—	3	μAdc
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)	I_{EBO}	—	100	μAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.25 Vdc)	h_{FE}	40	—	—
(I_C = 100 mAdc, V_{CE} = 0.5 Vdc)		60	—	
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	0.15	Vdc
(I_C = 100 mAdc, I_B = 5 mAdc)		—	0.30	
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	V_{BE}	0.28	0.40	Vdc
(I_C = 100 mAdc, I_B = 5 mAdc)		0.40	0.60	
Small Signal Current Gain (V_{CE} = 2 Vdc, I_C = 30 mAdc, f = 100 MHz)	$\|h_{fe}\|$	3.0	—	—
Collector Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	6	pF
Turn-on Time (I_C = 10 mAdc, I_{B1} = 5 mAdc, $V_{BE(0)}$ = 1.25 Vdc)	t_{on}	—	35	ns
Turn-off Time (I_C = 10 mAdc, I_{B1} = 5 mAdc, I_{B2} = 1.25 mA)	t_{off}	—	80	ns

2N995 (SILICON)

For Specifications, See 2N869 Data.

2N996 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose amplifier applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 12 Vdc (Min) @ I_C = 10 mAdc
- Collector-Base Breakdown Voltage —
  BV_{CBO} = 15 Vdc (Min) @ I_C = 10 μAdc
- Emitter-Base Breakdown Voltage —
  BV_{EBO} = 4.0 Vdc (Min) @ I_E = 10 μAdc

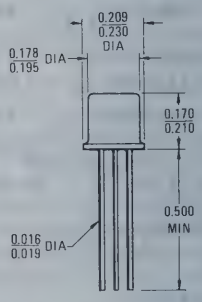
PNP SILICON TRANSISTOR

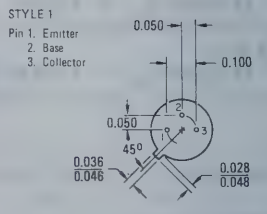


*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.86	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.





Collector Connected to Case
CASE 22(1)
(TO-18)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current	I_{CBO}			
(V_{CB} = 10 Vdc, I_E = 0)		–	5.0	nAdc
(V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)		–	15	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 20 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	35	–	–
Collector-Emitter Saturation Voltage (I_C = 60 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	–	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	–	0.95	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz to 1.0 MHz)	C_{ob}	–	10	pF

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

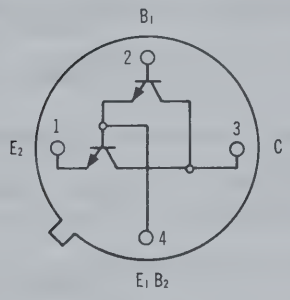
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N998 (SILICON)
2N999



CASE 20(8)
(TO-72)

Darlington amplifiers containing two NPN silicon annular transistors are designed for applications requiring very high-gain, low-noise, and high-input impedance.



MAXIMUM RATINGS

Rating	Symbol	2N998	2N999	Unit
Collector-Emitter Voltage	V_{CEO}	60	60	Vdc
Collector-Base Voltage	V_{CB}	100	60	Vdc
Emitter-Base Voltage	V_{EB}	15		Vdc
Collector Current	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.5 2.86		Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.8 10.3		Watts $mW/^oC$
Operating Junction Temperature	T_J	+200		^oC
Storage Temperature Range	T_{stg}	-65 to +200		^oC

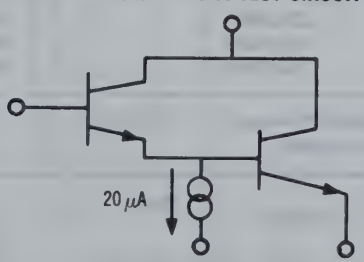
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N998	BV_{CBO}	100	—	Vdc
	2N999		60		
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	15	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0)	2N998	I_{CBO}	—	0.01	μAdc
(V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)	2N998		—	15	
(V_{CB} = 60 Vdc, I_E = 0)	2N999		—	0.01	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	2N999		—	10	
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N998	h_{FE}*	800	—	—
(I_C = 10 mAdc, V_{CE} = 5 Vdc)	2N998		1,600	8,000	
(I_C = 100 mAdc, V_{CE} = 5 Vdc)	2N998		2,000	—	
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N999		1,000	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N999		4,000	—	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	2N999		7,000	70,000	
(I_C = 100 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N999		1,000	—	
(I_C = 10 mAdc, V_{CE} = 5 Vdc, measured across each transistor within the device)	2N998		25	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, measured across each transistor within the device)	2N999		25	—	
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	2N998	C_{ob}	—	30	pF
	2N999		—	20	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	2N998	C_{ib}	—	50	pF
	2N999		—	10	
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	2N998	h_{fe}	1,000	—	—
Noise Figure** (I_C = 0.1 mAdc, V_{CE} = 10 Vdc, R_S = 5 kohms, f = 1 kHz, Bandwidth = 200 Hz)	2N998	NF**	—	6	dB

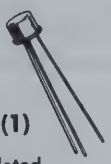
*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1%

**Measured with constant current supply of 20 μAdc connected to the emitter of the input transistor. (See Figure 1)

FIGURE 1 — NOISE FIGURE TEST CIRCUIT



2N1008, A, B (GERMANIUM)



CASE 31(1)
(TO-5)
All leads isolated

PNP germanium transistor for audio driver and medium speed switching applications.

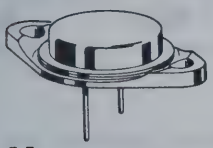
MAXIMUM RATINGS

Rating	Symbol	2N1008	2N1008A	2N1008B	Unit
Collector-Base Voltage	V_{CB}	20	40	60	Volts
Collector-Emitter Voltage	V_{CEO}	20	40	60	Volts
Emitter-Base Voltage	V_{EB}	15			Volts
Collector Current	I_C	300			mAdc
Base Current	I_B	30			mAdc
Collector Dissipation T_A = 25°C derate T_C = 25°C derate	P_D	200 2.78 300 4.0			mW mW/°C mW mW/°C
Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +100			°C

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	UNIT
Collector Leakage Current	I_{CBO}				μAdc
(V_{CB} = 10 Vdc) 2N1008		---	5.0	10	
(V_{CB} = 10 Vdc, T_A = 85°C) 2N1008		---	---	500	
(V_{CB} = 25 Vdc) 2N1008A		---	5.0	10	
(V_{CB} = 25 Vdc, T_A = 85°C) 2N1008A		---	---	500	
(V_{CB} = 45 Vdc) 2N1008B		---	7.0	15	
(V_{CB} = 45 Vdc, T_A = 85°C) 2N1008B		---	---	750	
Emitter Leakage Current	I_{EBO}				μAdc
(V_{EB} = 10 Vdc) 2N1008		---	5.0	10	
2N1008A		---	---	10	
2N1008B		---	---	10	
Collector-Emitter Breakdown Voltage	BV_{CER}				Vdc
(I_C = 1.0 mAdc, R_{BE} = 10 K)					
2N1008		15	---	---	
2N1008A		35	---	---	
2N1008B		55	---	---	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	V_{CE} (sat)	---	---	0.25	Vdc
Small Signal Current Gain (I_C = -10 mAdc, V_{CE} = 5.0 Vdc, f = 1 kHz)	h_{fe}	40	---	150	---
Input Resistance (V_{CB} = 6 V, I_E = 1 mA)	h_{ie}	200	---	1000	ohms

2N1011 (GERMANIUM)



CASE 11
(TO-3)

PNP germanium power transistor for general purpose power amplifier and switching applications in military and industrial equipment. Operating temperature range and power dissipation exceed military specifications.

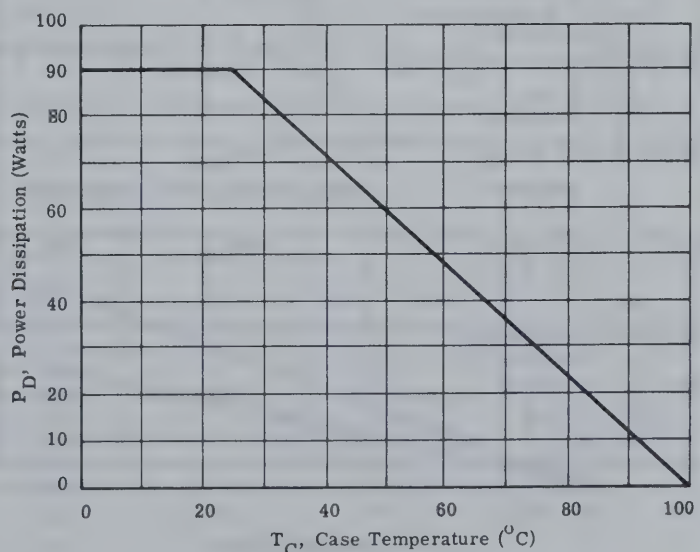
MAXIMUM RATINGS

Rating	Symbol	2N1011	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	80	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
Collector Current	I_C	5.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	90 1.2	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^oC/W$

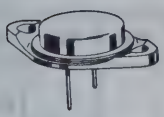
POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
DC Current Transfer Ratio V_{CE} = 2 V I_C = 1.0 Adc	h_{FE}	—	150	—
DC Current Transfer Ratio V_{CE} = 2 V I_C = 3.0 Adc	h_{FE}	30	75	—
Small-Signal Current Transfer Ratio Cutoff Frequency V_{CE} = 2 Vdc I_C = 3 Amp	$f_{\alpha e}$	5.0	—	kHz
Emitter-Base Cutoff Current V_{EB} = 40 Vdc I_C = 0	I_{EBO}	—	3.0	mAdc
Collector-Base Cutoff Current V_{CB} = 2 Vdc I_E = 0	I_{CBO}	—	200	μAdc
Collector-Base Cutoff Current V_{CB} = 80 Vdc I_E = 0	I_{CBO}	—	15.0	mAdc
Base Current V_{CE} = 2 Vdc I_C = 1 Adc	I_B	6.7	—	mAdc
Base Current V_{CE} = 2 Vdc I_C = 3 Adc	I_B	40	100	mAdc
Emitter-Base Voltage V_{CE} = 2 Vdc I_C = 3 Adc	V_{EB}	—	2.0	Vdc
Floating Potential V_{CB} = 50 Vdc (Voltmeter input resistance = 10 Megohm min)	V_{fl}	—	1.0	Vdc
Collector-Emitter Saturation Voltage I_C = 3 Adc I_B = 200 mAdc	$V_{CE(SAT)}$	—	1.5	Vdc
Collector-Emitter Voltage I_C = 300 mAdc I_B = 0	BV_{CEO}	40	—	Vdc
Collector-Emitter Voltage I_C = 300 mAdc V_{EB} = 0	BV_{CES}	80	—	Vdc
High-Temperature Operation T_C = +90°C min Collector Cutoff Current V_{CB} = 30 Vdc I_E = 0	I_{CBO}	—	20	mAdc

2N1021 (GERMANIUM)
2N1022



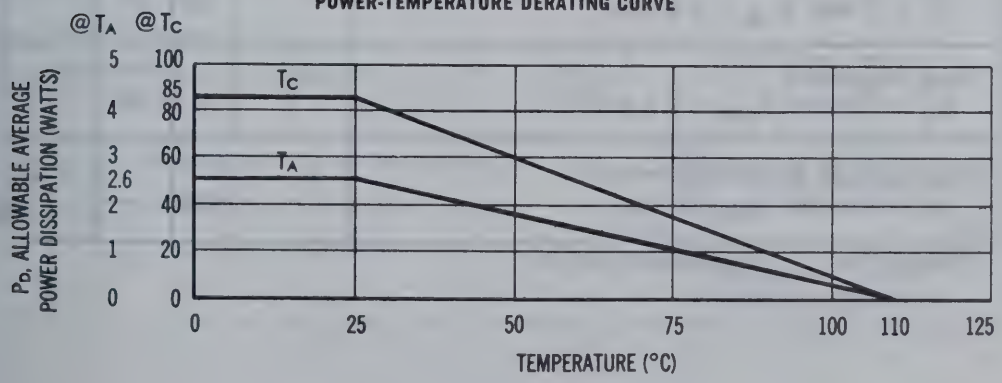
CASE 11
(TO-3)

PNP germanium power transistors for industrial and general purpose power amplifier and switching applications.

MAXIMUM RATINGS ($T_C = 25°C$ unless otherwise noted)

Rating	Symbol	2N1021	2N1022	Unit
Collector-Base Voltage	V_{CB}	100	120	Volts
Collector-Emitter Voltage	V_{CEX}	100	120	Volts
Collector-Emitter Voltage	V_{CEO}	50		Volts
Emitter-Base Voltage	V_{EB}	30		Volts
Collector Current	I_C	5.0		Amp
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +110		°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	85 1.0		Watts W/°C

POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 50 Vdc)	2N1021		—	0.5	
(V_{CB} = 60 Vdc)	2N1022		—	0.5	
(V_{CB} = 100 Vdc)	2N1021		—	2.0	
(V_{CB} = 120 Vdc)	2N1022		—	2.0	
(V_{CB} = 50 Vdc, T_C = +55°C)	2N1021		—	8.0	
(V_{CB} = 60 Vdc, T_C = +55°C)	2N1022		—	8.0	
Collector-Emitter Breakdown Voltage* (I_C = 200 mAdc)		BV_{CEO}*	50	—	Vdc
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = 10 Vdc)			—	0.5	
(V_{EB} = 30 Vdc)			—	2.0	
Base-Emitter Voltage (V_{CE} = -1.5 Vdc, I_C = 1.0 Adc)		V_{BE}	—	3.0	Vdc
Collector-Emitter Saturation Voltage (I_C = 5 Adc, I_B = 500 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
DC Current Gain		h_{FE}			—
(I_C = 1 Adc, V_{CE} = 1.5 Vdc)			40	—	
(I_C = 3 Adc, V_{CE} = 1.5 Vdc)			35	—	
(I_C = 5 Adc, V_{CE} = 1.5 Vdc)			30	90	
(I_C = 7 Adc, V_{CE} = 1.5 Vdc)			22	—	
Input Impedance (I_C = 1.0 Adc, V_{CE} = 1.5 Vdc)		h_{ie}	—	28	ohms
Current Gain-Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 2 Vdc)		f_T	200	—	kHz

*Sweep Test: 1/2 sine wave, 60 Hz .

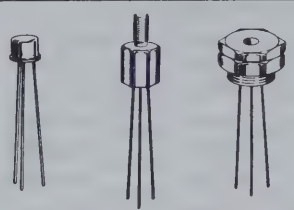
2N1038 thru 2N1041 (GERMANIUM)
2N2552 thru 2N2559

PNP GERMANIUM MEDIUM POWER TRANSISTORS

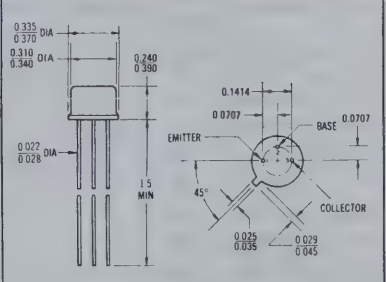
. . . designed for relay drivers, pulse amplifiers, audio amplifiers and high-current switching applications.

- High Current Capability — I_C = 3.0 Amperes
- Guaranteed Excellent Collector-Emitter Sustaining Voltage
- 20-Watt Power Dissipation at 25°C Case Temperature
- 100°C Maximum Junction Temperature

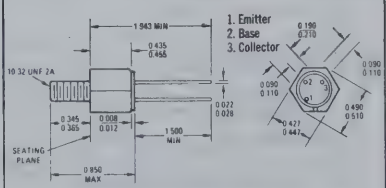
PNP GERMANIUM POWER TRANSISTORS
40–100 VOLTS
20 WATTS



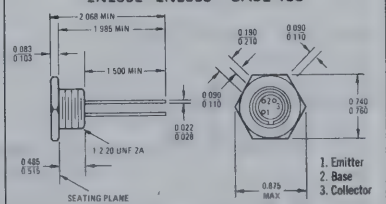
CASE 180 CASE 183 CASE 184



2N1038–2N1041 CASE 180



2N2552–2N2555 CASE 183



2N2556–2N2559 CASE 184
Collector Connected to Case
(All Types)

MAXIMUM RATINGS

Rating	Symbol	2N1038 2N2552 2N2556	2N1039 2N2553 2N2557	2N1040 2N2554 2N2558	2N1041 2N2555 2N2559	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	20				Vdc
Collector Current — Continuous	I_C	3.0				Adc
Base Current — Continuous	I_B	1.0				Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	450 6.0				mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C (Note 1)	P_D	20 0.267				Watts W/°C
**Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +100				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.75	°C/W

*Indicates JEDEC Registered Data.

Note 1: Case Temperature shall be measured 0.100 ± 0.010 inches above the seating plane.

**Motorola guarantees this data in addition to the JEDEC Registered Data shown.

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	2N1038, 2N2552, 2N2556	$V_{CEO(sus)}$	30	-	Vdc
	2N1039, 2N2553, 2N2557		40	-	
	2N1040, 2N2554, 2N2558		50	-	
	2N1041, 2N2555, 2N2559		60	-	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 15 Vdc, I_B = 0)	2N1038, 2N2552, 2N2556		-	25	
(V_{CE} = 20 Vdc, I_B = 0)	2N1039, 2N2553, 2N2557		-	20	
(V_{CE} = 25 Vdc, I_B = 0)	2N1040, 2N2554, 2N2558		-	20	
(V_{CE} = 30 Vdc, I_B = 0)	2N1041, 2N2555, 2N2559		-	20	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1038, 2N2552, 2N2556		-	0.65	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1039, 2N2553, 2N2557		-	0.65	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1040, 2N2554, 2N2558		-	0.65	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1041, 2N2555, 2N2559		-	0.65	
(V_{CE} = 20 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1038, 2N2552, 2N2556		-	5.0	
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1039, 2N2553, 2N2557		-	5.0	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1040, 2N2554, 2N2558		-	5.0	
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1041, 2N2555, 2N2559		-	5.0	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 20 Vdc, I_E = 0)	2N1038, 2N2552, 2N2556		-	125	
(V_{CB} = 30 Vdc, I_E = 0)	2N1039, 2N2553, 2N2557		-	125	
(V_{CB} = 40 Vdc, I_E = 0)	2N1040, 2N2554, 2N2558		-	125	
(V_{CB} = 50 Vdc, I_E = 0)	2N1041, 2N2555, 2N2559		-	125	
**(V_{CB} = 40 Vdc, I_E = 0)	2N1038, 2N2552, 2N2556		-	750	
**(V_{CB} = 60 Vdc, I_E = 0)	2N1039, 2N2553, 2N2557		-	750	
**(V_{CB} = 80 Vdc, I_E = 0)	2N1040, 2N2554, 2N2558		-	750	
**(V_{CB} = 100 Vdc, I_E = 0)	2N1041, 2N2555, 2N2559		-	750	
Emitter Cutoff Current (V_{BE} = 20 Vdc, I_C = 0)		I_{EBO}	-	650	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 50 mAdc, V_{CE} = 0.5 Vdc)			33	200	
(I_C = 1.0 Adc, V_{CE} = 0.5 Vdc)			20	60	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Input Voltage (I_C = 1.0 Adc, V_{CE} = 0.5 Vdc)		V_{BE}	-	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 1.5 Vdc, f = 1.0 kHz)		h_{fe}	18	72	-
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 1.5 Vdc, f = 112.5 kHz)		$\lvert h_{fe} \rvert$	2.0	-	-

*Indicates JEDEC Registered Data.
**Motorola Guarantees this data in addition to the JEDEC Registered Data Shown.

2N1042 thru 2N1045 (GERMANIUM)
2N2560 thru 2N2567

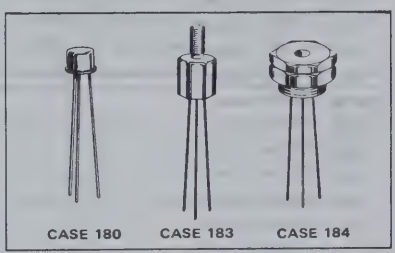
PNP GERMANIUM MEDIUM POWER TRANSISTORS

. . . designed for relay drivers, pulse amplifiers, audio amplifiers and high-current switching applications.

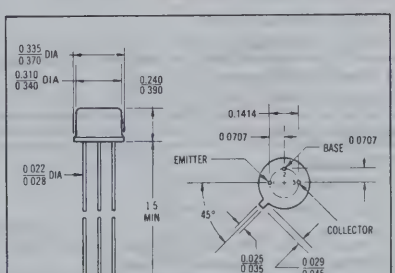
- High Current Capability — I_C = 3.5 Amperes
- Guaranteed Excellent Collector-Emitter Sustaining Voltage
- 20-Watt Power Dissipation at 25°C Case Temperature
- 100°C Maximum Junction Temperature

PNP GERMANIUM POWER TRANSISTORS

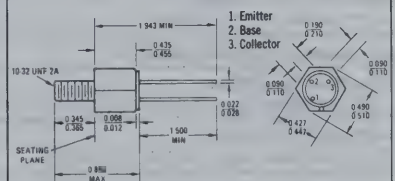
40–100 VOLTS
20 WATTS



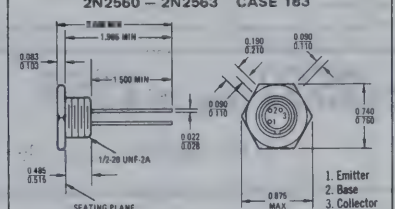
CASE 180 CASE 183 CASE 184



2N2564 – 2N2567 CASE 180



2N2560 – 2N2563 CASE 183



2N1042 – 2N1045 CASE 184
Collector Connected to Case
(All Types)

MAXIMUM RATINGS

Rating	Symbol	2N1042 2N2560 2N2564	2N1043 2N2561 2N2565	2N1044 2N2562 2N2566	2N1045 2N2563 2N2567	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	20				Vdc
Collector Current — Continuous	I_C	3.5				Adc
Base Current — Continuous	I_B	1.0				Adc
Total Device Dissipation @ T_A = 25°C	P_D	450				mW
Derate above 25°C		6.0				mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	20				Watts
Derate above 25°C (Note 1)		0.267				W/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +100				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.75	°C/W

*Indicates JEDEC Registered Data.

Note 1: Case Temperature shall be measured 0.100 ± 0.010 inches above the seating plane.

*Motorola guarantees this data in addition to the JEDEC Registered Data shown.

2N1042 thru 2N1045/2N2560 thru 2N2567 (continued)

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	2N1042,2N2560,2N2564	$V_{CEO(sus)}$	30	–	Vdc
	2N1043,2N2561,2N2565		40	–	
	2N1044,2N2562,2N2566		50	–	
	2N1045,2N2563,2N2567		60	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 15 Vdc, I_B = 0)	2N1042,2N2560,2N2564		–	25	
(V_{CE} = 20 Vdc, I_B = 0)	2N1043,2N2561,2N2565		–	20	
(V_{CE} = 25 Vdc, I_B = 0)	2N1044,2N2562,2N2566		–	20	
(V_{CE} = 30 Vdc, I_B = 0)	2N1045,2N2563,2N2567		–	20	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1042,2N2560,2N2564		–	0.65	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1043,2N2561,2N2565		–	0.65	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1044,2N2562,2N2566		–	0.65	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1045,2N2563,2N2567		–	0.65	
(V_{CE} = 20 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1042,2N2560,2N2564		–	5.0	
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1043,2N2561,2N2565		–	5.0	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1044,2N2562,2N2566		–	5.0	
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1045,2N2563,2N2567		–	5.0	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 20 Vdc, I_E = 0)	2N1042,2N2560,2N2564		–	125	
(V_{CB} = 30 Vdc, I_E = 0)	2N1043,2N2561,2N2565		–	125	
(V_{CB} = 40 Vdc, I_E = 0)	2N1044,2N2562,2N2566		–	125	
(V_{CB} = 50 Vdc, I_E = 0)	2N1045,2N2563,2N2567		–	125	
**(V_{CB} = 40 Vdc, I_E = 0)	2N1042,2N2560,2N2564		–	750	
**(V_{CB} = 60 Vdc, I_E = 0)	2N1043,2N2561,2N2565		–	750	
**(V_{CB} = 80 Vdc, I_E = 0)	2N1044,2N2562,2N2566		–	750	
**(V_{CB} = 100 Vdc, I_E = 0)	2N1045,2N2563,2N2567		–	750	
Emitter Cutoff Current (V_{BE} = 20 Vdc, I_C = 0)		I_{EBO}	–	650	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 0.5 Vdc)			50	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			–	150	
(I_C = 3.0 Adc, V_{CE} = 1.0 Vdc)			20	60	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc)			–	0.25	
(I_C = 3.0 Adc, I_B = 300 mAdc)			–	0.75	
Base-Emitter Input Voltage (I_C = 3.0 Adc, V_{CE} = 1.0 Vdc)		V_{BE}	–	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 1.5 Vdc, f = 1.0 kHz)		h_{fe}	25	100	–
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 1.5 Vdc, f = 125 kHz)		$\|h_{fe}\|$	2.0	–	–

*Indicates JEDEC Registered Data.

**Motorola Guarantees this data in addition to the JEDEC Registered Data Shown.

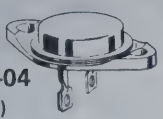
2N2552 thru 2N2559

For Specifications, See 2N1038 Data.

2N2560 thru 2N2567

For Specifications, See 2N1042 Data.

2N1073, A, B (GERMANIUM)



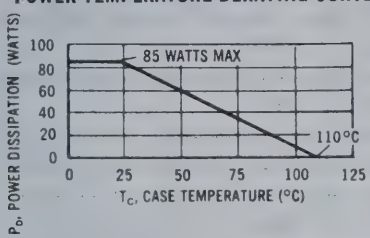
CASE 4-04
(TO-41)

PNP germanium power transistors for high-voltage power switching applications.

MAXIMUM RATINGS

Rating	Symbol	2N1073	2N1073A	2N1073B	Unit
Collector-Emitter Voltage	V_{CER}	40	80	120	Vdc
Collector-Base Voltage	V_{CB}	40	80	120	Vdc
Emitter-Base Voltage	V_{EB}	1.5	1.5	1.5	Vdc
Collector Current (Cont)	I_C	10	10	10	Amp
Base Current (Cont)	I_B	5.0			Amp
Emitter Reverse Current (Surge 60 cps Recurrent)	I_E	1.5			Amp
Storage and Operating Temperature	T_{stg} T_J	-65 to +110			°C
Collector Dissipation (25°C Mtg. Case Temp.)	P_D	85			Watts

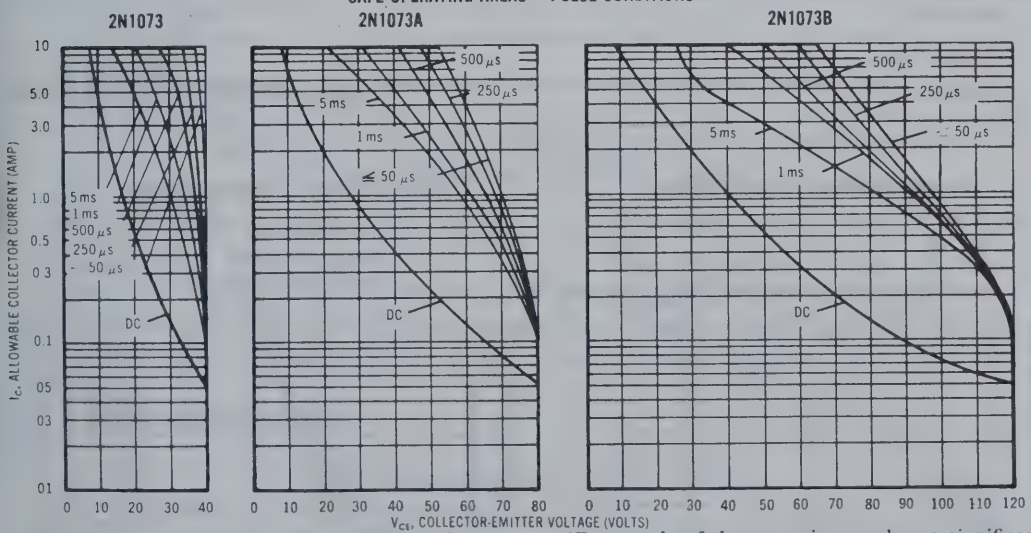
POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 85 watts at a case temperature of 25°C and is 0 watts at 110°C with a linear relation between the two temperatures such that:

$$\text{Allowable } P_D = \frac{110° - T_C}{1.0} \text{ Watts}$$

SAFE OPERATING AREAS — PULSE CONDITIONS



The Safe Operating Area Curves indicate Ic — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

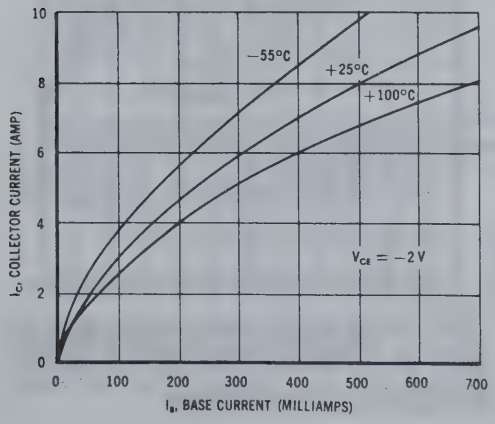
2N1073, A, B (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

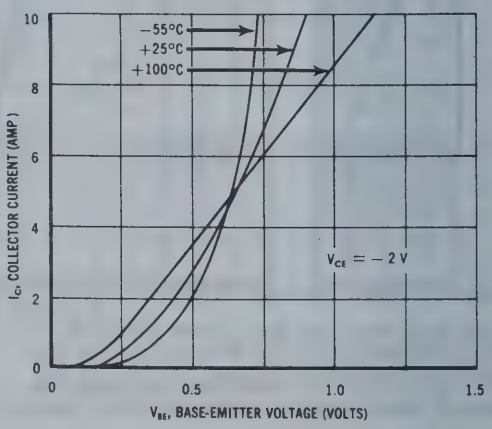
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 25 Vdc, I_E = 0)	2N1073		-	-	1.0	
(V_{CB} = 25 Vdc, I_E = 0, T_C = 85°C)	2N1073		-	-	15	
(V_{CB} = 40 Vdc, I_E = 0)	2N1073		-	-	20	
(V_{CB} = 60 Vdc, I_E = 0)	2N1073A		-	-	1.0	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 85°C)	2N1073A		-	-	15	
(V_{CB} = 80 Vdc, I_E = 0)	2N1073A		-	-	20	
(V_{CB} = 100 Vdc, I_E = 0)	2N1073B		-	-	2.0	
(V_{CB} = 100 Vdc, I_E = 0, T_C = 85°C)	2N1073B		-	-	20	
(V_{CB} = 120 Vdc, I_E = 0)	2N1073B		-	-	20	
(V_{CB} = 2.0 Vdc, I_E = 0)			-	-	0.3	
Emitter-Base Leakage Current (V_{EB} = 0.75 Vdc)		I_{EBO}	-	-	50	mAdc
Emitter Floating Potential		V_{EBF}				Vdc
(V_{CE} = 40 Vdc)	2N1073		-	-	1.0	
(V_{CE} = 80 Vdc)	2N1073A		-	-	1.0	
(V_{CE} = 120 Vdc)	2N1073B		-	-	1.0	
Collector-Emitter Breakdown Voltage*		BV_{CER}*				Vdc
(I_C = 50 mAdc, R_{BE} = 100Ω)	2N1073		40	-	-	
	2N1073A		80	-	-	
	2N1073B		120	-	-	
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20	-	60	-
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 12 Vdc, f = 30 kHz)		h_{fe}	-	15	-	-
Base Input Voltage (V_{CE} = 2.0 Vdc, I_C = 5.0 Adc)		V_{BE}	-	-	1.0	Vdc
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{CE(sat)}$	-	0.5	1.0	Vdc
Rise Time		t_r	-	5.5	-	μs
Storage Time		t_s	-	1.2	-	μs
Fall Time		t_f	-	2.0	-	μs

*To avoid excessive heating of collector junction, perform this test with a sweep method.

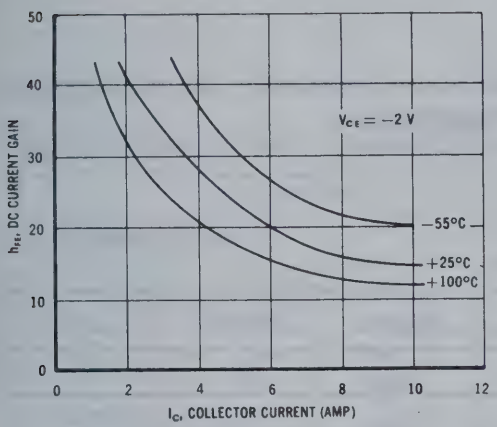
COLLECTOR CURRENT versus BASE CURRENT



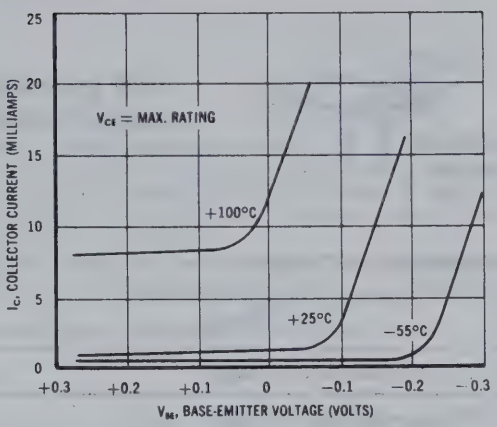
COLLECTOR CURRENT versus DRIVE VOLTAGE



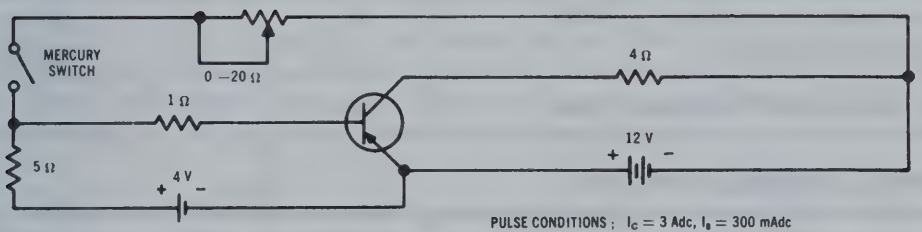
DC CURRENT GAIN versus COLLECTOR CURRENT



COLLECTOR CURRENT versus DRIVE VOLTAGE



SWITCHING TEST CIRCUIT



PULSE CONDITIONS ; $I_C = 3$ Adc, $I_B = 300$ mAdc

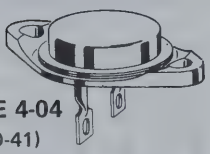
2N1099 (GERMANIUM)

For Specifications, See 2N277 Data.

2N1100 (GERMANIUM)

For Specifications, See 2N174 Data.

2N1120 (GERMANIUM)



CASE 4-04
(TO-41)

PNP germanium power transistor for military and industrial power applications.

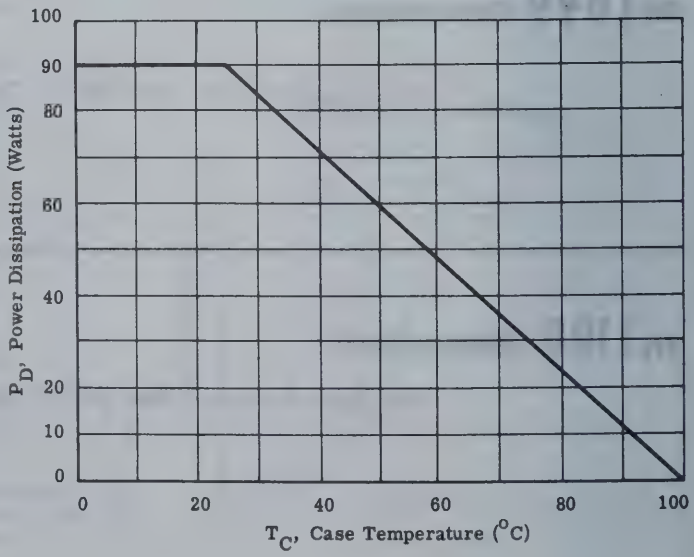
MAXIMUM RATINGS

Rating	Symbol	2N1120	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	70	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
Emitter Current	I_E	15	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	90 1.2	Watts $W/^oC$
Operating Junction Temperature Range	T_J	-65 to +100	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^oC/W$

POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 300 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 300 mAdc, V_{BE} = 0)	BV_{CES}	70	-	Vdc
Floating Potential (V_{CB} = 80 Vdc, I_E = 0) (Voltmeter Input Resistance = 10 meg. min.)	V_{EBF}	-	1.0	Vdc
Collector Cutoff Current (V_{CB} = 2 Vdc, I_E = 0)	I_{CBO}	-	0.3	mAdc
(V_{CB} = 30 Vdc, I_E = 0)			20	
(V_{CB} = 80 Vdc, I_E = 0)		-	15	
Emitter Cutoff Current (V_{BE} = 40 Vdc, I_C = 0)	I_{EBO}	-	5.0	mAdc
Base Current (V_{CE} = 2 Vdc, I_C = 5 Adc)	I_B	50	-	mAdc
(V_{CE} = 2 Vdc, I_C = 10 Adc)		200	500	
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	-	100	-
(I_C = 10.0 Adc, V_{CE} = 2.0 Vdc)		20	50	
Collector-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{BE(sat)}$	-	1.5	Vdc
Base-Emitter On Voltage (I_C = 10 Adc, V_{CE} = 2 Vdc)	$V_{BE(on)}$	-	2.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Common-Emitter Cutoff Frequency (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	$f_{\alpha e}$	3.0	-	kHz

2N1131 (SILICON)
2N1991



PNP silicon annular transistors for medium-current switching applications.

Collector connected to case

CASE 31
(TO-5)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage 2N1131 2N1991	V_{CB}	 50 30	Vdc
Collector-Emitter Voltage 2N1131 2N1991	V_{CEO}	 35 20	Vdc
Emitter-Base Voltage 2N1131, 2N1991	V_{EB}	 5	Vdc
Collector-Emitter Voltage ($R_{be} \leqq 10\,\Omega$) 2N1131	V_{CER}	 50	Vdc
Collector Current 2N1131	I_C	 600	mAdc
Total Device Dissipation @ 25°C Case Temperature Both Types Derating Factor Above 25°C 2N1131 2N1991	P_D	 2 13.3 16.0	 Watts mW/°C mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Both Types Derating Factor Above 25°C 2N1131 2N1991	P_D	 0.6 4.0 4.8	 Watt mW/°C mW/°C
Junction Temperature 2N1131 2N1991	T_J	 +175 +150	°C
Storage Temperature Range 2N1131 2N1991	T_{stg}	 -65 to +300 -65 to +150	°C

2N1131, 2N1991 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Types	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) (I_C = 1.0 mA, I_E = 0)	 2N1131 2N1991	BV_{CBO}	 50 30	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc pulse, I_B = 0)	 2N1131 2N1991	BV_{CEO}	 35 20	 — —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc pulsed, $R_{be} \leqq 10\Omega$)	2N1131	BV_{CER}	50	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C) (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)	 2N1131 2N1131 2N1131 2N1991 2N1991	I_{CBO}	 — — — — —	 1 100 100 5 200	μ Adc
Emitter Cutoff Current (V_{EB} = 2 Vdc, I_C = 0) (V_{EB} = 1 Vdc, I_C = 0)	 2N1131 2N1991	I_{EBO}	 — —	 100 200	μ Adc
DC Forward Current Transfer Ratio (I_C = 5 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	 2N1131 2N1991 2N1131 2N1991	h_{FE}	 15 15 20 15	 — — 45 60	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE\ (sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	 2N1131 2N1991	$V_{BE\ (sat)}$	 — —	 1.3 1.5	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	45	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	2N1131	C_{ib}	—	80	pF
AC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	 2N1131 2N1991	$\lvert h_{fe} \rvert$	 2.5 2.0		—
Small-Signal Forward Current Transfer Ratio (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz) (I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	 2N1131 2N1991	h_{fe}	 15 20	 50 —	—
Small Signal Input Resistance (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kHz) (I_C = 5 mAdc, V_{CB} = 10 Vdc, f = 1 kHz)	2N1131	h_{ib}	 25 —	 35 10	ohms
Small Signal Output Admittance (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz) (I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N1131	h_{ob}	 — —	 1 5	μ mhos
Small Signal Voltage Feedback Ratio (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz) (I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N1131	h_{rb}	 — —	 8 8	x 10^{-4}

Pulse Test: Pulse width $\leqq$ 300 μs Duty Cycle $\leqq$ 2%

2N1132, A (SILICON)

For Specifications, See 2N722 Data

2N1141 thru 2N1143 (GERMANIUM)
2N1195



CASE 31
(TO-5)

PNP germanium mesa transistors for amplifier, driver, oscillator and doubler applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N1141	2N1142	2N1143	2N1195	Unit
Collector-Base Voltage	V_{CB}	35	30	25	30	Vdc
Emitter-Base Voltage	V_{EB}	1.0	0.7	0.5	1.0	Vdc
Collector Current-Continuous	I_C	100	100	100	40	mAdc
Base Current	I_B	50	50	50	-	mAdc
Emitter Current-Continuous	I_E	100	100	100	-	mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	300	300	300	-	mW
Derate above 25^oC		4	4	4	-	$mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$	P_D	750	750	750	-	mW
Derate above 25^oC		10	10	10	-	$mW/^oC$
Collector Dissipation @ $T_A = 25^oC$	P_C	-	-	-	225	mW
Derate above 25^oC		-	-	-	3	$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100				^oC

TRANSISTOR SELECTION CHART

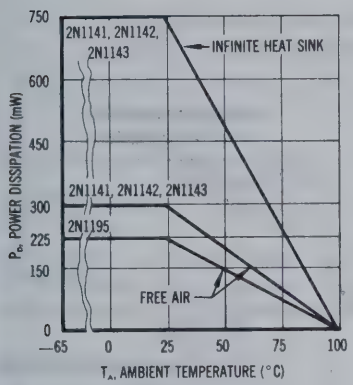
TYPE	Minimum BV_{CBO} @ $I_C = -100\mu$ Adc, $I_E = 0$			Typical 100 MHz Noise Figure @ $V_{CE} = -10$Vdc, $I_E = 1$mAdc $R_S = 75\Omega$			Minimum h_{fe} @ $I_C = -10$mAdc, $V_{CE} = -10$Vdc, f = 100 MHz		
	35 Vdc	30 Vdc	25 Vdc	4.0 db	4.5 db	5.0 db	12 db	10 db	8 db
2N1141	✓			✓			✓		
2N1142		✓			✓			✓	
2N1143			✓			✓			✓
2N1195		✓		✓			✓		

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

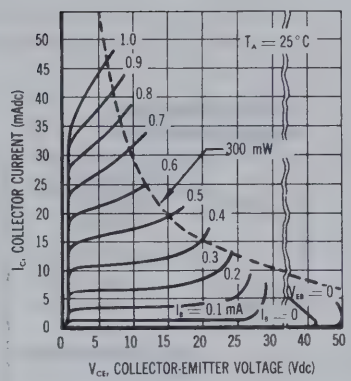
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	2N1141	BV_{CBO}	35	45	-	Vdc
	2N1142		30	45	-	
	2N1143		25	45	-	
	2N1195		30	45	-	
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	2N1141	BV_{EBO}	1.0	1.3	-	Vdc
	2N1142		0.7	1.3	-	
	2N1143		0.5	1.3	-	
	2N1195		1.0	1.3	-	
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)		I_{CBO}	-	0.5	5	μAdc
($V_{CB} = 20$ Vdc, $I_E = 0$)			-	0.5	5	
Emitter Cutoff Current ($V_{BE} = 0.5$ Vdc, $I_C = 0$)		I_{EBO}	-	0.2	-	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	2N1141, 2N1142, 2N1143	h_{FE}	10	25	-	-
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	2N1195		-	25	-	
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 10$ mAdc)	2N1141, 2N1142, 2N1143	$V_{CE(sat)}$	-	0.185	2	Vdc
($I_C = 50$ mAdc, $I_B = 10$ mAdc)	2N1195		-	0.185	-	

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Common-Base Cutoff Frequency (I_C = 10 mAdc, V_{CE} = 10 Vdc) All Types	$f_{\alpha b}$	-	1000	-	MHz
Collector Transition Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz) 2N1141	C_{Tc}	-	1.1	1.5	pF
2N1142, 2N1143, 2N1195		-	1.1	-	
Emitter Transition Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1 MHz) All Types	C_{Te}	-	2.5	-	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}				-
2N1141, 2N1195		12	18	-	
2N1142		10	18	-	
2N1143		8	18	-	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 1 kHz)	h_{fb}				-
2N1141, 2N1142, 2N1143		-	0.98	-	
2N1195		0.96	0.98	0.995	
Output Admittance (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 1 kHz)	h_{ob}				μmhos
2N1141, 2N1142, 2N1143		-	10	-	
2N1195		-	10	20	
Input Impedance (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 1 kHz)	h_{ib}				Ohms
2N1141, 2N1142, 2N1143		-	3.6	-	
2N1195		-	3.6	10	
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 1 kHz)	h_{rb}				-
2N1141, 2N1142, 2N1143		-	0.0013	-	
2N1195		-	0.0013	0.003	
Collector-Base Time Constant (I_E = 3 mAdc, V_{CB} = 10 Vdc, f = 30 MHz) All Types	$r'_b C_c$	-	23	-	ps
Extrinsic Base Resistance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 250 MHz)	r'_b				Ohms
2N1141		-	65	70	
2N1142		-	80	-	
2N1143		-	110	-	
2N1195		-	65	80	
Collector Series Resistance (I_E = 10 mAdc, V_{CB} = 10 Vdc) All Types	r'_c	-	2	-	Ohms
Noise Figure	NF				dB
(I_E = 0.8 mAdc, V_{CE} = 5 Vdc, R_S = 300 ohms, f = 4.5 MHz)					
2N1141, 2N1195		-	3.0	-	
2N1142		-	3.5	-	
2N1143		-	4.0	-	
(I_E = 1 mAdc, V_{CE} = 10 Vdc, R_S = 75 ohms, f = 100 MHz)					
2N1141		-	4.0	-	
2N1142, 2N1195		-	4.5	-	
2N1143		-	5.0	-	
(I_E = 1 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 200 MHz)					
2N1141		-	5.5	-	
2N1142, 2N1195		-	6.0	-	
2N1143		-	6.5	-	
Oscillator Efficiency (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 400 MHz)	η				%
2N1141		-	20	-	
2N1142		-	18	-	
2N1143		-	12	-	
2N1195		-	18	-	

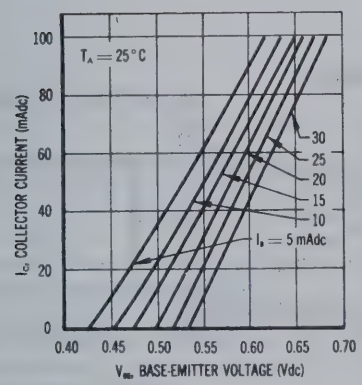
POWER-TEMPERATURE DERATING CURVE



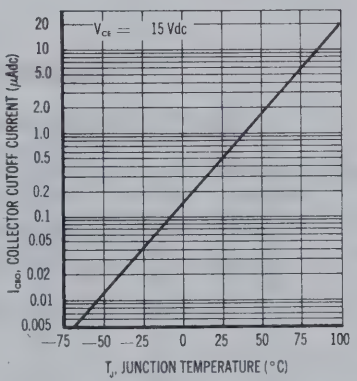
COLLECTOR CHARACTERISTICS, COMMON EMITTER



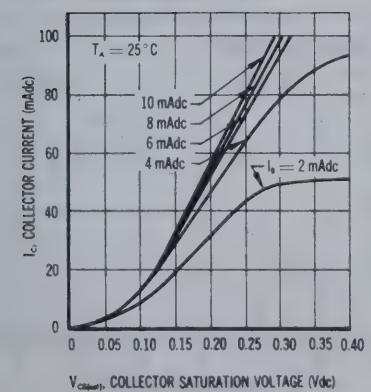
BASE CHARACTERISTICS, COMMON EMITTER



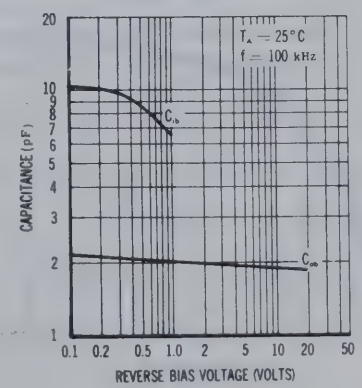
COLLECTOR CUTOFF CURRENT versus JUNCTION TEMPERATURE



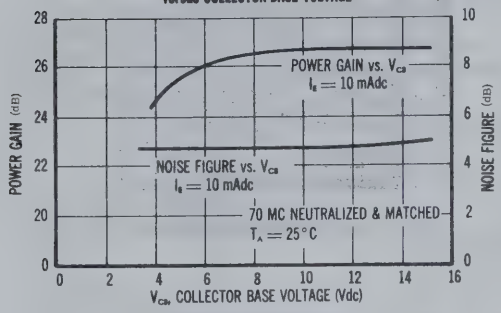
COLLECTOR SATURATION CHARACTERISTICS



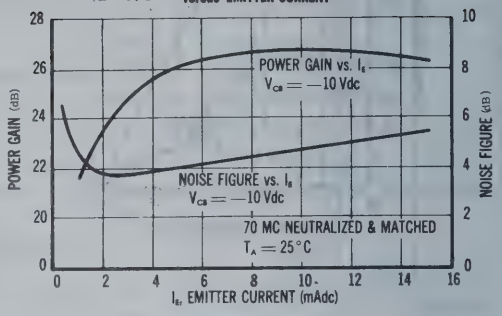
COLLECTOR INPUT AND OUTPUT CAPACITANCE versus VOLTAGE



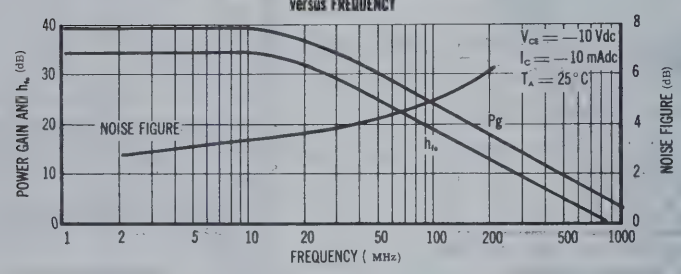
POWER GAIN AND NOISE FIGURE versus COLLECTOR-BASE VOLTAGE



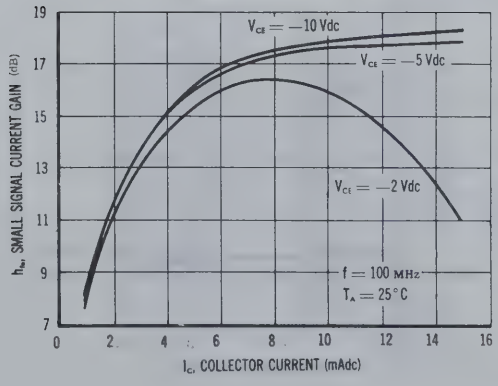
POWER GAIN AND NOISE FIGURE versus EMITTER CURRENT



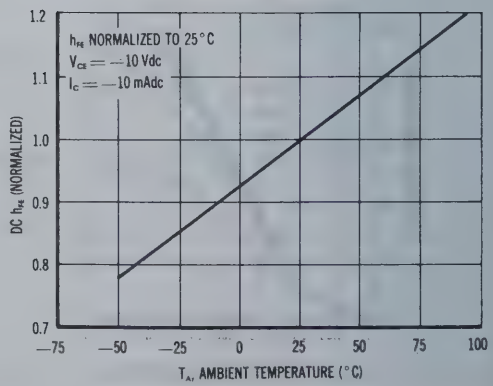
COMMON EMITTER POWER GAIN, h_{fe}, AND NOISE FIGURE versus FREQUENCY



SMALL SIGNAL CURRENT GAIN (h_{fe}) versus COLLECTOR CURRENT

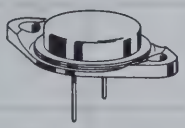


NORMALIZED h_{FE} versus AMBIENT TEMPERATURE



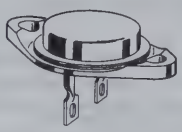
2N1162 thru 2N1167 (GERMANIUM)
2N1162A thru 2N1167A

PNP germanium power transistors for switching and amplifier applications in high reliability equipment.



CASE 11A
(TO-3 modified)

2N1162, A
2N1164, A
2N1166, A



CASE 4-04
(TO-41)

2N1163, A
2N1165, A
2N1167, A

MAXIMUM RATINGS

Apply also to standard, non-A series

Rating	Symbol	2N1162A 2N1163A	2N1164A 2N1165A	2N1166A 2N1167A	Units
Collector-Base Voltage	V_{CB}	50	80	100	Vdc
Collector-Emitter Voltage	V_{CES}	35	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	40	50	Vdc
Total Device Dissipation @ 25°C Derate above 25°C	P_D	106 1.25			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			°C

GROUP A ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current ($V_{CB} = V_{CB}$(max), $I_E = 0$)	I_{CBO1}	—	3.0	15	mA
Collector Cutoff Current (V_{CB} = 2 V, I_E = 0)	I_{CBO}	—	125	225	μA
(V_{CB} = 15 V, I_E = 0, T_C = 90°C) 2N1162A-3A*		—	10	20	mA
(V_{CB} = 30 V, I_E = 0, T_C = 90°C) 2N1164A-7A*		—	10	20	mA
Collector-Emitter Breakdown Voltage** (I_C = 500 mA, V_{EB} = 0) 2N1162A-3A*	BV_{CES}**	35	—	—	Vdc
2N1164A-5A*		60	—	—	
2N1166A-7A*		75	—	—	
Emitter Cutoff Current (V_{EB} = 12 V, I_C = 0)	I_{EBO}	—	0.5	1.2	mA
DC Forward Current Gain (V_{CE} = 1 V, I_C = 25 A)	h_{FE1}	15	25	—	—
(V_{CE} = 2 V, I_C = 5 A)	h_{FE}	—	65	125	
Collector-Emitter Saturation Voltage (I_C = 25 A, I_B = 1.6 A)	$V_{CE(sat)}$	—	0.3	0.8	volts
Base-Emitter Saturation Voltage (I_C = 25 A, I_B = 1.6 A)	$V_{BE(sat)}$	—	0.7	1.7	volts
Common Emitter-Cutoff Frequency (V_{CE} = 2 V, I_C = 2 A)	$f_{\alpha e}$	—	4.0	—	kHz

*Characteristics apply also to corresponding, non-A type numbers
**Sweep Method: 1/2 cycle sine wave, 60 Hz

SWITCHING CHARACTERISTICS (Typical)

Saturated Collector Current	Pulsed Drive Base Current		Response times in μs		
	On	Off	$t_d + t_r$	t_s	t_f
5 amp	330 mA	100 mA	11	5.0	17
10 amp	660 mA	200 mA	15	4.0	20
25 amp	1650 mA	500 mA	19	3.0	18

FIGURE 1 — POWER TEMPERATURE DERATING CURVE

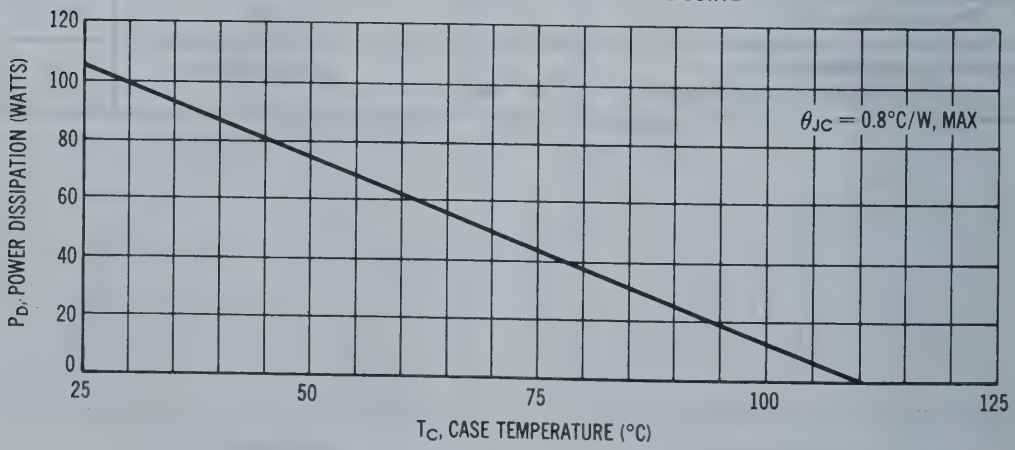
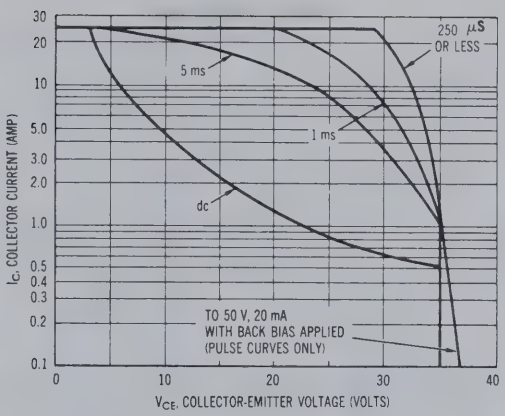
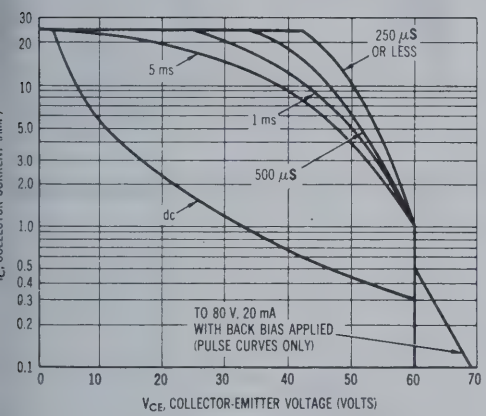
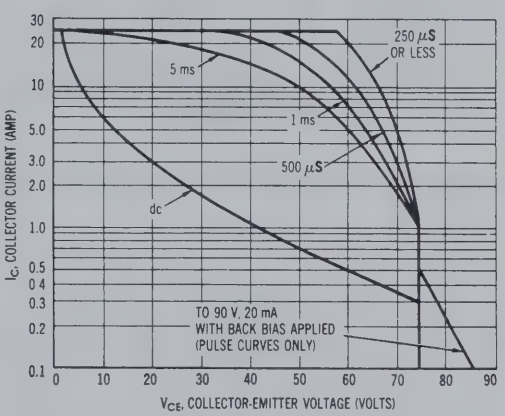


FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS

The active region safe operating area curves indicate I_C-V_{CE} limits to be observed in order to avoid secondary breakdown. (Secondary breakdown is independent of temperature and duty cycle.) These curves do not define operation in the avalanche region. To insure operation below the maximum junction temperature, power derating must be observed for both steady state and pulse conditions.







LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE

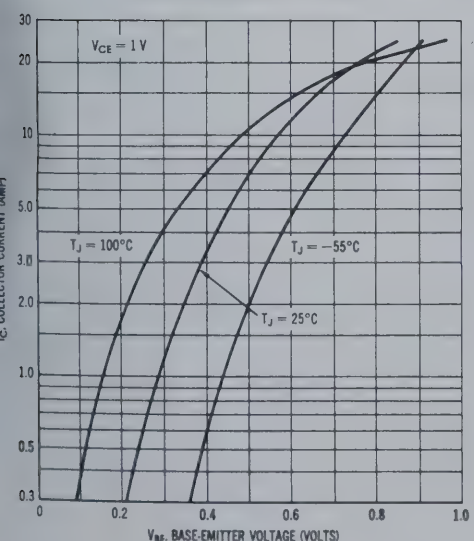


FIGURE 4 — INPUT ADMITTANCE

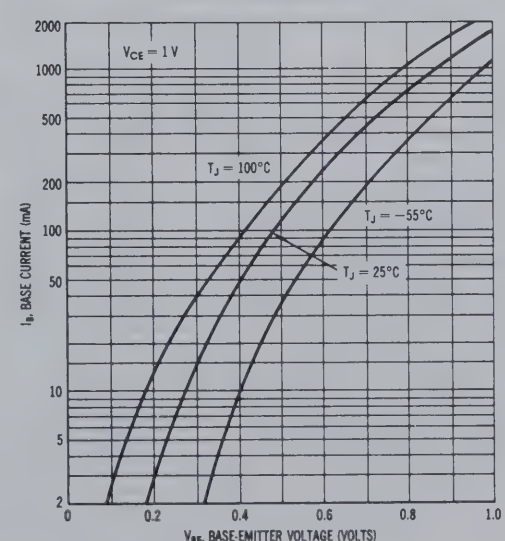


FIGURE 5 — CURRENT GAIN

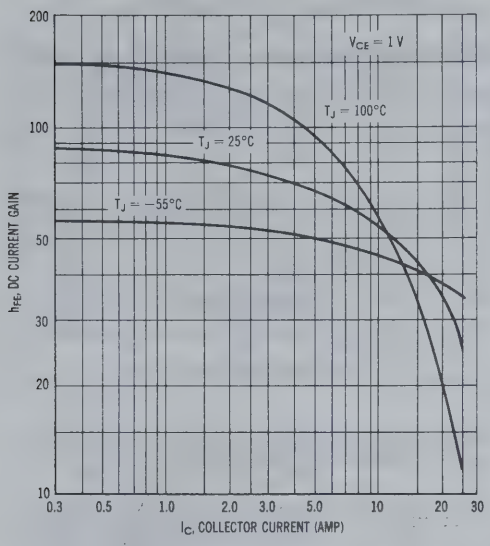
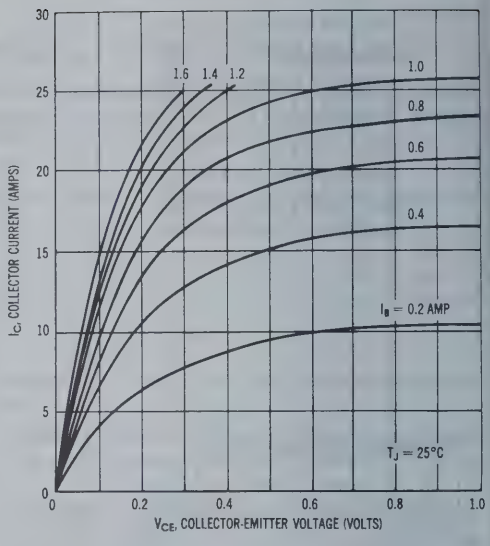


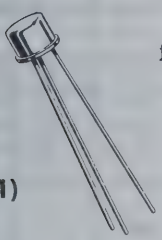
FIGURE 6 — SATURATION REGION



2N1175

FOR SPECIFICATIONS, SEE 2N1413-2N1415 DATA.

2N1185 thru 2N1188 (GERMANIUM)



CASE 31 (1)
(TO-5)

All leads isolated from case

PNP germanium transistors for high-gain audio amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage 2N1185 2N1186-2N1188	V_{CB}	 45 60	Vdc
Collector-Emitter Voltage 2N1185 2N1186-2N1188	V_{CER}	 30 45	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current* (Continuous)	I_C	500*	mAdc
Storage and Operating Temperature	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation in, Ambient (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance Junction to Ambient	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

*Limited by power dissipation

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

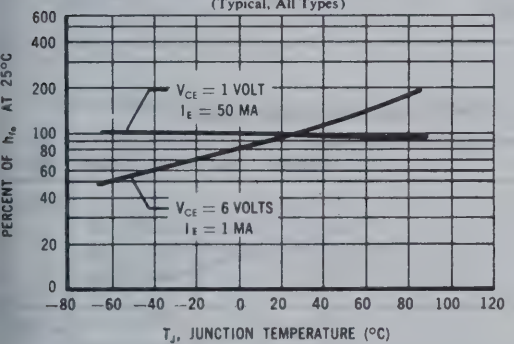
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 V, I_E = 0)	2N1185		-	3.0	10	
(V_{CB} = 45 V, I_E = 0)	2N1186 thru 2N1188		-	5.0	10	
(V_{CB} = 60 V, I_E = 0)	2N1186 thru 2N1188		-	-	50	
(V_{CB} = 10 V, I_E = 0, T_A = +71° C)	All Types		-	55	100	
Emitter-Base Cutoff Current		I_{EBO}				μAdc
(V_{EB} = 30 V, I_C = 0)			-	3.0	10	
Collector-Emitter Leakage Current		I_{CER}				μAdc
(V_{CE} = 30 V, R_{BE} = 10 K)	2N1185		-	-	600	
(V_{CE} = 45 V, R_{BE} = 10 K)	2N1186 thru 2N1188		-	-	600	
Collector-Emitter Punch-Thru Voltage		V_{pt}				Vdc
(V_F = 1.0 V,	2N1185		45	-	-	
VTVM Impedance ≥ 1 M ohm)	2N1186 thru 2N1188		60	-	-	
Output Capacitance		C_{ob}				pF
(V_{CB} = 6 V, I_E = 0)			-	10	25	
Noise Figure		NF				dB
(V_{CE} = 4.5 V, I_E = 0.5 mA, R_g = 1 K, f = 1 kHz, Δf = 1 Hz)			-	5.0	15	
Small Signal Current Gain Cutoff Frequency		$f_{\alpha b}$				MHz
(V_{CB} = 6 V, I_E = 1 mA)	2N1185		1.75	3.0	-	
	2N1186		0.75	1.5	-	
	2N1187		1.0	2.0	-	
	2N1188		1.25	2.5	-	
Input Impedance		h_{ib}				Ohms
(V_{CB} = 6 V, I_E = 1 mA, f = 1 kHz)	2N1185		27	35	37	
	2N1186		27	31	37	
	2N1187		27	34	37	
	2N1188		27	35	37	
Output Admittance		h_{ob}				μmho
(V_{CB} = 6 V, I_E = 1 mA, f = 1 kHz)	2N1185		0.2	0.50	0.7	
	2N1186		0.2	0.65	1.0	
	2N1187		0.2	0.60	0.9	
	2N1188		0.2	0.55	0.8	
Small Signal Current Gain		h_{fe}				-
(V_{CE} = 6 V, I_E = 1 mA, f = 1 kHz)	2N1185		190	260	400	
	2N1186		30	49	70	
	2N1187		50	80	120	
	2N1188		100	130	225	
DC Current Transfer Ratio		h_{FE}				-
(V_{CE} = 1.0 V, I_C = 10 mA)	2N1185		130	170	-	
	2N1186		33	44	-	
	2N1187		45	75	-	
	2N1188		80	115	-	

ELECTRICAL CHARACTERISTICS (continued)

Characteristics		Symbol	Min	Typ	Max	Unit
Base-Emitter Input Voltage (V_{CE} = 1.0 V, I_C = 10 mA)	2N1185	V_{BE}	-	0.215	0.240	Vdc
	2N1186		-	0.245	0.270	
	2N1187		-	0.235	0.260	
	2N1188		-	0.225	0.250	
Collector-Emitter Saturation Voltage		V_{CE} (sat)				Vdc
(I_C = 50 mA, I_B = 1.0 mA)	2N1185		-	0.175	0.250	
(I_C = 50 mA, I_B = 2.5 mA)	2N1186		-	0.175	0.250	
(I_C = 50 mA, I_B = 1.67 mA)	2N1187		-	0.175	0.250	
(I_C = 50 mA, I_B = 1.25 mA)	2N1188		-	0.175	0.250	
Collector-Emitter Saturation Voltage		V_{CE} (sat)				Vdc
(I_C = 100 mA, I_B = 2.0 mA)	2N1185		-	0.250	0.500	
(I_C = 100 mA, I_B = 5.0 mA)	2N1186		-	0.250	0.500	
(I_C = 100 mA, I_B = 3.33 mA)	2N1187		-	0.250	0.500	
(I_C = 100 mA, I_B = 2.5 mA)	2N1188		-	0.250	0.500	

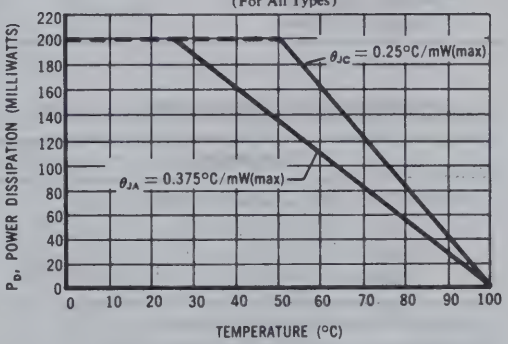
SMALL SIGNAL CURRENT GAIN(h_{fe}) versus TEMPERATURE

(Typical, All Types)

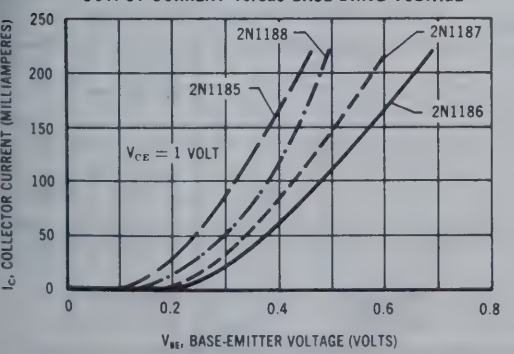


POWER-TEMPERATURE DERATING CURVE

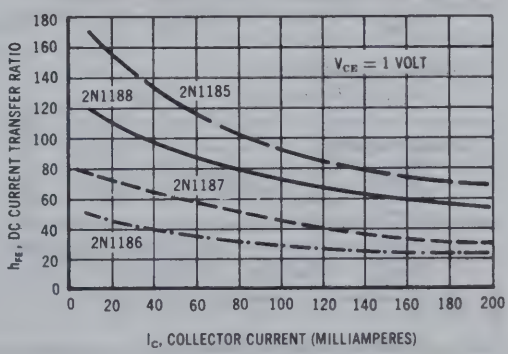
(For All Types)



OUTPUT CURRENT versus BASE DRIVE VOLTAGE



DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT



2N1189 2N1190 (GERMANIUM)



CASE 31(1)
(TO-5)
All leads isolated

PNP germanium transistors for high-gain audio amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CER}	30	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current (Continuous)	I_C	500*	mAdc
Junction, Storage Temperature	T_J, T_{stg}	-65 to +100	°C
Collector Dissipation, Ambient (Derate 2.67 mW/° C above 25° C)	P_D	200	mW
Thermal Resistance (Junction to Ambient)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

*Limited by power dissipation.

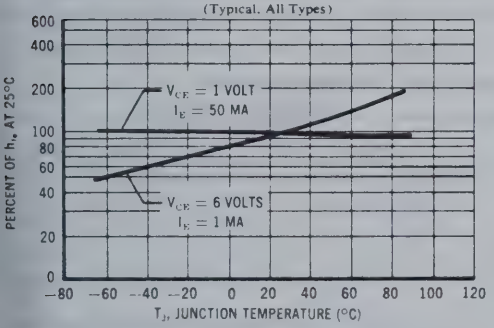
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 45 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0, T_A = + 71°C)	I_{CBO}	 — — —	 3.0 — 55	 10 50 100	μAdc
Emitter-Base Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)	I_{EBO}	—	3.0	10	μAdc
Collector-Emitter Leakage Current (V_{CE} = 30 Vdc, R_{BE} = 10K)	I_{CER}	—	—	600	μAdc
Collector-Emitter Punch-Thru Voltage (V_{EB} = 1 Vdc, VTVM Impedance ≥ 1 M ohm	V_{pt}	45	—	—	Vdc
Output Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	12.0	25	pF
Noise Figure (V_{CE} = 4.5 V_{dc}, I_E = 0.5 mAdc R_g = 1 K, f = 1 kHz Δf = 1 Hz)	NF	—	5.0	15	dB
Small-Signal Current-Gain Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc) 2N1189 2N1190	$f_{\alpha b}$	 1.75 2.25	 3.5 4.5	 — —	MHz

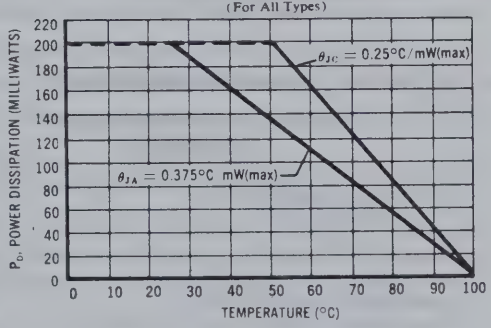
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Impedance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)		h_{ib}	27	31	37	Ohms
Output Admittance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)		h_{ob}	0.1	—	0.9	μmho
Small Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N1189	h_{fe}	75	120	175	—
	2N1190		125	190	300	
DC Current Transfer Ratio (V_{CE} = 1.0 Vdc, I_E = 10 mAdc)	2N1189	h_{FE}	60	115	—	—
	2N1190		100	170	—	
Base-Emitter Drive Voltage (V_{CE} = 1.0 Vdc, I_E = 10 mAdc)	2N1189	V_{BE}	—	0.24	0.26	Vdc
	2N1190		—	0.22	0.25	
Collector-Emitter Saturation Voltage		V_{CE} (sat)				Vdc
(I_C = 50 mAdc, I_B = 1.5 mA)	2N1189		—	0.14	0.22	
(I_C = 50 mAdc, I_B = 1.0 mA)	2N1190		—	0.15	0.22	
(I_C = 100 mAdc, I_B = 3.0 mA)	2N1189		—	0.17	0.3	
(I_C = 100 mAdc, I_B = 2.0 mA)	2N1190		—	0.19	0.3	

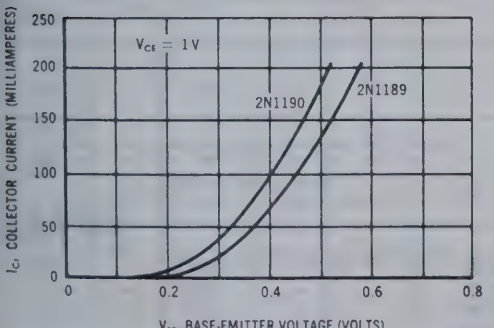
SMALL SIGNAL CURRENT GAIN(h_{fe}) versus TEMPERATURE
(Typical, All Types)



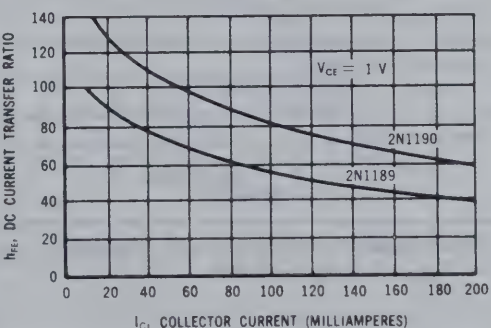
POWER-TEMPERATURE DERATING CURVE
(For All Types)



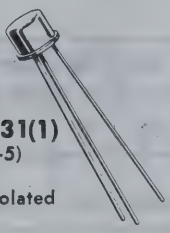
OUTPUT CURRENT versus BASE DRIVE VOLTAGE



DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT



2N1191 thru 2N1194 (GERMANIUM)



CASE 31(1)
(TO-5)

All leads isolated

PNP germanium transistors for high-gain audio amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CER}	25	Vdc
Emitter-Base Voltage	V_{EB}	25	Vdc
Collector Current (Continuous)	I_C	200	mAdc
Storage and Operating Temperature	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation in Ambient (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance (Junction to Ambient)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

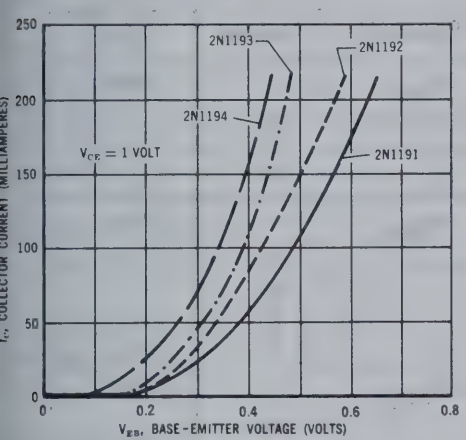
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 25 V, I_E = 0) (V_{CB} = 1.0 V, I_E = 0)		I_{CBO}	– –	– 2.0	15 –	μAdc μAdc
Emitter-Base Cutoff Current (V_{EB} = 25 V, I_C = 0)		I_{EBO}	–	–	15	μAdc
Collector-Emitter Leakage Current (V_{CB} = 25 V, R_{BE} = 10 K)		I_{CER}	–	–	600	μAdc
Output Capacitance (V_{CE} = 6 V, I_E = 1.0 mA)		C_{ob}	–	20	–	pF
Noise Figure (V_{CE} = 4.5 V, I_E = 0.5 mA, f = 1 kHz, R_g = 100 ohms)		NF	–	10	–	dB
Small Signal Current Gain Cutoff Frequency (V_{CB} = 6 V, I_E = 1.0 mA)	2N1191 2N1192 2N1193 2N1194	$f_{\alpha b}$	– – – –	1.5 2.0 2.5 3.0	– – – –	MHz

2N1191 thru 2N1194 (continued)

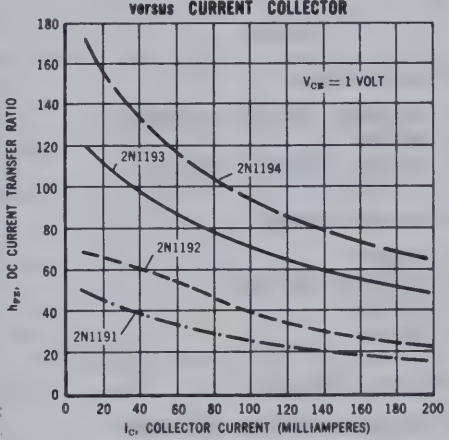
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
Small Signal Current Gain (V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kHz)	2N1191	h_{fe}	30	40	70	–
	2N1192		50	75	125	
	2N1193		100	160	250	
	2N1194		190	280	500	
DC Current Gain (V_{CE} = 1 V, I_C = 10 mA)	2N1191	h_{FE}	20	–	80	–
	2N1192		40	–	135	
	2N1193		70	–	300	
	2N1194		125	–	600	
Small Signal Power Gain (V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kHz, matched)	2N1191	G_e	–	42	–	dB
	2N1192		–	44	–	
	2N1193		–	46	–	
	2N1194		–	48	–	
Base-Emitter Input Voltage (V_{CE} = 6 V, I_C = 1.0 mA)		V_{BE}	–	–	0.3	Vdc

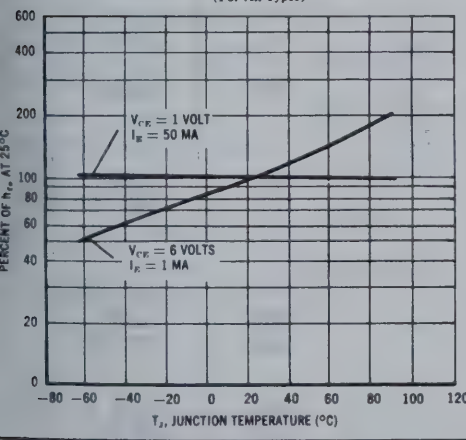
OUTPUT CURRENT versus BASE DRIVE VOLTAGE



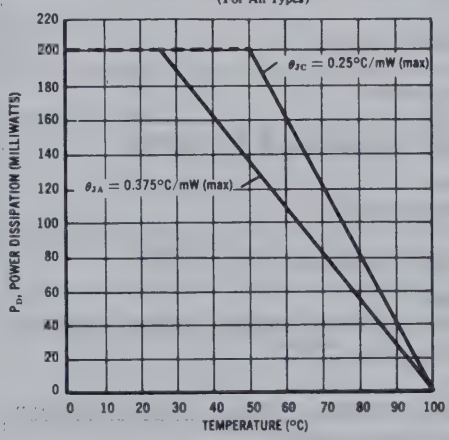
DC CURRENT TRANSFER RATIO versus CURRENT COLLECTOR



SMALL SIGNAL CURRENT GAIN versus TEMPERATURE
(For All Types)



POWER-TEMPERATURE DERATING CURVE
(For All Types)



2N1195

FOR SPECIFICATIONS, SEE 2N1141 DATA.

2N1204, A (GERMANIUM)
2N1494, A
2N1495
2N1496
2N2096
2N2097
2N2099
2N2100

PNP germanium epitaxial mesa transistors for high-speed, high-current switching in line and core driver applications.



CASE 31
(TO-5)

2N1204,A
2N1495
2N2099
2N2100



CASE 25

2N1494,A
2N1496
2N2096
2N2097

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}		Vdc
2N1204, 2N1204A, 2N1494, 2N1494A		20	
2N2096, 2N2099		25	
2N1495, 2N1496, 2N2097, 2N2100		40	
Collector-Emitter Voltage	V_{CEO}		Vdc
2N2096, 2N2099		12	
2N1204, 2N1204A, 2N1494A		15	
2N2097, 2N2100		20	
2N1495, 2N1496		25	
Collector-Emitter Voltage	V_{CES}		Vdc
2N1204, 2N1204A, 2N1494, 2N1494A		20	
2N2096, 2N2099		25	
2N1495, 2N1496, 2N2097, 2N2100		40	
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_C = 25°C	P_D		
All Types		750	mW
Derate above 25°C		10	mW/°C
Total Device Dissipation @ T_A = 25°C	P_D		
TO-5 Case			
2N1204, 2N1204A, 2N1495, 2N2099, 2N2100		300	mW
Derate above 25°C		4.0	mW/°C
Case 25			
2N1494, 2N1494A, 2N1496, 2N2096, 2N2097		500	mW
Derate above 25°C		6.67	mW/°C
Operating Junction and Storage Temperature Range	T_J T_{stg}	-65 to +100	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 100 μAdc, I_E = 0)	2N1204, 2N1204A, 2N1494, 2N1494A		20	40	–	
	2N2096, 2N2099		25	–	–	
	2N1495, 2N1496, 2N2097, 2N2100		40	–	–	
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 100 μAdc, V_{BE} = 0)	2N1204, 2N1204A, 2N1494, 2N1494A		20	40	–	
	2N2096, 2N2099		25	–	–	
	2N1495, 2N1496, 2N2097, 2N2100		40	–	–	
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 2 mAdc, I_B = 0)	2N1204, 2N1204A, 2N1494, 2N1494A		15	25	–	
(I_C = 10 mAdc, I_B = 0)	2N2096, 2N2099		12	–	–	
	2N2097, 2N2100		20	–	–	
	2N1495, 2N1496		25	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1 mAdc, I_C = 0)	2N1204, 2N1204A, 2N1494 thru 2N1496, 2N1494A		4	–	–	
(I_E = 10 mAdc, I_C = 0)	2N2096, 2N2097, 2N2099, 2N2100		4	–	–	
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 5 Vdc, I_E = 0)	2N1204, 2N1204A, 2N1494 thru 2N1496, 2N1494A		–	0.4	7	
(V_{CB} = 12 Vdc, I_E = 0)	2N2096, 2N2099		–	–	12	
(V_{CB} = 15 Vdc, I_E = 0)	2N2097, 2N2100		–	–	12	
Emitter Cutoff Current		I_{EBO}				μAdc
(V_{BE} = 0.5 Vdc, I_C = 0)	2N1494 thru 2N1496, 2N1494A		–	–	5	
(V_{BE} = 1 Vdc, I_C = 0)	2N2096, 2N2097, 2N2099, 2N2100		–	10	50	
DC Current Gain		h_{FE}				–
(I_C = 200 mAdc, V_{CE} = 0.5 Vdc)	2N1204A, 2N1494A, 2N1495, 2N1496		25	–	–	
(I_C = 200 mAdc, V_{CE} = 1 Vdc)	2N2097, 2N2100		30	70	–	
(I_C = 400 mAdc, V_{CE} = 1.5 Vdc)*	2N1204, 2N1494, 2N2096, 2N2099		15	35	–	
	2N2097, 2N2100		20	50	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)	2N2097, 2N2100		–	–	0.3	
(I_C = 200 mAdc, I_B = 10 mAdc)	2N1204, 2N1204A, 2N1494, 2N1494A		–	–	0.4	
	2N2097, 2N2100		–	–	0.5	
	2N2096, 2N2099		–	–	0.6	
(I_C = 200 mAdc, I_B = 20 mAdc)	2N1495, 2N1496		–	–	0.3	
(I_C = 400 mAdc, I_B = 25 mAdc)**	2N1204A, 2N1494A, 2N1495, 2N1496		–	–	0.7	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)	2N2097, 2N2100		–	–	0.5	
(I_C = 200 mAdc, I_B = 10 mAdc)	2N1204, 2N1204A, 2N1494 thru 2N1496, 2N1494A		0.40	0.60	0.72	
	2N2097, 2N2100		–	–	0.8	
	2N2096, 2N2099		–	–	0.9	
Collector Output Capacitance		C_{ob}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 4 MHz)	2N1204, 2N1204A, 2N1494 thru 2N1496, 2N1494A		–	3.5	6.5	
	2N2096, 2N2097, 2N2099, 2N2100		–	3.5	20	
Input Capacitance		C_{ib}				pF
(V_{BE} = 1 Vdc, I_C = 0, f = 4 MHz)	All Types		–	8	50	
AC Current Gain		h_{fe}				–
(I_C = 20 mA, V_{CE} = 10 V, f = 100 MHz)	2N1204, 2N1204A, 2N1494, 2N1494A		1.1	2	–	
	2N1495, 2N1496		1.5	–	–	
Rise Time (Figure 5)		t_r				ns
	2N2097, 2N2100		–	–	20	
	2N1204, 2N1204A, 2N1494, 2N1494A, 2N2096, 2N2099		–	–	35	
	2N1495, 2N1496		–	–	55	
Minority Carrier Storage Time Constant		τ_s				ns
(Figure 4)	2N1204, 2N1204A, 2N1494, 2N1494A		–	30	75	
	2N1495, 2N1496		–	–	90	
Storage Time (Figure 6)		t_s				ns
	2N2097, 2N2100		–	–	50	
	2N2096, 2N2099		–	–	70	
Fall Time (Figure 6)		t_f				ns
	2N2097, 2N2100		–	–	40	
	2N2096, 2N2099		–	–	60	

*Pulse Test: Pulse width ≤ 1 ms, Duty cycle ≤ 6%
**Pulse Test: Pulse width ≤ 5 ms, Duty cycle ≤ 2%

FIGURE 1 — TYPICAL RISE AND FALL TIME BEHAVIOR

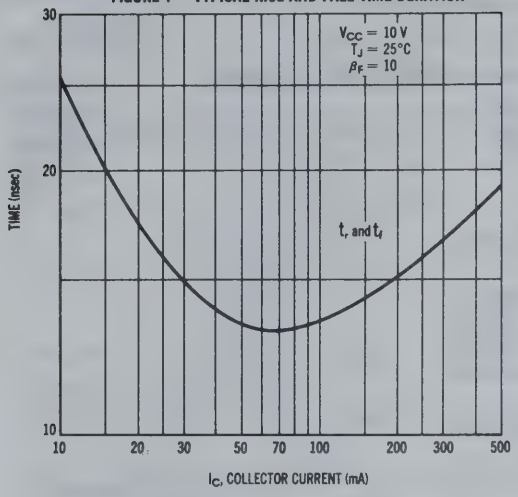


FIGURE 2 — STORAGE TIME VARIATIONS

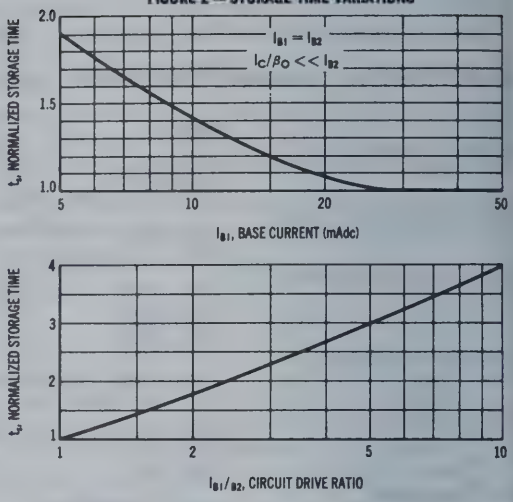


FIGURE 3 — TOTAL CONTROL CHARGE

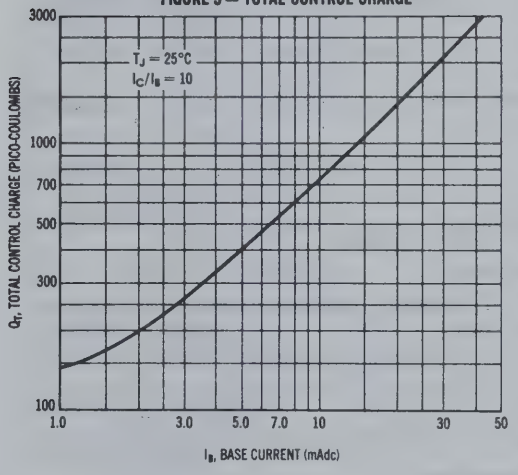
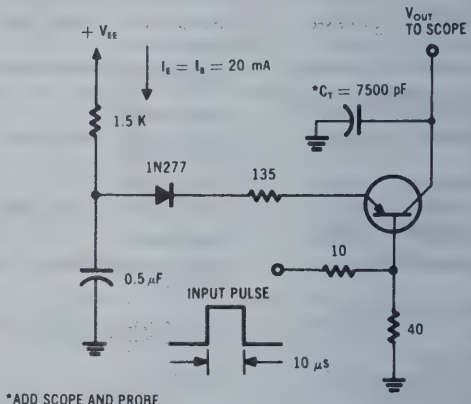


FIGURE 4 — CARRIER STORAGE TIME CONSTANT TEST CIRCUIT



*ADD SCOPE AND PROBE CAPACITANCE TO C_T FOR CORRECT CALCULATION OF T_S (K's).

$$T_S = \frac{C_T V_{OUT}}{I_E}$$

FIGURE 5 — RISE TIME TEST CIRCUIT

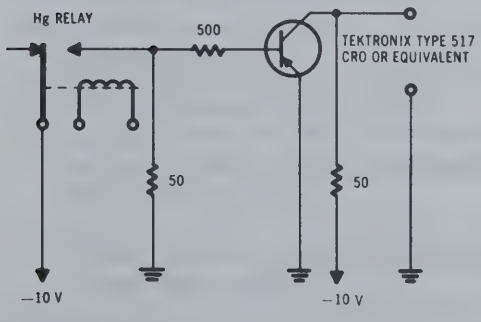
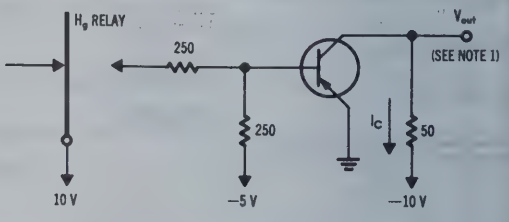


FIGURE 6 — STORAGE AND FALL TIME TEST CIRCUIT



NOTE 1: SCOPE IMPEDANCE SUFFICIENTLY HIGH SO THAT DOUBLING OR HALVING ITS VALUE DOES NOT CHANGE THE READING.

SCOPE RISE TIME FAST ENOUGH SO THAT DOUBLING OR HALVING ITS VALUE DOES NOT CHANGE THE READING.

FIGURE 7 — COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT

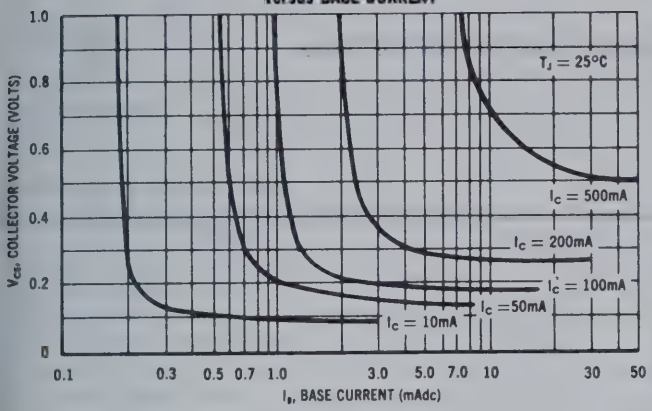


FIGURE 8 — BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

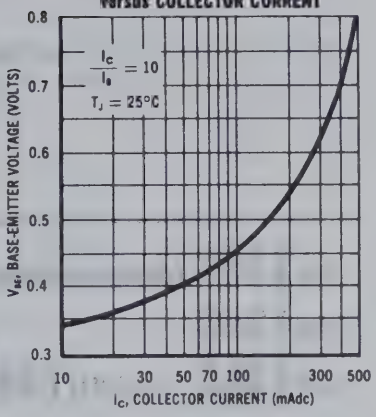


FIGURE 9 — TEMPERATURE COEFFICIENTS

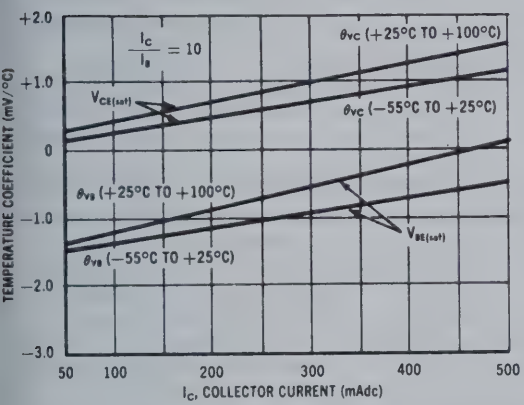


FIGURE 10 — NORMALIZED CURRENT GAIN CHARACTERISTICS

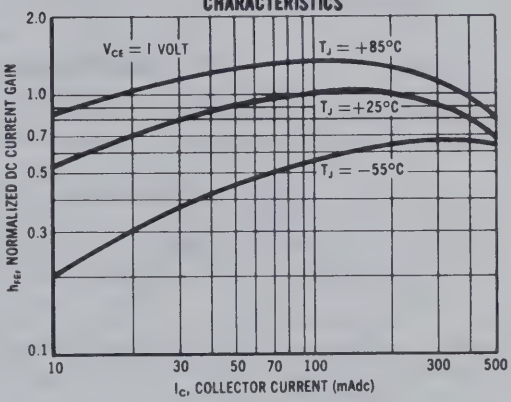


FIGURE 11 — LEAKAGE CHARACTERISTICS COMMON EMITTER

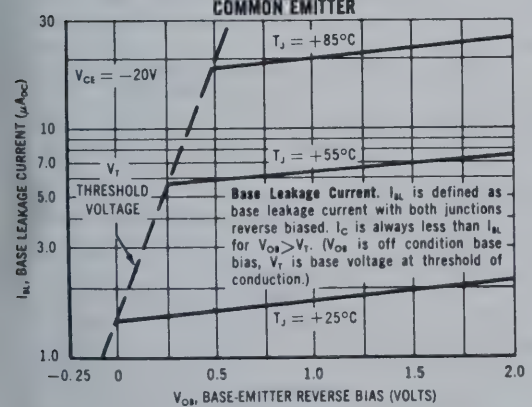
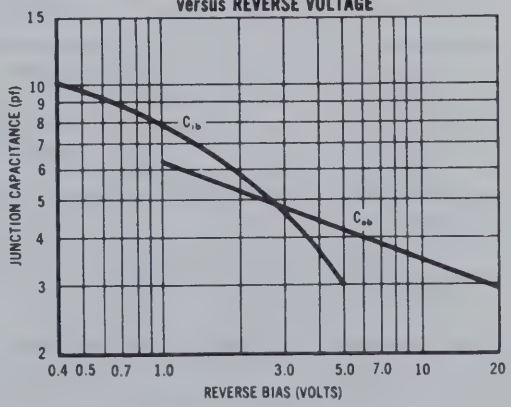


FIGURE 12 — JUNCTION CAPACITANCE versus REVERSE VOLTAGE



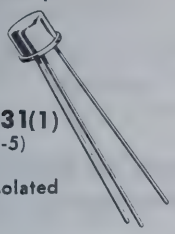
2N1358, A (GERMANIUM)

For Specifications, See 2N174 Data.

2N1359 (GERMANIUM)
2N1360
2N1362 thru 2N1365

For Specifications, See 2N375 Data.

2N1408 (GERMANIUM)



CASE 31(1)
(TO-5)

All leads isolated

PNP germanium transistor for high voltage neon driver, solenoid and relay driver circuits.

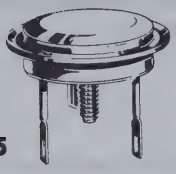
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Volts
Collector-Emitter Voltage	V_{CES}	50	Volts
Emitter-Base Voltage	V_{EB}	10	Volts
Collector Current	I_C	200	mA
Collector Dissipation at $T_A = 25°C$	P_D	150	mW
derating factor		2.0	mW/°C
Junction Temperature Range	T_J	-65 to +100	°C

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)	I_{CBO}	---	7.0	μAdc
Emitter-Base Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	---	7.0	μAdc
Collector-Emitter Leakage Current (V_{CB} = 50 Vdc, R_{BE} = 0)	I_{CES}	---	150	μAdc
Collector-Base Breakdown Voltage (I_C = 25 μAdc, I_E = 0)	BV_{CBO}	50	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 25 μAdc, I_C = 0)	BV_{EBO}	10	---	Vdc
Collector-Emitter Punch-Thru Voltage (I_E = 25 μAdc)	V_{pt}	50	---	Vdc
Base-Emitter Input Voltage (I_B = 1.0 mAdc, V_{CE} = 1.0 Vdc)	V_{BE}	---	0.6	Vdc
DC Current Gain (V_{CE} = 1 Vdc, I_B = 1 mAdc)	h_{FE}	10	---	---
Small Signal Current Gain (V_{CE} = 5.0 Vdc, I_E = 1.0 mA, f = 1 kHz)	h_{fe}	10	---	---
Output Admittance (V_{CB} = 5.0 Vdc, I_E = 1.0 mA, f = 1 kHz)	h_{ob}	---	2.0	μmhos

2N1412 (GERMANIUM)
2N1412A



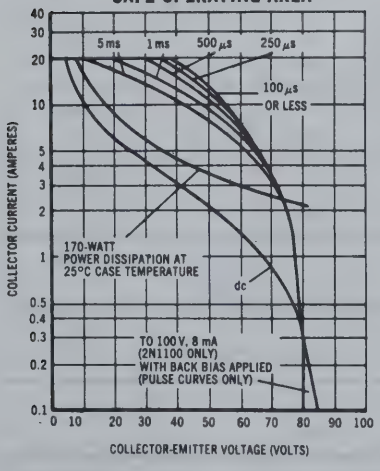
CASE 5
(TO-36)

PNP germanium power transistors for high-voltage power amplifier and switching applications in military and industrial equipment.

MAXIMUM RATINGS

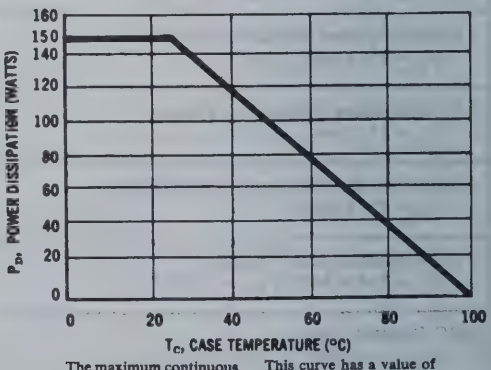
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	100	Vdc
Collector-Emitter Voltage	V_{CES}	80	Vdc
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Emitter-Base Voltage	V_{EB}	60	Vdc
Emitter Current (Continuous)	I_E	15	Amp
Base Current (Continuous)	I_B	4.0	Amp
Junction & Storage Temperature	T_{stg}	-65 to +100	°C
Thermal Resistance	θ_{JC}	0.5	°C/W

SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 100°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{100° - T_C}{0.5}$$

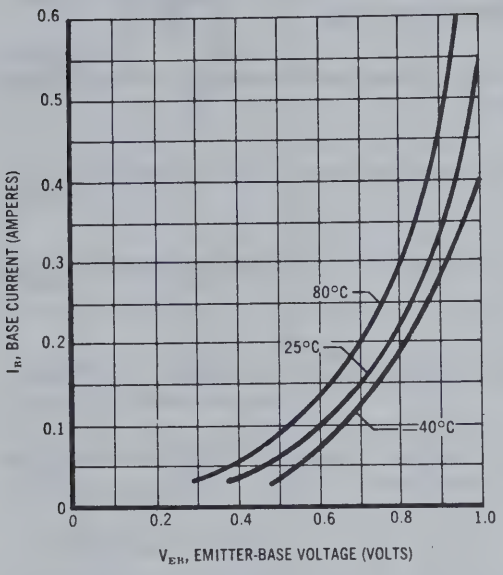
2N1412 (continued)

ELECTRICAL CHARACTERISTICS

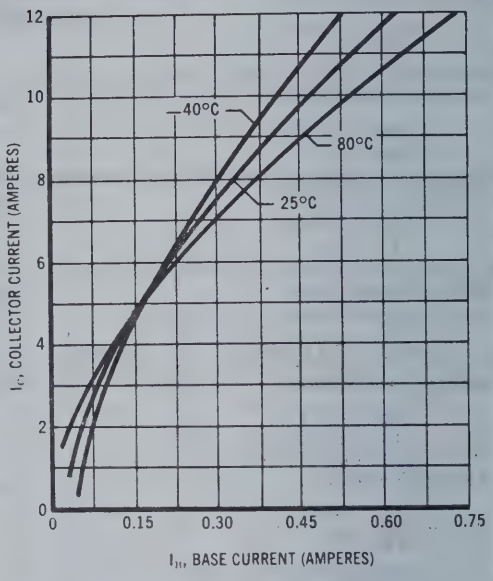
Characteristic	Symbol	Minimum	Maximum	Unit
Emitter Cutoff Current V_{EB} = –2.0 Vdc I_C = 0	I_{EBO}	—	200	μAdc
Emitter Cutoff Current V_{EB} = –60 Vdc I_C = 0	I_{EBO}	—	10	mAdc
Collector Cutoff Current V_{CB} = –2.0 Vdc I_E = 0	I_{CBO}	—	200	μAdc
Collector Cutoff Current V_{CB} = –100 Vdc I_E = 0	I_{CBO}	—	10	mAdc
Emitter-Base Voltage V_{CE} = –2.0 Vdc I_C = –1.2 Adc	V_{EB}		0.5	Vdc
Emitter-Base Voltage V_{CE} = –2.0 Vdc I_C = –5.0 Adc	V_{EB}		0.9	Vdc
Floating Potential V_{CB} = –100 Vdc I_E = 0 (Voltmeter input resistance = 10 Megohm min)	V_{fl}		1.0	Vdc
Collector-Emitter Saturation Voltage I_C = –12 Adc I_B = –2.0 Adc	$V_{CE(SAT)}$		0.7	Vdc
Forward Current Transfer Ratio* V_{CE} = –2.0 Vdc I_C = –15 Adc	h_{FE}	10	—	—
Forward Current Transfer Ratio V_{CE} = –2.0 Vdc I_C = –5.0 Adc	h_{FE}	25	50	—
Collector-Emitter Breakdown Voltage* I_C = –1 Adc I_B = 0	BV_{CEO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* V_{EB} = 0 I_C = 300 mA	BV_{CES}	80	—	Vdc
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency V_{CE} = –12 Vdc I_C = –5.0 Adc	$f_{\alpha e}$	5.0	—	kHz
High-Temperature Operation Emitter Cutoff Current T_C = +71°C min V_{EB} = –30 Vdc	I_{EBO}	—	6.0	mAdc
Collector Cutoff Current V_{CB} = –30 Vdc I_E = 0	I_{CBO}	—	6.0	mAdc

*Test by sweep method with a short duty cycle (about 1%) to avoid excessive heating.

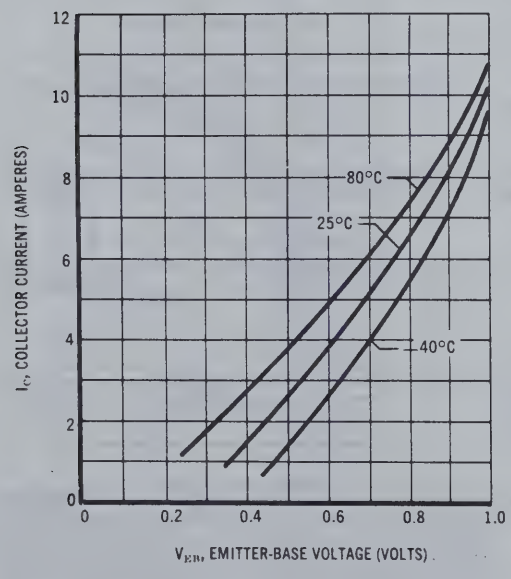
INPUT CHARACTERISTICS



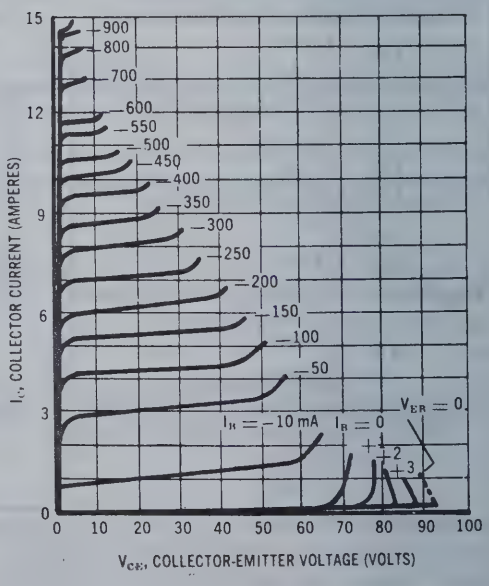
CURRENT TRANSFER CHARACTERISTICS



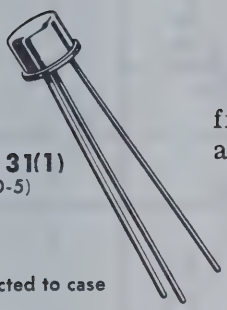
TRANSCONDUCTANCE CHARACTERISTICS



OUTPUT CHARACTERISTICS



2N1413 thru 2N1415 (GERMANIUM)
2N1175



CASE 31(1)
(TO-5)

Base connected to case

PNP germanium transistors for general-purpose low-frequency amplifier and switching applications. Characteristic curves similar to 2N524-2N527 series.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	35	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_j & T_{stg}	-65 to +100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = 30 Vdc, I_E = 0	I_{CBO}	–	12	μAdc
Emitter Cutoff Current V_{EB} = 10 Vdc, I_C = 0	I_{EBO}	–	10	μAdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 10 K	BV_{CER}	25	–	Vdc
Punch-Thru Voltage	V_{pt}	25	–	Vdc
DC Current Gain I_C = 20 mAdc, V_{CE} = 1 Vdc	h_{FE}			–
2N1413		25	42	
2N1414		34	65	
2N1415		53	90	
2N1175		70	140	

2N1413 thru 2N1415, 2N1175 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
DC Current Gain I_C = 100 mAdc, V_{CE} = 1 Vdc	h_{FE}			
2N1413		23	–	–
2N1414		30	–	
2N1415		47	–	
2N1175		62	–	
Base Input Voltage V_{CE} = 1 Vdc, I_C = 20 mAdc	V_{BE}			
2N1175		–	260	mVdc
Output Capacitance; Input AC Open Circuit V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 MHz	C_{ob}	–	40	pF
Frequency Cutoff V_{CE} = 5 Vdc, I_E = 1 mAdc	$f_{\alpha b}$			
2N1413		0.8	–	MHz
2N1414		1.0	–	
2N1415		1.3	–	
2N1175		1.5	–	
Small-Signal Short-Circuit Forward-Transfer Current Ratio V_{CE} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz	h_{fe}			
2N1413		20	41	–
2N1414		30	64	
2N1415		44	88	
2N1175		60	120	
Small-Signal Open Circuit Output Admittance V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz	h_{ob}			
2N1413		0.10	1.3	μmh
2N1414		0.10	1.2	
2N1415		0.10	1.0	
2N1175		0.10	0.9	
Small-Signal Open-Circuit Reverse-Transfer Voltate Ratio V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz	h_{rb}			
2N1413		1.0	10	$X10^{-4}$
2N1414		1.0	11	
2N1415		1.0	12	
2N1175		1.0	14	
Small-Signal Short-Circuit Input Impedance V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz	h_{ib}			
2N1413		26	36	ohms
2N1414		26	35	
2N1415		26	33	
2N1175		26	31	

2N1420

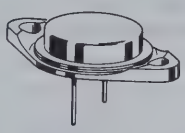
For Specifications, See 2N718 Data.

2N1494, A, 2N1495, 2N1496

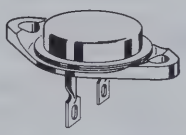
For Specifications, See 2N1204 Data.

2N1529 thru 2N1538 (GERMANIUM)
2N1529A thru 2N1532A, 2N1534A thru 2N1537A

PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.



CASE 11
(TO-3)



CASE 4-04
(TO-41)

For units with solder lugs attached, specify devices MP1529, A etc. (TO-41 package)

MAXIMUM RATINGS

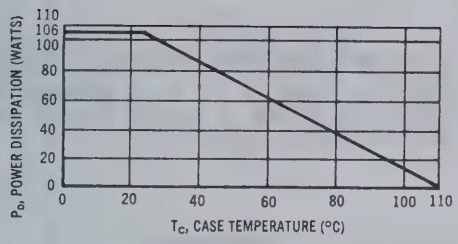
Rating	Symbol	2N1529 2N1534	2N1530 2N1535	2N1531 2N1536	2N1532 2N1537	2N1533 2N1538	Units
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	120	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEO}	20	30	40	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	50	60	Vdc
Collector Current (Continuous)	I_C	5.0					Amp
Collector Current (Peak)	I_C	10					Amp
Junction Temperature Range	T_J	-65 to +110					°C
Total Device Dissipation (25°C Case Temperature)	P_D	106					Watts
Thermal Resistance	θ_{JC}	0.8					°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise specified.)

Characteristics apply to corresponding "A" type numbers also.

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO1}			mA
(V_{CB} = 25V)	2N1529, 2N1534		—	2.0	
(V_{CB} = 40V)	2N1530, 2N1535		—	2.0	
(V_{CB} = 55V)	2N1531, 2N1536		—	2.0	
(V_{CB} = 65V)	2N1532, 2N1537		—	2.0	
(V_{CB} = 80V)	2N1533, 2N1538		—	2.0	
Collector-Base Cutoff Current		I_{CBO}			mA
(V_{CB} = 2V)			—	0.2	
(V_{CB} = 1 2 BV_{CES} rating; T_C = +90°C)			—	20	
Emitter-Base Cutoff Current		I_{EBO}			mA
(V_{EB} = 12V)			—	0.5	
Collector-Emitter Breakdown Voltage		BV_{CES}			volts
(I_C = 500 mA, V_{EB} = 0)	2N1529, 2N1534		30	—	
	2N1530, 2N1535		45	—	
	2N1531, 2N1536		60	—	
	2N1532, 2N1537		75	—	
	2N1533, 2N1538		90	—	
Collector-Emitter Leakage Current		I_{CEX}			mA
(V_{BE} = 1V, V_{CE} @ rated BV_{CBO})			—	20	
Collector-Emitter Breakdown Voltage		BV_{CEO}			volts
(I_C = 500 mA, I_B = 0)	2N1529, 2N1534		20	—	
	2N1530, 2N1535		30	—	
	2N1531, 2N1536		40	—	
	2N1532, 2N1537		50	—	
	2N1533, 2N1538		60	—	
Collector-Base Breakdown Voltage		BV_{CBO}			volts
(I_C = 20 mA)	2N1529, 2N1534		40	—	
	2N1530, 2N1535		60	—	
	2N1531, 2N1536		80	—	
	2N1532, 2N1537		100	—	
	2N1533, 2N1538		120	—	
Current Gain		h_{FE1}			—
(V_{CE} = 2V, I_C = 3A)	2N1529 - 2N1532		20	40	
	2N1534 - 2N1537		35	70	
	2N1529 - 2N1533		20	40	
	2N1534 - 2N1538		35	70	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			volts
(I_C = 3A, I_B = 300 mA)	2N1529 - 2N1532		—	1.7	
	2N1534 - 2N1537		—	1.5	
	2N1529 - 2N1533		—	1.7	
	2N1534 - 2N1538		—	1.5	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			volts
(I_C = 3A, I_B = 300 mA)	2N1529 - 2N1532		—	1.5	
	2N1534 - 2N1537		—	1.2	
	2N1529 - 2N1533		—	1.5	
	2N1534 - 2N1538		—	1.2	
Transconductance		g_{FE}			mhos
(V_{CE} = 2V, I_C = 3A)	2N1529 - 2N1532		1.2	—	
	2N1534 - 2N1537		1.5	—	
	2N1529 - 2N1533		1.2	—	
	2N1534 - 2N1538		1.5	—	

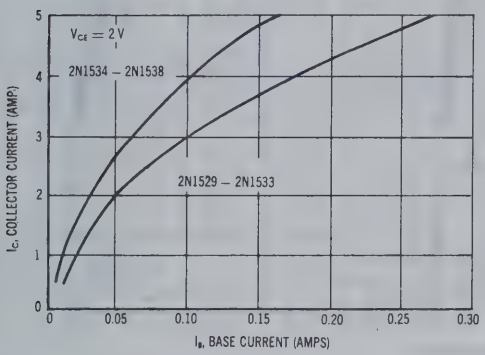
POWER-TEMPERATURE DERATING CURVE



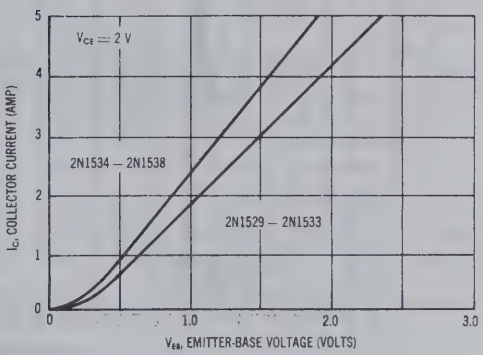
The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For dc or frequencies below 25 Hz the transistor must be operated within the constant $P_D = V_C \times I_C$ hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{110^{\circ} - Tc}{0.8}$$

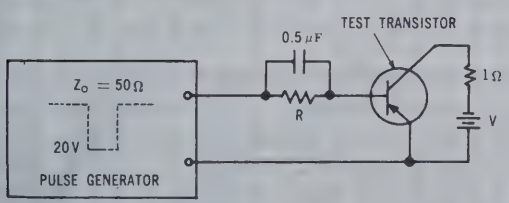
COLLECTOR CURRENT versus BASE CURRENT



COLLECTOR CURRENT versus EMITTER BASE VOLTAGE



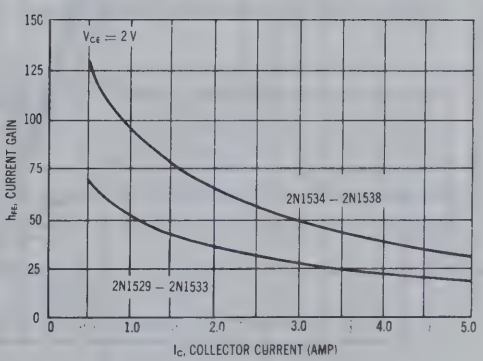
SWITCHING TIME MEASURING CIRCUIT



TYPICAL SWITCHING CHARACTERISTICS

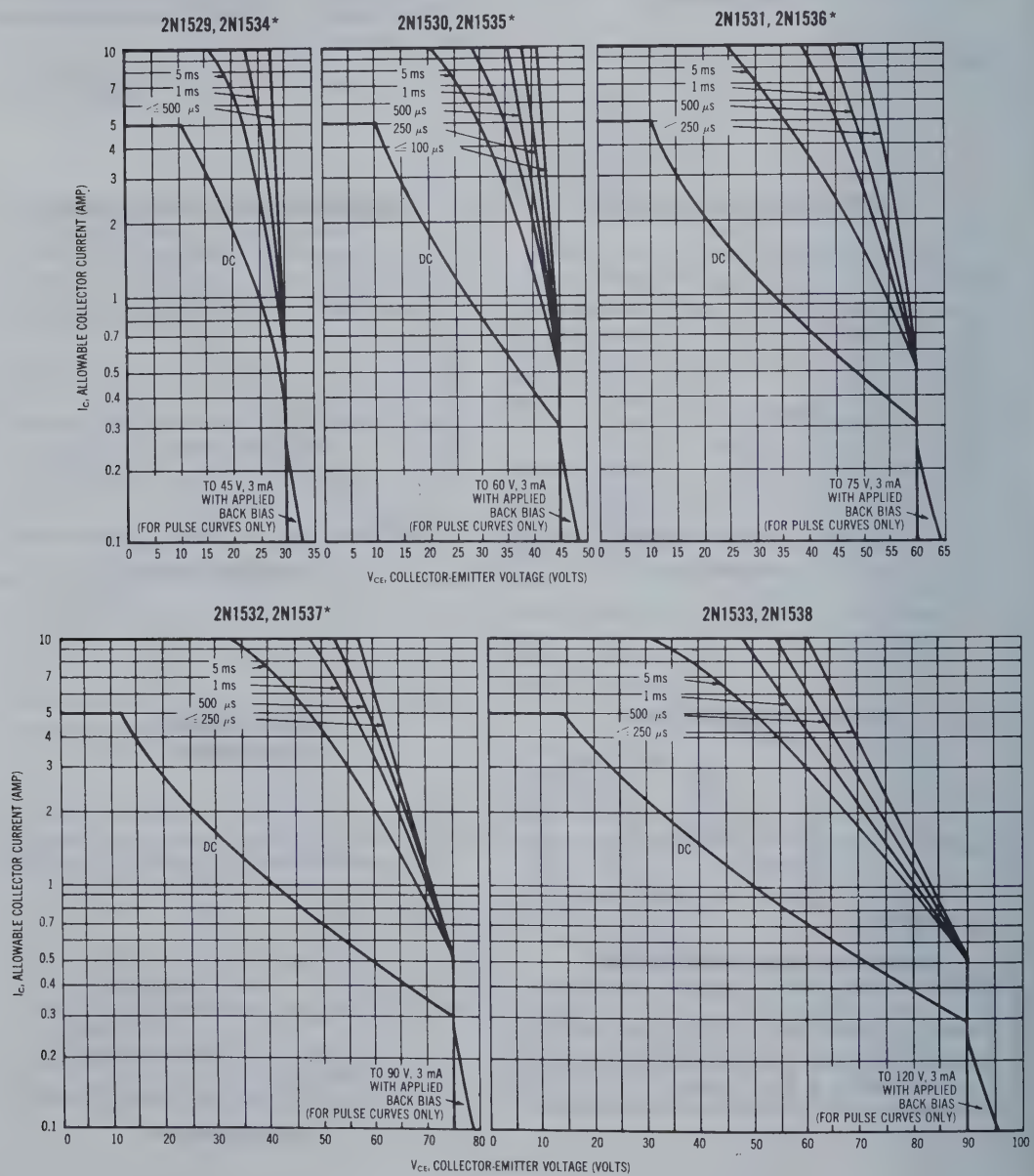
	I_C (AMP)	V (VOLTS)	R (ohms)	$t_d + t_r$ (μS)	t_s (μS)	t_f (μS)
2N1529-33	3	3	65	10	2	5
2N1534-38	3	3	100	8	3	5

DC CURRENT GAIN versus COLLECTOR CURRENT



SAFE OPERATING AREAS — PULSE CONDITIONS

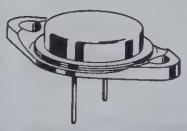
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.



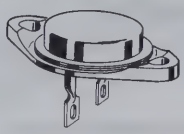
*Characteristics apply to corresponding "A" type numbers also.

2N1539 thru 2N1548 (GERMANIUM)
2N1539A thru 2N1542A, 2N1544A thru 2N1547A

PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.



CASE 11
(TO-3)



CASE 4-04
(TO-41)

For units with solder lugs attached, specify devices MP1539, A etc. (TO-41 package)

MAXIMUM RATINGS

Rating	Symbol	2N1539 2N1544	2N1540 2N1545	2N1541 2N1546	2N1542 2N1547	2N1543 2N1548	Unit
Collector-Emitter Voltage	V_{CEO}	20	30	40	50	60	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	120	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	50	60	Vdc
Collector Current-Continuous	I_C	5.0					Adc
Peak	I_C	10					Adc
Total Device Dissipation @T_C = 25° C	P_D	106					Watts
Operating Junction Temperature Range	T_J	-65 to +110					°C

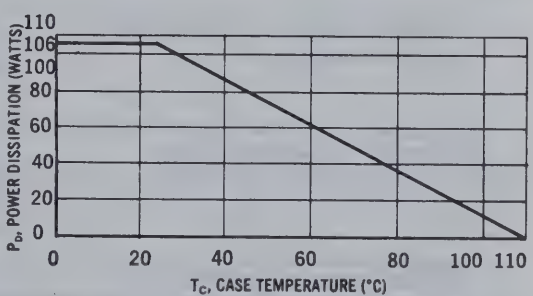
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For d.c. or frequencies below 25 cps the transistor must be operated within the constant P_D = Vc x Ic hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{110^{\circ} - Tc}{0.8}$$

POWER-TEMPERATURE DERATING CURVE



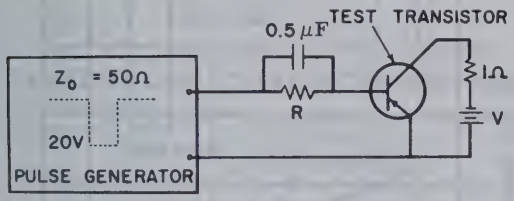
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage‡ (I_C = 500 mAdc, I_B = 0)	2N1539, 2N1544	BV_{CEO}‡	20	-	volts
	2N1540, 2N1545		30	-	
	2N1541, 2N1546		40	-	
	2N1542, 2N1547		50	-	
	2N1543, 2N1548		60	-	
Collector-Emitter Breakdown Voltage‡ (I_C = 500 mAdc, V_{BE} = 0)	2N1539, 2N1544	BV_{CES}‡	30	-	volts
	2N1540, 2N1545		45	-	
	2N1541, 2N1546		60	-	
	2N1542, 2N1547		75	-	
	2N1543, 2N1548		90	-	
Collector-Base Breakdown Voltage (I_C = 20 mAdc, I_E = 0)	2N1539, 2N1544	BV_{CBO}	40	-	volts
	2N1540, 2N1545		60	-	
	2N1541, 2N1546		80	-	
	2N1542, 2N1547		100	-	
	2N1543, 2N1548		120	-	
Collector Cutoff Current (V_{CE} @ rated V_{CB}, V_{BE} = 1.0 Vdc)		I_{CEX}	-	20	mA
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	0.2	mA
(V_{CB} = 1/2 V_{CES} rating, T_C = 90°C)			-	20	
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	2N1539, 2N1544	I_{CBO1}	-	2.0	mA
(V_{CB} = 40 Vdc, I_E = 0)	2N1540, 2N1545		-	2.0	
(V_{CB} = 55 Vdc, I_E = 0)	2N1541, 2N1546		-	2.0	
(V_{CB} = 65 Vdc, I_E = 0)	2N1542, 2N1547		-	2.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N1543, 2N1548		-	2.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N1539-2N1542	h_{FE1}	50	100	-
	2N1544-2N1547		75	150	
	2N1543		50	100	
	2N1548		75	150	
DC Transconductance (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N1539-2N1542	g_{FE}	3.0	-	mhos
	2N1544-2N1547		5.0	-	
	2N1543		3.0	-	
	2N1548		5.0	-	
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc)	2N1539-2N1542	$V_{CE(sat)}$	-	0.3	volts
	2N1544-2N1547		-	0.2	
	2N1543		-	0.3	
	2N1548		-	0.2	
Base-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc)	2N1539-2N1542	$V_{BE(sat)}$	-	0.7	volts
	2N1544-2N1547		-	0.5	
	2N1543		-	0.7	
	2N1548		-	0.5	
DYNAMIC CHARACTERISTICS					
Common-Emitter Cutoff Frequency (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		$f_{\alpha e}$	Typ 4.0		kHz

Characteristics apply to corresponding A type numbers also.

‡To avoid excessive heating of collector junction, perform this test with a sweep method.

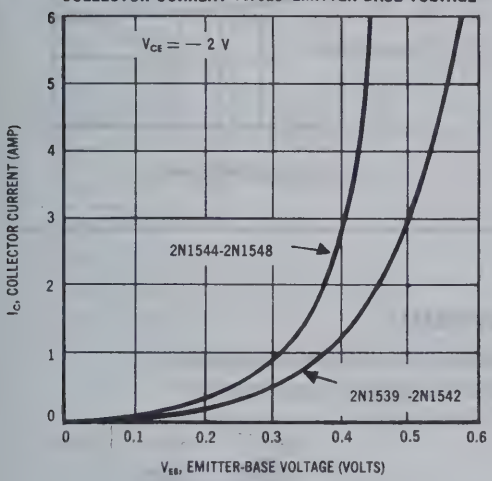
SWITCHING TIME MEASURING UNIT



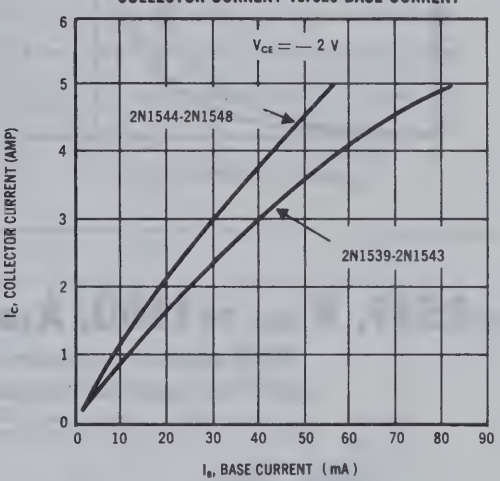
Devices	Conditions*			Typical Switching Times		
	I_C (Amp)	V (Volts)	R (ohms)	$t_d + t_r$ (μs)	t_s (μs)	t_f (μs)
2N1539-43	3	3	165	5	3	5
2N1544-48	3	3	250	5	3	8

*Input Pulse Repetition Rate = 2 kHz, Pulse Width = 50 μs

COLLECTOR CURRENT versus EMITTER BASE VOLTAGE



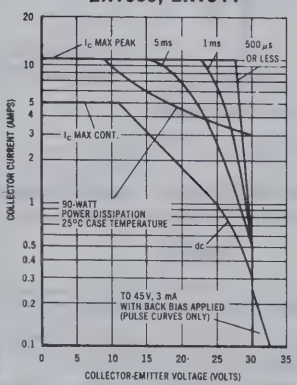
COLLECTOR CURRENT versus BASE CURRENT



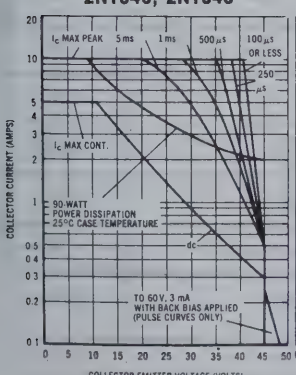
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate Ic — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum TJ, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

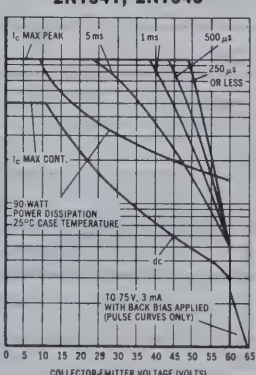
2N1539, 2N1544



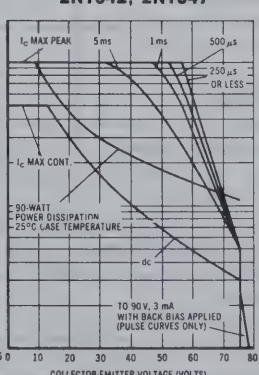
2N1540, 2N1545



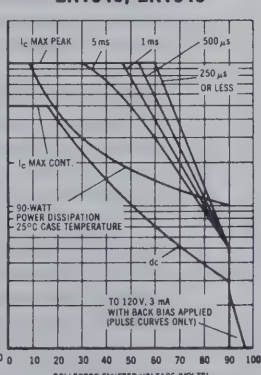
2N1541, 2N1546



2N1542, 2N1547

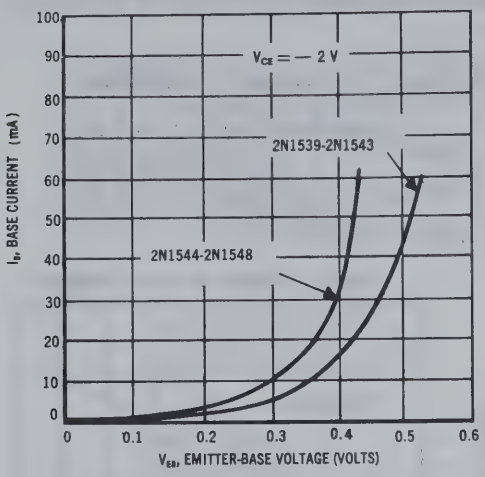


2N1543, 2N1548

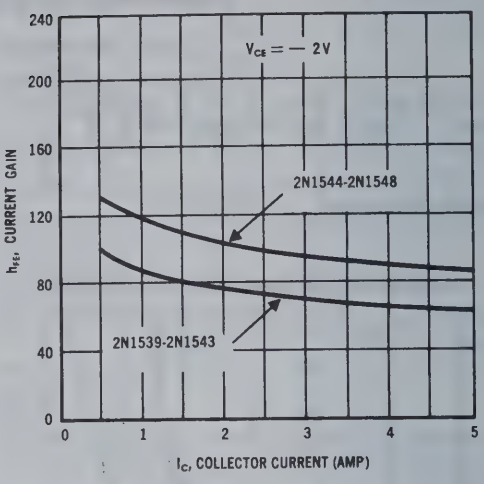


2N1539 thru 2N1548 (continued)

BASE CURRENT versus EMITTER BASE VOLTAGE

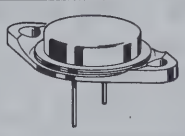


DC CURRENT GAIN versus COLLECTOR CURRENT



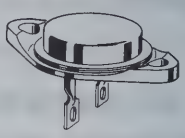
2N1549, A thru 2N1560, A (GERMANIUM)

PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.



CASE 11A
(TO-3 modified)

For units with solder lugs attached, specify devices MP1549, A etc. (TO-41 package)



CASE 4-04
(TO-41)

MAXIMUM RATINGS Apply to corresponding "Hi-Rel" Series also

Rating	Symbol	2N1549 2N1553 2N1557	2N1550 2N1554 2N1558	2N1551 2N1555 2N1559	2N1552 2N1556 2N1560	Units
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	Vdc
Collector-Emitter Voltage	V_{CES}*	30	45	60	75	Vdc
Collector-Emitter Voltage	V_{CEO}*	20	30	40	50	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	50	Vdc
Collector Current (Continuous)	I_C	15				Amp
Collector Current (Peak)	I_C	20				Amp
Collector Junction Temperature	T_J	-65 to +110				°C
Collector Dissipation (25°C Case Temp.)	P_D	106				Watts
Thermal Resistance	θ_{JC}	0.8				°C/W

*To avoid excessive heating of collector junction, perform this test with a sweep method.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristics apply to corresponding A type numbers also.

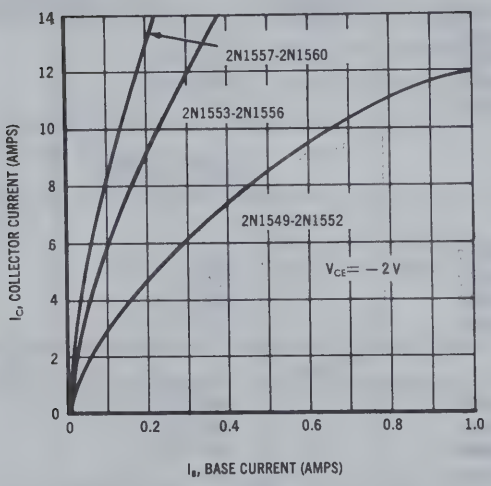
Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current	I_{CBO1}			mA
(V_{CB} = 25 V) 2N1549, 2N1553, 2N1557		-	3.0	
(V_{CB} = 40 V) 2N1550, 2N1554, 2N1558		-	3.0	
(V_{CB} = 55 V) 2N1551, 2N1555, 2N1559		-	3.0	
(V_{CB} = 65 V) 2N1552, 2N1556, 2N1560		-	3.0	
Collector-Base Cutoff Current	I_{CBO}			mA
(V_{CB} = 2 V)		-	0.2	
(V_{CB} = 1/2 BV_{CES} rating; T_C = +90°C)		-	20	
Emitter-Base Cutoff Current (V_{EB} = 12 V)	I_{EBO}	-	0.5	mA
Collector-Emitter Breakdown Voltage (I_C = 300 mA)	BV_{CES}			volts
2N1549, 2N1553, 2N1557		30	-	
2N1550, 2N1554, 2N1558		45	-	
2N1551, 2N1555, 2N1559		60	-	
2N1552, 2N1556, 2N1560		75	-	
Collector-Emitter Leakage Current (V_{BE} = 1.0 V, V_{CE} @ rated BV_{CBO})	I_{CEX}	-	20	mA
Collector-Emitter Breakdown Voltage* (I_C = 300 mA, I_B = 0)	BV_{CEO}*			volts
2N1549, 2N1553, 2N1557		20	-	
2N1550, 2N1554, 2N1558		30	-	
2N1551, 2N1555, 2N1559		40	-	
2N1552, 2N1556, 2N1560		50	-	
Collector-Base Breakdown Voltage (I_C = 20 mA)	BV_{CBO}			volts
2N1549, 2N1553, 2N1557		40	-	
2N1550, 2N1554, 2N1558		60	-	
2N1551, 2N1555, 2N1559		80	-	
2N1552, 2N1556, 2N1560		100	-	
Current Gain (V_{CE} = 2.0 V, I_C = 10 A)	h_{FE1}			-
2N1549 - 2N1552		10	30	
2N1553 - 2N1556		30	60	
2N1557 - 2N1560		50	100	
Base-Emitter Drive Voltage (I_C = 10 A, I_B = 1.0 A)	V_{BE}			volts
2N1549 - 2N1552		-	1.3	
2N1553 - 2N1556		-	1.0	
2N1557 - 2N1560		-	0.85	
Collector Saturation Voltage (I_C = 10 A, I_B = 1.0 A)	$V_{CE(sat)}$			volts
2N1549 - 2N1552		-	1.0	
2N1553 - 2N1556		-	0.7	
2N1557 - 2N1560		-	0.5	

*To avoid excessive heating of collector junction, perform this test with a sweep method.

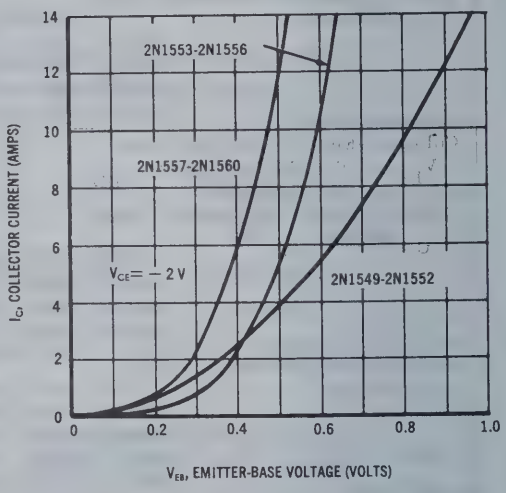
ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Transconductance (V_{CE} = 2.0 V, I_C = 10 A)	g_{FE}			mhos
2N1549 - 2N1552		6.0	18	
2N1553 - 2N1556		8.0	30	
2N1557 - 2N1560		12	40	
Frequency Cutoff	f_{ae}	Typ		kHz
2N1549 - 2N1552		10		
2N1553 - 2N1556		6.0		
2N1557 - 2N1560		5.0		

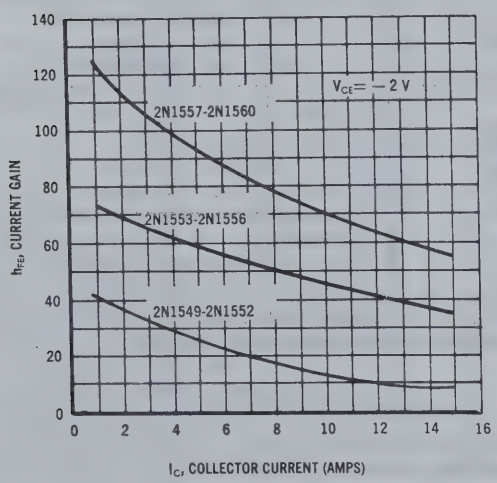
COLLECTOR CURRENT versus BASE CURRENT



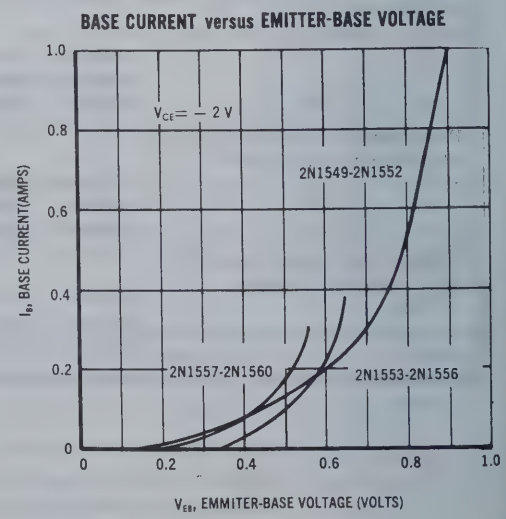
COLLECTOR CURRENT versus EMITTER-BASE VOLTAGE



CURRENT GAIN versus COLLECTOR CURRENT



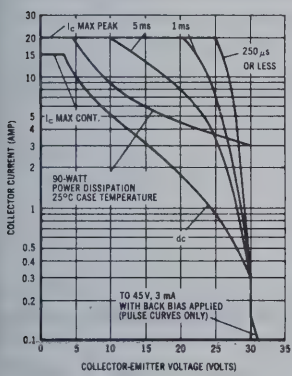
BASE CURRENT versus EMITTER-BASE VOLTAGE



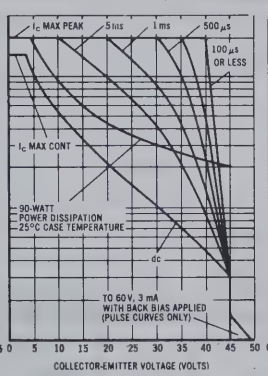
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

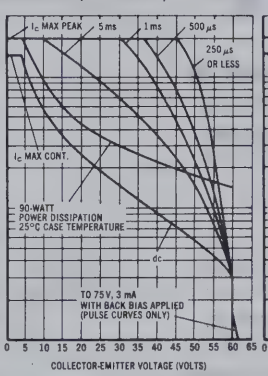
2N1549, 2N1553, 2N1557



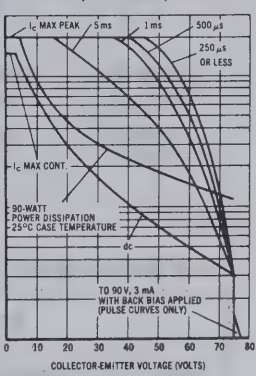
2N1550, 2N1554, 2N1558



2N1551, 2N1555, 2N1559

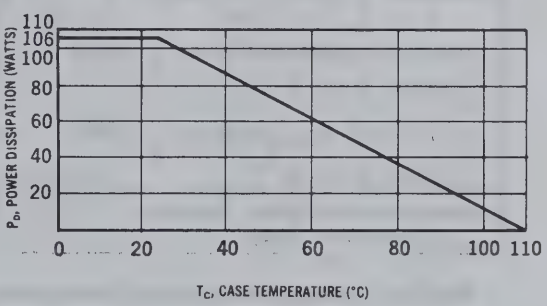


2N1552, 2N1556, 2N1560

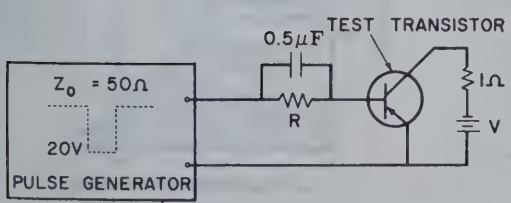


POWER-TEMPERATURE DERATING CURVE

The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For dc or frequencies below 25 Hz the transistor must be operated within the constant $P_D = Vc \times Ic$ hyperbolic curve. This curve has a value of 106 watts at case temperatures of 25°C and is 0 watts at 110°C with a linear relation between the two temperatures such that P_D allowable $= \frac{110^{\circ} - Tc}{0.8}$



SWITCHING TIME MEASURING UNIT



Devices	Conditions*			Typical Switching Times		
	I_C (Amp)	V (Volts)	R (ohms)	$t_d + t_r$ (μs)	t_s (μs)	t_f (μs)
2N1549 -52	10	10	10	5	2	10
2N1553 -56	10	10	30	10	5	25
2N1557 -60	10	10	50	10	5	25

*Input Pulse Repetition Rate = 2 kHz, Pulse Width = 50 μs

2N1561 (GERMANIUM)
2N1562
2N1692
2N1693





PNP germanium mesa transistors for VHF power amplifier applications.

Collector connected to case; stud isolated from case

CASE 23
(TO-107)
2N1561
2N1562

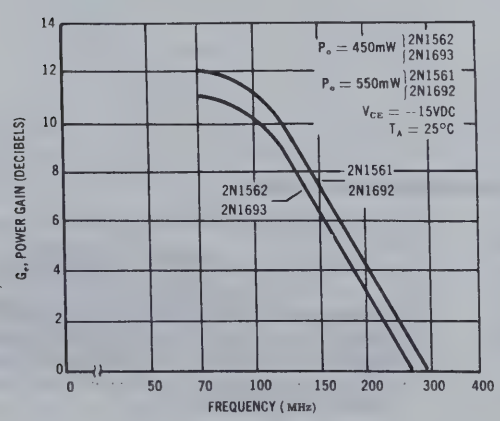
CASE 24
(TO-102)
2N1692
2N1693

MAXIMUM RATINGS

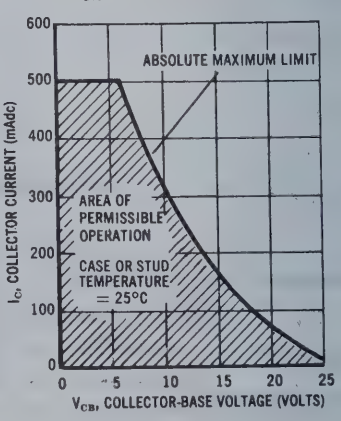
Rating	Symbol	2N1561	2N1562	2N1692	2N1693	Unit
Collector-Emitter Voltage	V_{CE}	25	25	25	25	Vdc
Collector-Base Voltage	V_{CB}	25	25	25	25	Vdc
Emitter-Base Voltage*	V_{EB}*	3	2	3	2	Vdc
Collector Current-Continuous Peak	I_C	250 500	250 500	250 500	250 500	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	250 3.33	250 3.33	350 4.67	350 4.67	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	3 40	3 40	3 40	3 40	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to 100				^oC

*May be exceeded provided total rated device dissipation is not exceeded.

POWER GAIN versus FREQUENCY



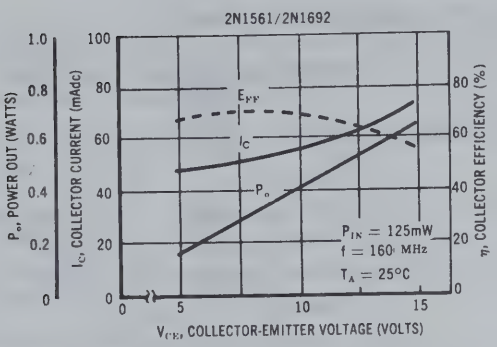
SAFE OPERATING AREA

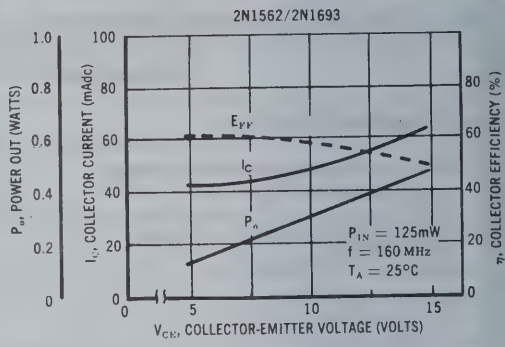


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

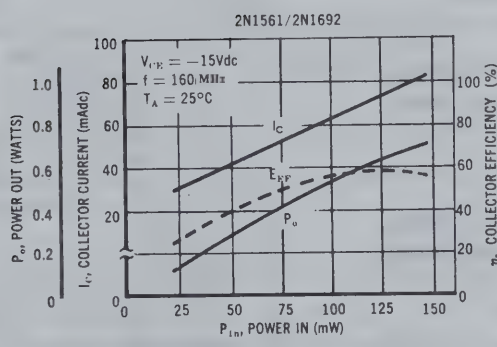
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	25	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	-	Adc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	1.5	10	μAdc
Emitter Cutoff Current (V_{BE} = 0.4 Vdc, I_C = 0) 2N1562, 2N1693	I_{EBO}	-	5.0	-	mAdc
(V_{BE} = 1.0 Vdc, I_C = 0) 2N1561, 2N1692		-	5.0	-	
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 40 mAdc) 2N1561, 2N1692	$V_{CE(sat)}$	-	-	3.0	Vdc
(I_C = 200 mAdc, I_B = 40 mAdc) 2N1562, 2N1693		-	-	4.0	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N1561, 2N1692	f_T	-	500	-	MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N1562, 2N1693		-	450	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	7	10	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 160 MHz) 2N1561, 2N1692	h_{fe}	-	10	-	dB
2N1562, 2N1693		-	9	-	
Extrinsic Base Resistance (I_E = 20 mAdc, V_{CB} = 10 Vdc, f = 300 MHz)	r'_b	-	25	-	Ohms
FUNCTIONAL TEST					
Power Gain (I_C = 100 mAdc, V_{CE} = 15 Vdc, P_{out} = 0.5 W, f = 160 MHz) 2N1561, 2N1692	G_{pe}	6	-	-	dB
(I_C = 100 mAdc, V_{CE} = 15 Vdc, P_{out} = 0.4 W, f = 160 MHz) 2N1562, 2N1693		5	-	-	
Power Output (I_C = 100 mAdc, V_{CE} = 15 Vdc, P_{in} = 125 mW, f = 160 MHz)	P_{out}				Watt
2N1561, 2N1692		0.5	-	-	
2N1562, 2N1693		0.4	-	-	

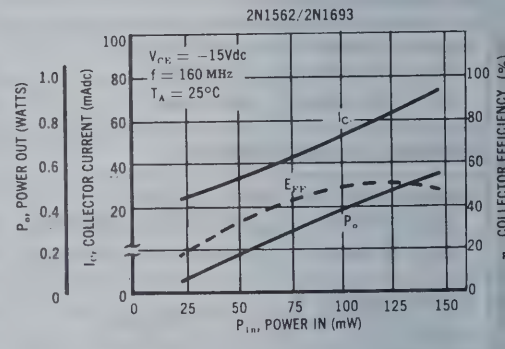
POWER OUT, COLLECTOR CURRENT AND COLLECTOR EFFICIENCY versus COLLECTOR-EMITTER VOLTAGE



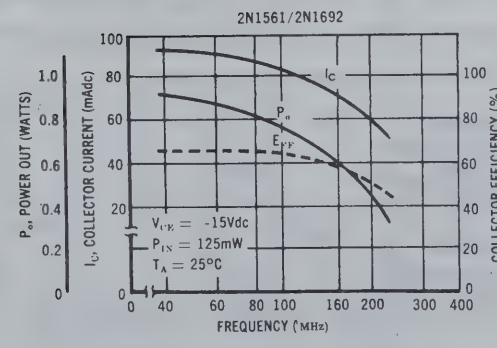


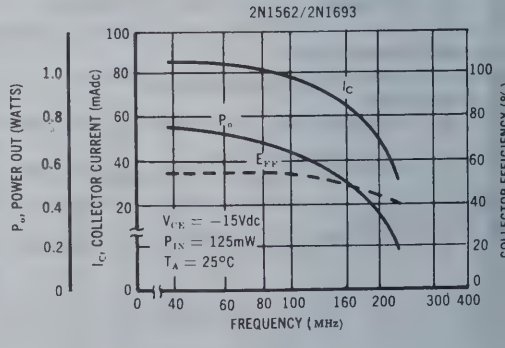
POWER OUT, COLLECTOR CURRENT AND COLLECTOR EFFICIENCY versus POWER IN





POWER OUT, COLLECTOR CURRENT AND COLLECTOR EFFICIENCY versus FREQUENCY





2N1595 thru 2N1599 (SILICON)



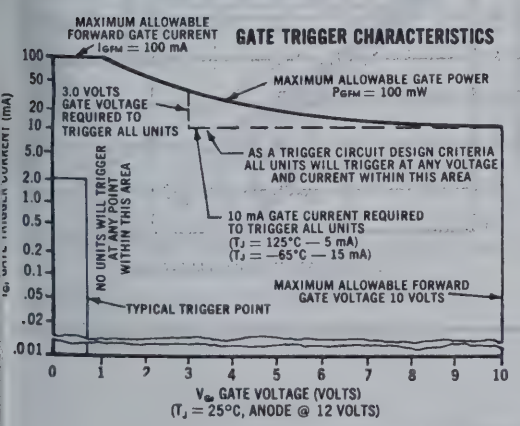
CASE 31(2)
(TO-5)

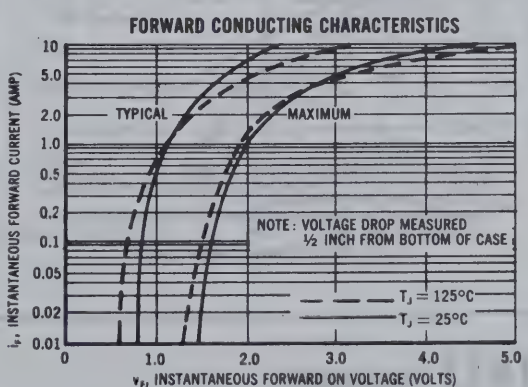
Industrial-type, low-current silicon controlled rectifiers in a three-lead package ideal for printed-circuit applications. Current handling capability of 1.6 amperes at junction temperatures to 125°C.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*		Volts
2N1595		50	
2N1596		100	
2N1597		200	
2N1598		300	
2N1599		400	
Forward Current RMS (All Conduction Angles)	I_f	1.6	Amp
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)	$I_{FM(surge)}$	15	Amp
Peak Gate Power - Forward	P_{GFM}	0.1	Watt
Average Gate Power - Forward	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current - Forward	I_{GFM}	0.1	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	10	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*V_{ROM} for all types can be applied on a continuous dc basis without incurring damage.





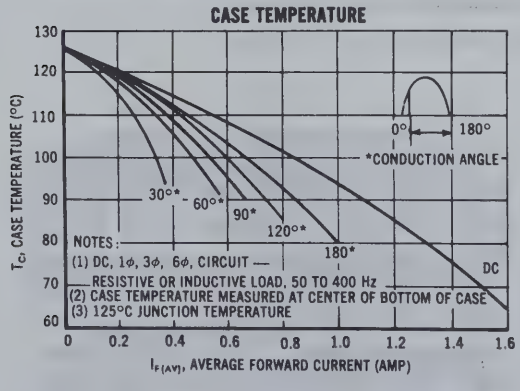
2N1595 thru 2N1599 (continued)

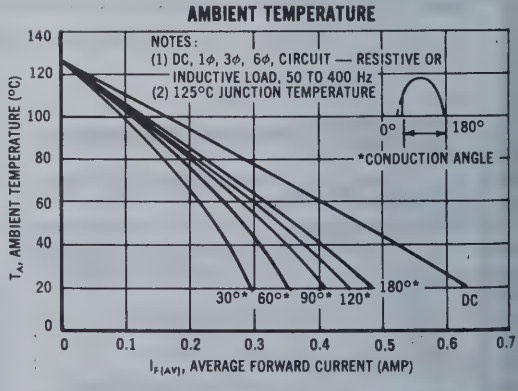
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* ($T_J = 125°C$) 2N1595	V_{FOM}*	50	—	—	Volts
2N1596		100	—	—	
2N1597		200	—	—	
2N1598		300	—	—	
2N1599		400	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, $T_J = 125°C$)	I_{FOM}	—	—	1.0	mA
Peak Reverse Blocking Current (Rated V_{ROM}, $T_J = 125°C$)	I_{ROM}	—	—	1.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 12\ \Omega$)	I_{GT}	—	2.0	10.0	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 12\ \Omega$)	V_{GT}	—	0.7	3.0	Volts
(Anode Voltage = Rated V_{FOM}, $R_L = 12\Omega$, $T_J = 125°C$)	V_{GNT}	0.2	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	5.0	—	mA
Forward On Voltage (I_F = 1 Adc)	V_F	—	1.1	2.0	Volts
Turn-On Time ($t_d + t_r$) (I_G = 10 mA, I_F = 1A)	t_{on}	—	0.8	—	μs
Turn-Off Time (I_F = 1 A, I_R = 1 A, dv/dt = 20 V/μs, $T_J = 125°C$) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)	t_{off}	—	10	—	μs

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage.

CURRENT DERATING



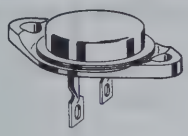


2N1613 (SILICON)

For Specifications, See 2N718A Data.

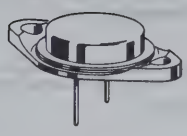
2N1651 thru 2N1653 (Germanium)

2N2285 thru 2N2287 (Germanium)



CASE 161
(TO-41)

2N1651 thru 2N1653
Collector connected to case



CASE 3A
(TO-3 modified)

2N2285 thru 2N2287

PNP Germanium power transistors designed for high-current switching applications requiring low saturation voltages and fast switching times in addition to good safe operating area.

MAXIMUM RATINGS

Rating	Symbol	2N1651 2N2285	2N1652 2N2286	2N1653 2N2287	Unit
Collector-Emitter Voltage	V_{CEO}	30	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	100	120	Vdc
Emitter-Base Voltage	V_{EB}	←	1.5	→	Vdc
Collector Current - Continuous	I_C	←	25	→	Adc
Base Current - Continuous	I_B	←	5.0	→	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	←	106 1.25	→	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	←	-65 to +110	→	°C

THERMAL CHARACTERISTICS

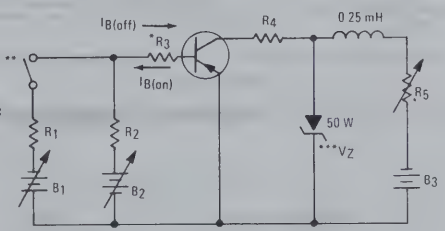
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT

R_1 = 1.0 Ohm, 20 Watts
R_2 = 7.5 Ohms, 2.0 Watts
R_3 = 0.1 Ohm, 1.0%
$R_4 \leq 0.04$ Ohm

R_5: I_C Adjust @ $V_{CE} = V_Z$
B_1: Adjust for $I_{B(on)} = \frac{I_C}{10}$
B_2 = 1.5 Vdc, Adjust for $I_{B(off)} = 0.2$ Adc
B_3 = 12 Vdc

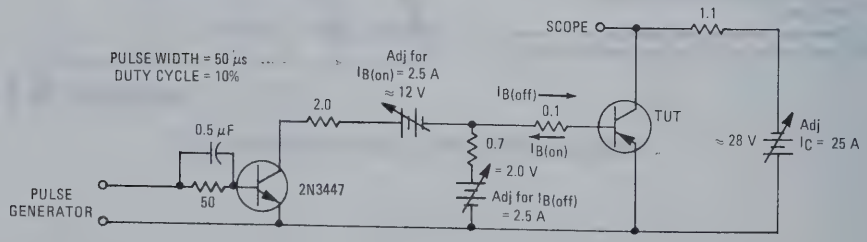
*Not required if current probe is used to read I_{B1}
**PRF ≈ 60 Hz
***Zener selected to establish Sustaining Voltage.
NOTE: Series impedance and inductance must be kept to a minimum.



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	2N1651, 2N2285	BV_{CEO}	30	-	Vdc
	2N1652, 2N2286		60	-	
	2N1653, 2N2287		80	-	
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 25 Adc)	2N1651, 2N2285	$V_{CE(sus)}$	40	-	Vdc
	2N1652, 2N2286		45	-	
	2N1653, 2N2287		50	-	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO1}	-	200	μAdc
Collector Cutoff Current		I_{CBO2}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N1651, 2N2285		-	5.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N1652, 2N2286		-	5.0	
(V_{CB} = 100 Vdc, I_E = 0)	2N1653, 2N2287		-	5.0	
Collector Cutoff Current		I_{CBO3}			mAdc
(V_{CB} = 40 Vdc, I_E = 0, T_C = 100°C) (+0, -3.0°C)	2N1651, 2N2285		-	35	
(V_{CB} = 80 Vdc, I_E = 0, T_C = 100°C) (+0, -3.0°C)	2N1652, 2N2286		-	35	
(V_{CB} = 100 Vdc, I_E = 0, T_C = 100°C) (+0, -3.0°C)	2N1653, 2N2287		-	35	
Collector Cutoff Current		I_{CBO4}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N1651, 2N2285		-	20	
(V_{CB} = 100 Vdc, I_E = 0)	2N1652, 2N2286		-	20	
(V_{CB} = 120 Vdc, I_E = 0)	2N1653, 2N2287		-	20	
Emitter Cutoff Current (V_{EB} = 1.5 Vdc, I_C = 0)		I_{EBO}	-	50	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)			35	140	
(I_C = 25 Adc, V_{CE} = 1.5 Vdc)			20	-	
Collector-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{CE(sat)}$	-	0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{BE(sat)}$	-	0.65	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)		h_{fe}	20	-	-
SWITCHING CHARACTERISTICS					
Rise Time	(I_C = 25 Adc, $I_{B(on)}$ = 2.5 Adc, $I_{B(off)}$ = 2.5 Adc) (See Figure 2)	t_r	-	12	μs
Storage Time		t_s	-	10	μs
Fall Time		t_f	-	8.0	μs

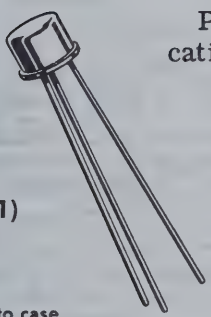
FIGURE 2 – SWITCHING TIME TEST CIRCUIT



2N1692, 2N1693

For Specifications, See 2N1561 Data.

2N1705 thru 2N1707 (GERMANIUM)



CASE 31(1)
(TO-5)

Base connected to case

PNP germanium transistors for audio driver applications in transistorized radio receivers.

MAXIMUM RATINGS

Rating	Symbol	2N1705	2N1706	2N1707	Unit
Collector-Base Voltage	V_{CB}	18	25	30	Volts
Collector-Emitter Voltage (R_{BE} = 1 K)	V_{CER}	12	18	25	Volts
Emitter-Base Voltage	V_{EB}	5.0	5.0	10	Volts
Collector Current	I_C	400			mA
Collector Dissipation at T_C = 25°C	P_D	200			mW
Junction Temperature Range	T_J	-65 to +100			°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = -10 Vdc)	2N1705		---	5.0	10	
	2N1706		---	---	10	
(V_{CB} = -25 Vdc)	2N1707		---	---	15	
Emitter-Base Cutoff Current		I_{EBO}				μAdc
(V_{EB} = -5 Vdc)	2N1705		---	4.0	20	
	2N1706		---	---	20	
(V_{EB} = -10 Vdc)	2N1707		---	---	10	
Collector-Emitter Voltage		BV_{CER}				Vdc
(I_C = 1 mAdc, R_{BE} = 1 K)	2N1705		12	---	---	
	2N1706		18	---	---	
	2N1707		25	---	---	
Base-Emitter Voltage		V_{BE}				V
(I_C = 10 mA, V_{CE} = 5 V)	2N1706		0.15	---	0.35	
(I_C = 20 mA, V_{CE} = 1 V)	2N1705		0.2	---	0.4	
DC Current Gain		h_{FE}				---
(I_C = 10 mAdc, V_{CE} = -5 V)	2N1707		40	90	150	
(I_C = 20 mAdc, V_{CE} = -1 V)	2N1706		60	---	120	
Small Signal Current Gain		h_{fe}				---
(I_C = 1 mA, V_{CE} = -6 V, f = 1 kHz)	2N1705		70	110	150	
(I_C = 10 mA, V_{CE} = -5 V, f = 1 kHz)	2N1706		50	90	150	
	2N1707		30	---	150	
Output Admittance Conductance		h_{ob}				μmhos
(I_C = 1 mA, V_{CB} = -6 V, f = 1 kHz)	2N1705		---	0.5	---	
(I_C = 10 mA, V_{CE} = -5 V, f = 1 kHz)	2N1706, 2N1707		---	3.0	---	
Input Impedance		h_{ib}				ohms
(I_C = 1 mA, V_{CE} = -6 V, f = 1 kHz)	2N1705		---	30	---	
(I_C = 10 mA, V_{CE} = -5 V, f = 1 kHz)	2N1706, 2N1707		---	4.0	---	
Voltage Feedback Ratio						
(I_C = 1 mA, V_{CB} = -6 V, f = 1 kHz)	2N1705	h_{rb}	---	3.0	---	$X10^{-4}$
(I_C = 10 mA, V_C = -5 V, f = 1 kHz)	2N1706	h_{re}	---	0.69	---	$X10^{-3}$
	2N1707	h_{rb}	---	4.5	---	$X10^{-4}$
Frequency Cutoff		$f_{\alpha b}$				MHz
(I_C = 1 mA, V_C = -6 V)	2N1706, 2N1707		---	3.0	---	
	2N1705		---	4.0	---	
Output Capacitance		C_{ob}				pF
(I_C = 1 mA, V_{CB} = -6 V, f = 1 MHz)			---	20	---	
Noise Figure		NF				dB
(I_C = 1 mA, V_{CB} = -6 V, R_s = 1 K, f = 1 kHz)	2N1705		---	6.0	---	

2N1708 (SILICON)

CASE 26
(TO-46)



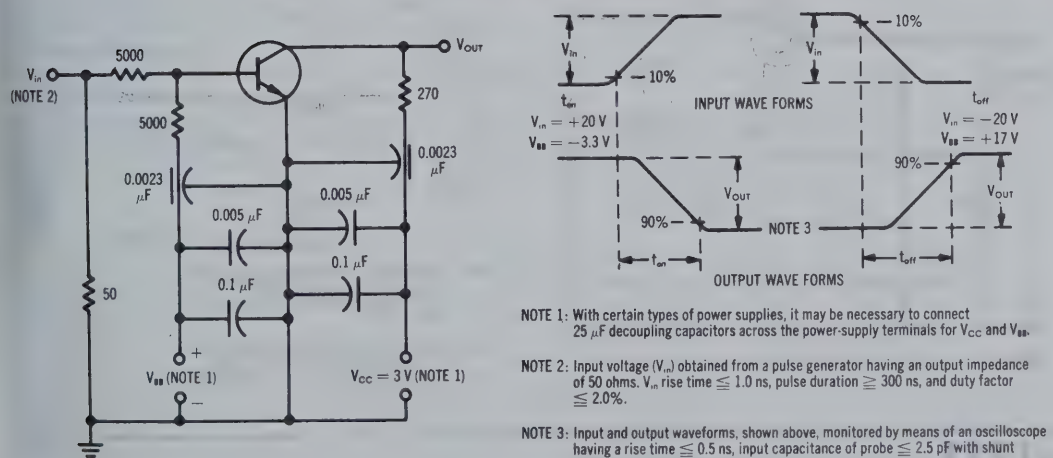
Collector electrically connected to case

NPN silicon transistor designed for very high-speed, low-power saturated switching applications for computers in military and industrial service.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 6.67	Watt mW/°C
Operating Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT



NOTE 1: With certain types of power supplies, it may be necessary to connect 25 μF decoupling capacitors across the power-supply terminals for V_{CC} and V_{BB}.

NOTE 2: Input voltage (V_{in}) obtained from a pulse generator having an output impedance of 50 ohms. V_{in} rise time ≦ 1.0 ns, pulse duration ≧ 300 ns, and duty factor ≦ 2.0%.

NOTE 3: Input and output waveforms, shown above, monitored by means of an oscilloscope having a rise time ≦ 0.5 ns, input capacitance of probe ≦ 2.5 pF with shunt resistance ≧ 3000 ohms.

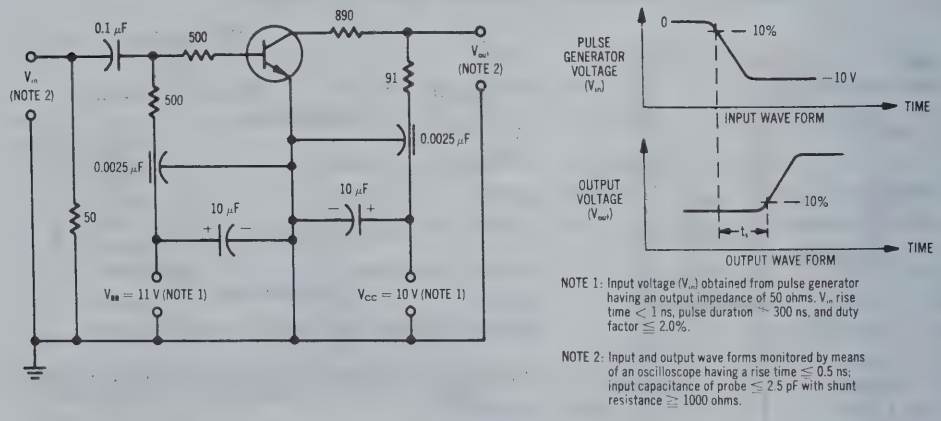
2N1708 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	12	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector-Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0.25 Vdc, T_A = 100°C)	I_{CEX}	-	15	μAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	0.025 15	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	-	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	- -	0.22 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	6.0	pF
Turn-On Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{on}	-	40	ns
Turn-Off Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{off}	-	75	ns
Storage Time (Figure 2) (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	-	25	ns

* Pulse Test: Pulse Length ≤ 6.0 ms, Duty Cycle ≤ 30%.

FIGURE 2 — STORAGE TIME TEST CIRCUIT



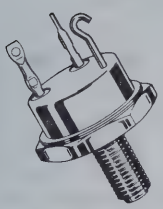
NOTE 1: Input voltage (V_{in}) obtained from pulse generator having an output impedance of 50 ohms. V_{in} rise time < 1 ns, pulse duration ≈ 300 ns, and duty factor ≦ 2.0%.

NOTE 2: Input and output wave forms monitored by means of an oscilloscope having a rise time ≦ 0.5 ns; input capacitance of probe ≦ 2.5 pF with shunt resistance ≧ 1000 ohms.

2N1711

For Specifications, See 2N718A Data.

2N1724 (SILICON)
2N1725



CASE 9
(TO-61)

NPN silicon power transistors designed for switching and amplifier applications.

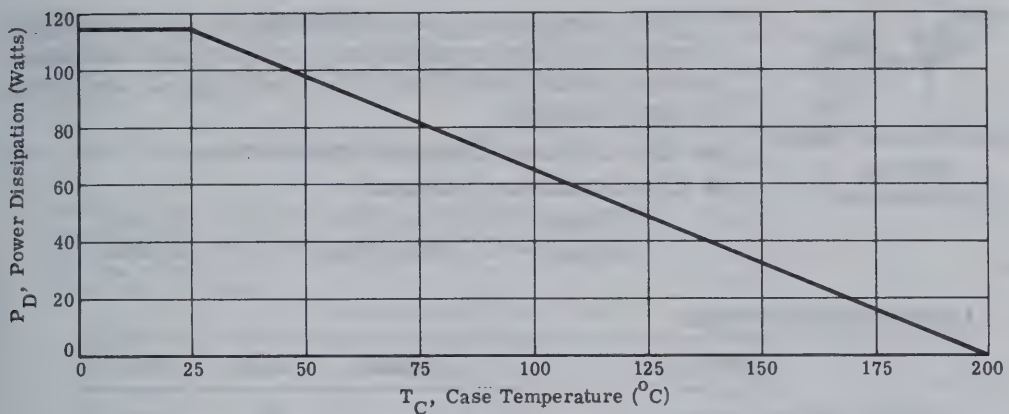
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	120	Vdc
Collector-Emitter Voltage	V_{CE}	80	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current (Continuous)	I_C	5.0	Adc
Power Dissipation	P_D	117	Watts
Thermal Resistance, Junction to Case	θ_{JC}	1.5	$^oC/W$
Junction Operating Temperature Range	T_J	-65 to +200	^oC

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Emitter-Base Cutoff Current		I_{EBO}				mAdc
(V_{EB} = 9 Vdc)	2N1725		-	-	0.5	
(V_{EB} = 10 Vdc)			-	-	10.0	
Collector-Emitter Cutoff Current		I_{CES}				mAdc
(V_{CE} = 60 Vdc, V_{BE} = 0)			-	-	1.0	
(V_{CE} = 60 Vdc, V_{BE} = 0, T_C = 150°C)			-	-	2.0	
(V_{CE} = 120 Vdc, V_{BE} = 0, T_C = 150°C)			-	-	10.0	
Collector-Base Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 3 Vdc, I_E = 0)			-	-	0.1	
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$				Vdc
(I_C = 200 mAdc, I_B = 0)			80	-	-	
DC Current Gain		h_{FE}				
(V_{CE} = 15 Vdc, I_C = 2 Adc)	2N1724		20	40	90	
	2N1725		50	90	150	
(V_{CE} = 15 Vdc, I_C = 2 Adc, T_A = -55°C)	2N1724		12	-	-	
	2N1725		25	-	-	
(V_{CE} = 15 Vdc, I_C = 0.1 Adc)	2N1724		20	-	-	
	2N1725		50	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 2 Adc, I_B = 200 mAdc)				0.5	1.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 2 Adc, I_B = 200 mAdc)				1.2	2.0	
High Frequency Current Gain		h_{fe}				
(V_{CE} = 15 Vdc, I_C = 0.5 Adc, f = 10 MHz)			1.0	1.6	-	
Common Base Output Capacitance		C_{ob}				pF
(V_{CB} = 10 Vdc, f = 0.1 MHz)				260	550	
Switching Times						μs
(I_C = 2 Adc, I_{B1} = $-I_{B2}$ = 0.2 Adc)						
Delay time plus Rise time		$t_d + t_r$	-	0.15	-	
Storage time		t_s	-	1.3	-	
Fall time		t_f		0.14		

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



SAFE OPERATING AREAS

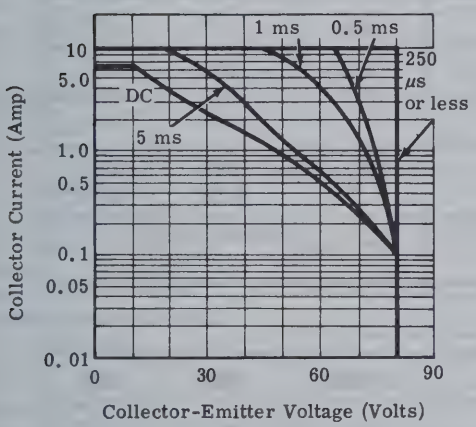
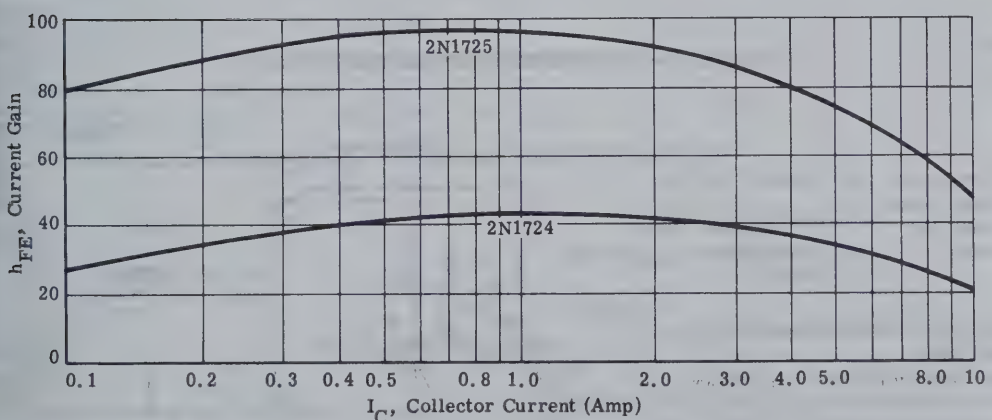


FIGURE 2 — 2N1724, 2N1725

In using these curves the average power derating curve (Fig. 1) must be observed to ensure operation below the maximum junction temperature.

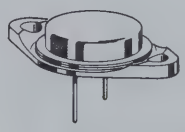
FIGURE 3 — DC CURRENT GAIN versus COLLECTOR CURRENT



2N1742

For Specifications, See 2N499 Data.

2N1751 (GERMANIUM)



Collector Connected to Case

CASE 3A
(TO-3 modified)

PNP Germanium power transistor designed for high-current switching applications requiring low saturation voltages, short switching times and good sustaining voltage capability.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages –
  $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 20 Adc
  $V_{BE(sat)}$ = 0.7 Vdc (Max) @ I_C = 20 Adc

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
*Collector-Base Voltage	V_{CB}	80	Vdc
*Emitter-Base Voltage	V_{EB}	2.5	Vdc
*Collector Current - Continuous	I_C	25	Adc
Base Current - Continuous	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	106 1.25	Watts W/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

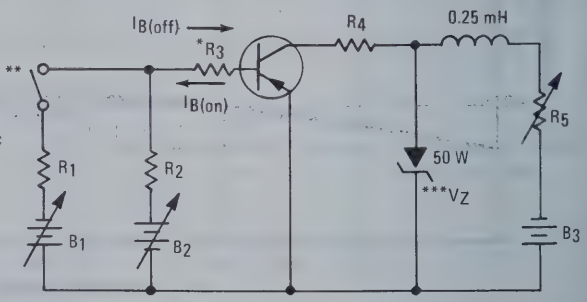
Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT

R_1 = 1.0 Ohm, 20 Watts
R_2 = 10 Ohms, 2.0 Watts
R_3 = 0.1 Ohm, 1.0%
$R_4 \leq$ 0.04 Ohm

R_5: I_C Adjust @ $V_{CE} = V_Z$
B_1: Adjust for $I_{B(on)} = \frac{I_C}{10}$
B_2 = 2.0 Vdc, Adjust for $I_{B(off)}$ = 0.2 Adc
B_3 = 12 Vdc



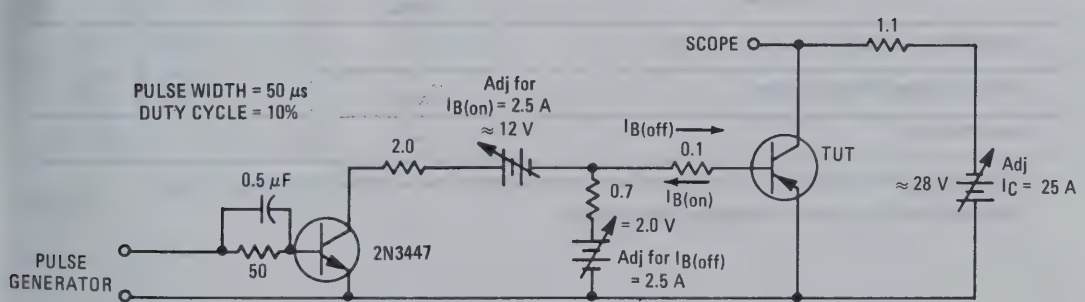
*Not required if current probe is used to read I_B
**PRF ≈ 60 Hz
***Zener selected to establish Sustaining Voltage.
NOTE: Series impedance and inductance must be kept to a minimum. Adjust input pulse width for I_C = 25 A condition.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	60	-	Vdc
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 25 Adc)	$V_{CE(sus)}$	45	-	Vdc
*Floating Potential (V_{CB} = 80 Vdc, I_E = 0)	V_{EBF}	-	1.0	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 80 Vdc, R_{BE} = 50 Ohms)	I_{CER}	-	50	mAdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{BE} = 0)	I_{CES}	-	5.0	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	I_{CBO1}	-	200	μAdc
Collector Cutoff Current *(V_{CB} = 80 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0, T_C = 100°C, +0, -3°C)	I_{CBO2}	- -	5.0 25	mAdc
*Emitter Cutoff Current (V_{EB} = 2.5 Vdc, I_C = 0)	I_{EBO}	-	50	mAdc
ON CHARACTERISTICS				
*DC Current Gain (I_C = 20 Adc, V_{CE} = 1.5 Vdc)	h_{FE}	30	90	-
Collector-Emitter Saturation Voltage (I_C = 20 Adc, I_B = 2.5 Adc)	$V_{CE(sat)}$	-	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 20 Adc, I_B = 2.5 Adc)	$V_{BE(sat)}$	-	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
*Common-Base Cutoff Frequency (I_C = 0.5 Adc, V_{CB} = 10 Vdc)	$f_{\alpha b}$	1.5	-	MHz
*Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)	h_{fe}	20	-	-
SWITCHING CHARACTERISTICS				
Rise Time	t_r	-	12	μs
Storage Time (I_C = 25 Adc, $I_{B(on)}$ = 2.5 Adc, $I_{B(off)}$ = 2.5 Adc) (See Figure 2)	t_s	-	10	μs
Fall Time	t_f	-	8.0	μs

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



2N1842 thru 2N1850 (SILICON)



CASE 64
(TO-48)

Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 16 amperes at junction temperatures to 100°C.

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted)

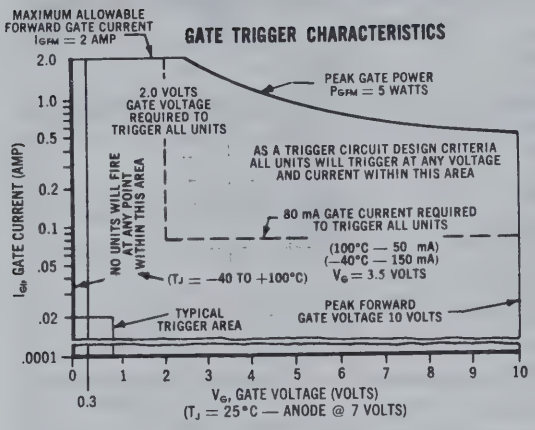
Rating		Symbol	Value	Unit
Peak Reverse Blocking Voltage*		$V_{ROM(rep)}$*		Volts
	2N1842		25	
	2N1843		50	
	2N1844		100	
	2N1845		150	
	2N1846		200	
	2N1847		250	
	2N1848		300	
	2N1849		400	
	2N1850		500	
Peak Reverse Blocking Voltage (Transient) (Non-Recurrent 5 ms max.)		$V_{ROM(non-rep)}$		Volts
	2N1842		35	
	2N1843		75	
	2N1844		150	
	2N1845		225	
	2N1846		300	
	2N1847		350	
	2N1848		400	
	2N1849		500	
	2N1850		600	
Forward Current RMS (All Conduction Angles)		I_f	16	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t ≤ 8.3 ms)		I^2t	60	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -40 to +100°C)		$I_{FM(surge)}$	125	Amp
Peak Gate Power - Forward		P_{GFM}	5.0	Watts
Average Gate Power Forward		$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward		I_{FGM}	2.0	Amp
Peak Gate Voltage - Forward		V_{GFM}	10	Volts
Reverse		V_{GRM}	5.0	
Operating Junction Temperature Range		T_J	-40 to +100	°C
Storage Temperature Range		T_{stg}	-40 to +125	°C
Stud Torque		—	30	in. lb.

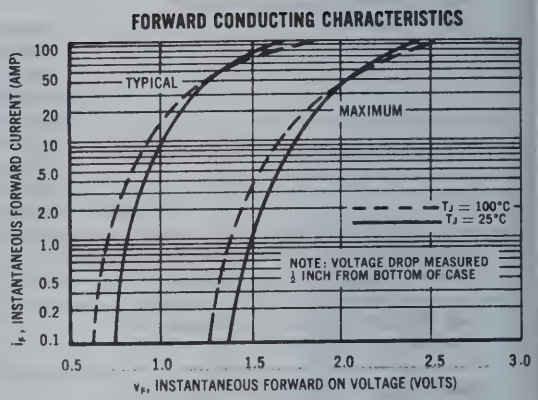
*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

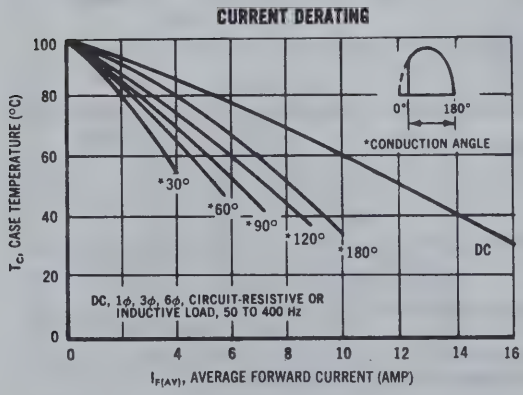
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

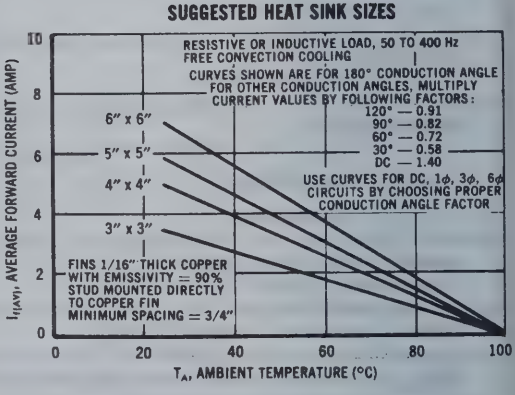
Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 100°C)		V_{FOM}*				Volts
	2N1842		25	—	—	
	2N1843		50	—	—	
	2N1844		100	—	—	
	2N1845		150	—	—	
	2N1846		200	—	—	
	2N1847		250	—	—	
	2N1848		300	—	—	
	2N1849		400	—	—	
	2N1850		500	—	—	
Peak Forward or Reverse Blocking Current (Rated V_{FOM} or V_{ROM} gate open, T_J = 100°C)		I_{FOM} I_{ROM}	—	—	6.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		I_{GT}	—	15	80	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		V_{GT}	—	0.8	2.0	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50Ω, T_J = 100°C)		V_{GNT}	0.3	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_{HO}	—	20	—	mA
Forward On Voltage (I_F = 16 Adc)		V_F	—	1.1	1.8	Volts
Turn-On Time (t_d + t_r) (I_G = 50 mA, I_F = 10 A)		t_{on}	—	1.0	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A; dv/dt = 20 V/μs, T_J = 100°C) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)		t_{off}	—	25	—	μs
Forward Voltage Application Rate (Gate open, T_J = 100°C)		dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case)		θ_{JC}	—	1.0	2.0	°C/W

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage.
Ratings apply for zero or negative voltage.


GATE TRIGGER CHARACTERISTICS
MAXIMUM ALLOWABLE FORWARD GATE CURRENT
I_{GFM} = 2 AMP
PEAK GATE POWER
P_{GFM} = 5 WATTS
2.0 VOLTS GATE VOLTAGE REQUIRED TO TRIGGER ALL UNITS
AS A TRIGGER CIRCUIT DESIGN CRITERIA ALL UNITS WILL TRIGGER AT ANY VOLTAGE AND CURRENT WITHIN THIS AREA
NO UNITS WILL FIRE AT ANY VOLTAGE WITHIN THIS AREA
80 mA GATE CURRENT REQUIRED TO TRIGGER ALL UNITS
(100°C — 50 mA)
(—40°C — 150 mA)
V_G = 3.5 VOLTS
(T_J = —40 TO +100°C)
TYPICAL TRIGGER AREA
PEAK FORWARD GATE VOLTAGE 10 VOLTS
I_{GT}, GATE CURRENT (AMP)
V_G, GATE VOLTAGE (VOLTS)
(T_J = 25°C — ANODE @ 7 VOLTS)


FORWARD CONDUCTING CHARACTERISTICS
TYPICAL
MAXIMUM
T_J = 100°C
T_J = 25°C
NOTE: VOLTAGE DROP MEASURED ⅛ INCH FROM BOTTOM OF CASE
i_F, INSTANTANEOUS FORWARD CURRENT (AMP)
v_F, INSTANTANEOUS FORWARD ON VOLTAGE (VOLTS)


CURRENT DERATING
*CONDUCTION ANGLE
*30°
*60°
*90°
*120°
*180°
DC
DC, 1φ, 3φ, 6φ, CIRCUIT-RESISTIVE OR INDUCTIVE LOAD, 50 TO 400 Hz
T_C, CASE TEMPERATURE (°C)
$I_{F(AV)}$, AVERAGE FORWARD CURRENT (AMP)


SUGGESTED HEAT SINK SIZES
RESISTIVE OR INDUCTIVE LOAD, 50 TO 400 Hz
FREE CONVECTION COOLING
CURVES SHOWN ARE FOR 180° CONDUCTION ANGLE
FOR OTHER CONDUCTION ANGLES, MULTIPLY CURRENT VALUES BY FOLLOWING FACTORS:
120° — 0.91
90° — 0.82
60° — 0.72
30° — 0.58
DC — 1.40
USE CURVES FOR DC, 1φ, 3φ, 6φ CIRCUITS BY CHOOSING PROPER CONDUCTION ANGLE FACTOR
6″ x 6″
5″ x 5″
4″ x 4″
3″ x 3″
FINS 1/16″ THICK COPPER WITH EMISSIVITY = 90% STUD MOUNTED DIRECTLY TO COPPER FIN MINIMUM SPACING = 3/4″
$I_{F(AV)}$, AVERAGE FORWARD CURRENT (AMP)
T_A, AMBIENT TEMPERATURE (°C)

2N1842A thru 2N1850A (SILICON)



CASE 64
(TO-48)

Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 16 amperes at junction temperatures to 125°C.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

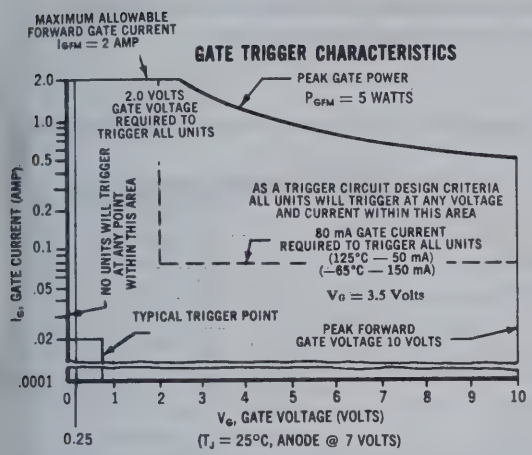
Rating		Symbol	Value	Unit
Peak Reverse Blocking Voltage*		$V_{ROM(rep)}$*		Volts
	2N1842A		25	
	2N1843A		50	
	2N1844A		100	
	2N1845A		150	
	2N1846A		200	
	2N1847A		250	
	2N1848A		300	
	2N1849A		400	
	2N1850A		500	
Peak Reverse Blocking Voltage (Transient) (Non-Recurrent 5 ms max.)		$V_{ROM(non-rep)}$		Volts
	2N1842A		35	
	2N1843A		75	
	2N1844A		150	
	2N1845A		225	
	2N1846A		300	
	2N1847A		350	
	2N1848A		400	
	2N1849A		500	
	2N1850A		600	
Forward Current RMS		I_f	16	Amp
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)		$I_{FM(surge)}$	125	Amp
Circuit Fusing Considerations (T_J = -65 to +125°C, t ≦ 8.3 ms)		I^2t	60	A^2s
Peak Gate Power - Forward		P_{GFM}	5.0	Watts
Average Gate Power - Forward		$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward		I_{GFM}	2.0	Amp
Peak Gate Voltage - Forward		V_{GFM}	10	Volts
Reverse		V_{GRM}	5.0	
Operating Junction Temperature Range		T_J	-65 to +125	°C
Storage Temperature Range		T_{stg}	-65 to +150	°C
Stud Torque		—	30	in. lb.

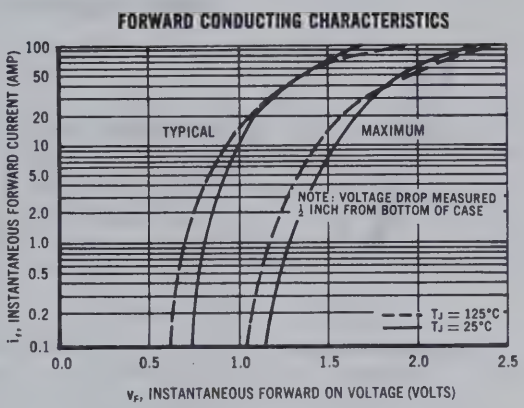
*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

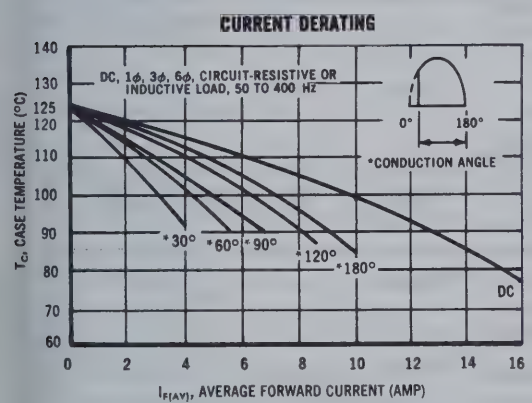
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

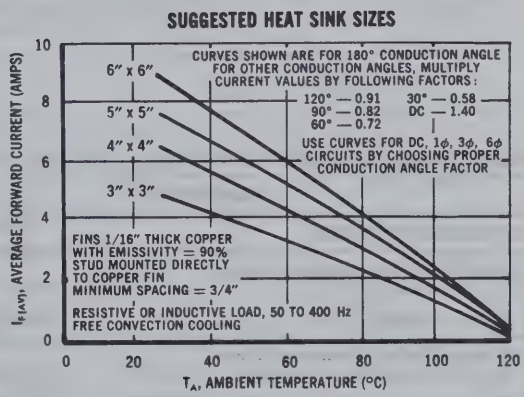
Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* ($T_J = 125°C$)		V_{FOM}*				Volts
	2N1842A		25	—	—	
	2N1843A		50	—	—	
	2N1844A		100	—	—	
	2N1845A		150	—	—	
	2N1846A		200	—	—	
	2N1847A		250	—	—	
	2N1848A		300	—	—	
	2N1849A		400	—	—	
	2N1850A		500	—	—	
Peak Forward or Reverse Blocking Current (V_{FOM}, OR V_{ROM}, gate open, $T_J = 125°C$)		I_{FOM} I_{ROM}	—	—	6.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)		I_{GT}	—	15	80	mA
Gate Trigger Voltage (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)		V_{GT}	—	0.8	2.0	Volts
(Anode Voltage = Rated V_{FOM}, $R_L = 50\ \Omega$, $T_J = 125°C$)		V_{GNT}	0.25	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_{HO}	—	20	—	mA
Forward On Voltage (I_F = 16 Adc)		V_F	—	1.1	1.6	Volts
Turn-On Time ($t_d + t_r$) (I_G = 50 mA, I_F = 10 A)		t_{on}	—	1.0	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A, dv/dt = 20 V/μs, $T_J = 125°C$)		t_{off}	—	30	—	μs
Forward Voltage Application Rate (Gate Open, $T_J = 125°C$)		dv/dt	—	30	—	V/ μs
Thermal Resistance (Junction to Case)		θ_{JC}	—	1.0	2.0	°C/W

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage.
Ratings apply for zero or negative gate voltage.


GATE TRIGGER CHARACTERISTICS
MAXIMUM ALLOWABLE FORWARD GATE CURRENT I_{GFM} = 2 AMP
PEAK GATE POWER P_{GFM} = 5 WATTS
2.0 VOLTS GATE VOLTAGE REQUIRED TO TRIGGER ALL UNITS
NO UNITS WILL TRIGGER AT ANY POINT WITHIN THIS AREA
AS A TRIGGER CIRCUIT DESIGN CRITERIA ALL UNITS WILL TRIGGER AT ANY VOLTAGE AND CURRENT WITHIN THIS AREA
80 mA GATE CURRENT REQUIRED TO TRIGGER ALL UNITS (125°C — 50 mA) (—65°C — 150 mA)
V_G = 3.5 Volts
TYPICAL TRIGGER POINT
PEAK FORWARD GATE VOLTAGE 10 VOLTS
I_G, GATE CURRENT (AMP)
V_G, GATE VOLTAGE (VOLTS)
(T_J = 25°C, ANODE @ 7 VOLTS)


FORWARD CONDUCTING CHARACTERISTICS
TYPICAL
MAXIMUM
NOTE: VOLTAGE DROP MEASURED ½ INCH FROM BOTTOM OF CASE
T_J = 125°C
T_J = 25°C
i_F, INSTANTANEOUS FORWARD CURRENT (AMP)
v_F, INSTANTANEOUS FORWARD ON VOLTAGE (VOLTS)


CURRENT DERATING
DC, 1ϕ, 3ϕ, 6ϕ, CIRCUIT-RESISTIVE OR INDUCTIVE LOAD, 50 TO 400 Hz
0°
180°
*CONDUCTION ANGLE
*30°
*60°
*90°
*120°
*180°
DC
T_C, CASE TEMPERATURE (°C)
$I_{F(AV)}$, AVERAGE FORWARD CURRENT (AMP)


SUGGESTED HEAT SINK SIZES
CURVES SHOWN ARE FOR 180° CONDUCTION ANGLE
FOR OTHER CONDUCTION ANGLES, MULTIPLY CURRENT VALUES BY FOLLOWING FACTORS:
120° — 0.91
90° — 0.82
60° — 0.72
30° — 0.58
DC — 1.40
USE CURVES FOR DC, 1ϕ, 3ϕ, 6ϕ CIRCUITS BY CHOOSING PROPER CONDUCTION ANGLE FACTOR
6″ x 6″
5″ x 5″
4″ x 4″
3″ x 3″
FINS 1/16″ THICK COPPER WITH EMISSIVITY = 90% STUD MOUNTED DIRECTLY TO COPPER FIN
MINIMUM SPACING = 3/4″
RESISTIVE OR INDUCTIVE LOAD, 50 TO 400 Hz
FREE CONVECTION COOLING
$I_{F(AV)}$, AVERAGE FORWARD CURRENT (AMPS)
T_A, AMBIENT TEMPERATURE (°C)

2N1893 (SILICON)
2N2405

NPN silicon annular transistors designed for medium-power amplifier and switching applications.



Collector connected to case

CASE 31
(TO-5)

MAXIMUM RATINGS

Rating	Symbol	2N1893	2N2405	Unit
Collector-Emitter Voltage	V_{CEO}	80	90	Vdc
Collector-Emitter Voltage	V_{CER}	100	140	Vdc
Collector-Base Voltage	V_{CB}	120		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current	I_C	0.5	1.0	Adc
Total Device Dissipation @ T_A = 25°C	P_D	0.8	1.0	Watt
Derate above 25°C		4.57	5.71	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	3.0	5.0	Watts
Derate above 25°C		17.2	28.6	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N1893	2N2405	Unit
Thermal Resistance, Junction to Case	θ_{JC}	58.3	35	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	219	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

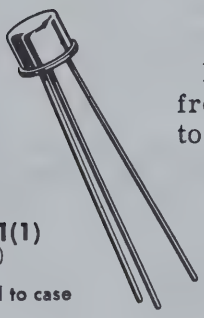
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, I_B = 0)	2N1893	$BV_{CEO(sus)}$*	80	-	Vdc
(I_C = 100 mAdc, I_B = 0)	2N2405		90	-	
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, R_{BE} = 10 ohms)	2N1893	$BV_{CER(sus)}$	100	-	Vdc
	2N2405		140	-	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	120	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0)		I_{CBO}	-	0.01	μAdc
(V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)	2N1893		-	15	
	2N2405		-	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	0.01	μAdc

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			-
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N1893		20	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N1893		35	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N1893		20	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N1893		40	120	
	2N2405		60	200	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N1893		-	1.2	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N1893		-	5.0	
	2N2405		-	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N1893		-	0.9	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N1893		-	1.3	
	2N2405		-	1.1	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N1893	f_T	50	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, 100 kHz ≤ f ≤ 1.0 MHz)		C_{ob}	-	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, 100 kHz ≤ f ≤ 1.0 MHz)	2N1893	C_{ib}	-	85	pF
Input Impedance		h_{ib}			ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N1893		20	30	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N1893, 2N2405		4.0	8.0	
Voltage Feedback Ratio		h_{rb}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N1893		-	1.25	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N1893		-	1.5	
	2N2405		-	3.0	
Small-Signal Current Gain		h_{fe}			-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1893		30	100	
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2405		50	275	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N1893		45	-	
Output Admittance		h_{ob}			μmho
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N1893		-	0.5	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N1893, 2N2405		-	0.5	

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N1924 thru 2N1926 (GERMANIUM)



CASE 31(1)
(TO-5)
Base connected to case

PNP germanium transistors for general purpose, low-frequency applications. Characteristics curves similar to 2N524-2N527 series.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	25	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_J & T_{stg}	-65 to +100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = -45 Vdc, I_E = 0	I_{CBO}	–	10	μAdc
Emitter Cutoff Current V_{EB} = -25 Vdc, I_C = 0	I_{EBO}	–	10	μAdc
Collector-Base Voltage I_C = 200 μAdc, I_E = 0	V_{CBO}	60	–	Vdc
Collector-Emitter Voltage I_C = 50 μAdc, V_{BE} = +1.5 Vdc, R_{BE} = 10 K	V_{CEX}	50	–	Vdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 10 K	V_{CER}	40	–	Vdc
Punch-Thru Voltage (V_{EB} = 1 Vdc, VTVM Z ≥ 1 Megohm)	V_{pt}	50	–	Vdc

ELECTRICAL CHARACTERISTICS (continued)

Characteristics	Symbol	Min	Max	Unit
DC Current Gain I_C = 20 mAdc, V_{CE} = -1 Vdc	h_{FE}			
2N1924		34	65	–
2N1925		53	90	
2N1926		72	121	
DC Current Gain I_C = 100 mAdc, V_{CE} = -1 Vdc	h_{FE}			
2N1924		30	–	–
2N1925		47	–	
2N1926		65	–	
Collector-Emitter Saturation Voltage	$V_{CE(SAT)}$			
I_B = 1.33 mAdc, I_C = 20 mAdc 2N1924		50	110	mVdc
I_B = 1.0 mAdc, I_C = 20 mAdc 2N1925		55	110	
I_B = 0.67 mAdc, I_C = 20 mAdc 2N1926		60	110	
Base Input Voltage V_{CE} = -1 Vdc, I_C = 20 mAdc	V_{BE}			
2N1924		200	300	mVdc
2N1925		190	290	
2N1926		180	280	
Output Capacitance; Input AC Open Circuit V_{CB} = -5 Vdc, I_E = 1 mAdc, f = 1 MHz	C_{ob}	–	30	pF
Frequency Cutoff V_{CB} = -5 Vdc, I_E = 1 mAdc	$f_{\alpha b}$			
2N1924		1.0	–	MHz
2N1925		1.3	–	
2N1926		1.5	–	
Small-Signal Short-Circuit Forward-Transfer Current Ratio V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 kHz	h_{fe}			
2N1924		30	64	–
2N1925		44	88	
2N1926		60	120	
Small-Signal Open Circuit Output Admittance V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 kHz	h_{oe}			
2N1924		15	60	μmho
2N1925		20	65	
2N1926		25	70	
Small-Signal Open-Circuit Reverse-Transfer Voltage Ratio V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 kHz	h_{re}			
2N1924		2.0	8.0	$X10^{-4}$
2N1925		3.0	9.0	
2N1926		4.0	10	
Small-Signal Short-Circuit Input Impedance V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 kHz	h_{ie}			
2N1924		700	2200	ohms
2N1925		1200	3200	
2N1926		1500	4200	

2N1959 (SILICON)



CASE 31
(TO-5)

Collector connected to case

NPN silicon annular transistor designed for high-speed, medium-power saturated switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage R_{BE} = 10 ohms	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	600 4.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 1.3	Watts mW/°C
Operating Junction Temperature Range	T_J	-65to + 175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

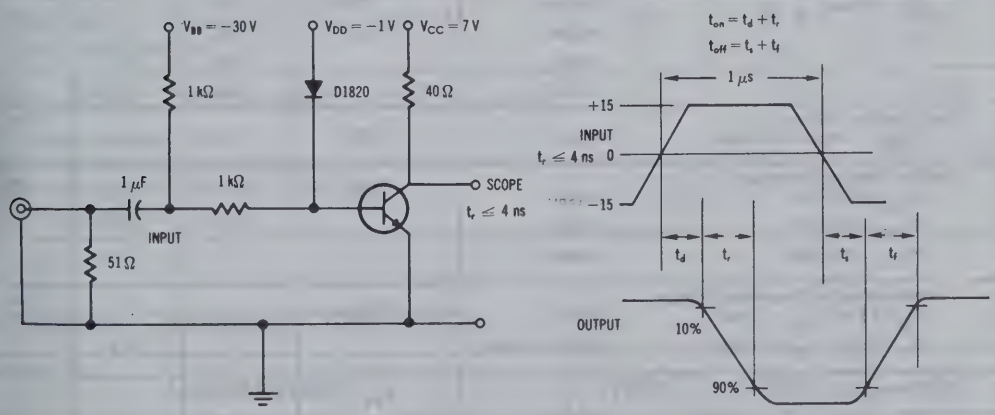
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 50 μAdc, R_{BE} = 10 ohms)	BV_{CER}	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.5 300	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	120	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 25 mAdc, V_{CB} = 10 Vdc, f = 100 MHz)	f_T	100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	18	pF
Turn-On Time	t_{on}	—	65	ns
Turn-Off Time	t_{off}	—	45	ns
Storage Time	t_s	—	25	ns

Figure 1 (V_{CC} = 7 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc,

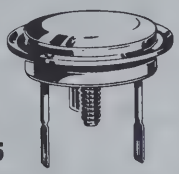
*t_{on}, t_{off}, and t_s measured from 50% point of input pulse.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



2N1970 (GERMANIUM)

2N1980 thru 2N1982



CASE 5
(TO-36)

PNP germanium power transistors for general purpose amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	2N1970	2N1980	2N1981	2N1982	Unit
Collector-Base Voltage	V_{CB}	100	50	70	90	Volts
Collector-Emitter Voltage	V_{CEO}	50	30	40	50	Volts
Emitter-Base Voltage	V_{EB}	40	20	20	20	Volts
Collector Current	I_C	15				Amp
Power Dissipation at $T_C = 25^oC$	P_D	170				Watts
Junction Temperature Range	T_J	-65 to +110				^oC

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = -100 Vdc)	2N1970		—	4.0	
(V_{CB} = -50 Vdc)	2N1980		—	6.0	
(V_{CB} = -70 Vdc)	2N1981		—	6.0	
(V_{CB} = -90 Vdc)	2N1982		—	6.0	
(V_{CB} = -2 Vdc)	2N1980-2N1982		—	0.3	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = -40 Vdc)	2N1970		—	4.0	
(V_{EB} = -20 Vdc)	2N1980-2N1982		—	5.0	
(V_{EB} = -2 Vdc)	2N1980-2N1982		—	0.3	
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 1 Adc, I_B = 0)	2N1970		50	—	
	2N1980		30	—	
	2N1981		40	—	
	2N1982		50	—	
Base-Emitter Voltage		V_{BE}			Vdc
(V_{CE} = -2 Vdc, I_C = 5 Adc)	2N1970		—	0.9	
Emitter Floating Potential		V_{EBF}			Vdc
(V_{CB} = -50 Vdc)	2N1980		—	1.0	
(V_{CB} = -70 Vdc)	2N1981		—	1.0	
(V_{CB} = -90 Vdc)	2N1982		—	1.0	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 12 Adc, I_B = 2 Adc)	2N1970		—	1.0	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N1980-2N1982		—	0.5	
DC Current Gain		h_{FE}			—
(I_C = 5 Adc, V_{CE} = -2 Vdc)	2N1970		17	40	
	2N1980-2N1982		50	100	
(I_C = 12 Adc, V_{CE} = -2 Vdc)	2N1970		10	—	
Common Emitter Cutoff Frequency		$f_{\alpha e}$			kHz
(V_{CE} = -4 V, I_C = 5 A)	2N1970		5.0	—	
(V_{CE} = -5 V, I_C = 2 A)	2N1980-2N1982		3.0	—	

2N1983 (SILICON)
2N1984



NPN silicon annular small-signal transistor.

CASE 31
(TO-5)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 4.8	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 16	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	62.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	208	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	25	-	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, $R_{BE} \leq$ 10 ohms)		$BV_{CER(sus)}$*	30	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	5.0	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)			-	200	
Emitter-Cutoff Current ($V_{EB(off)}$ = 2.0 Vdc, I_C = 0)		I_{EBO}	-	100	μAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	-	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	40	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)		C_{ob}	-	45	pF
Input Impedance (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc)	2N1983	h_{ie}	-	2.0	k ohm
	2N1984		-	1.2	
Input Resistance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	20	30	ohm
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)			4.0	8.0	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1983	h_{rb}	-	7.0	X 10^{-4}
	2N1984		-	5.0	
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1983		-	7.0	
	2N1984		-	5.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1983	h_{fe}	70	210	-
	2N1984		35	100	
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1983		80	240	
	2N1984		40	120	
Output Admittance (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc)	2N1983	h_{oe}	-	200	-
	2N1984		-	100	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	-	1.0	μmho
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)			-	1.5	

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N1990 (SILICON)



CASE 79
(TO-39)

NPN silicon transistor designed for driving neon display tubes.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current-Continuous	I_C	1.0	Adc
Total Device Dissipation $T_A = 25°C$ Derate above 25°C	P_D	0.6 4.8	W mW/°C
Total Device Dissipation $T_C = 2.5°C$ @ $T_C = 100°C$	P_D	2.0 1.0	W
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	62.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	208	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current (V_{CE} = 75 Vdc, I_B = 10 μAdc) (V_{CE} = 75 Vdc, I_B = 250 μAdc, $T_A = 150°C$	I_{CEX}	- -	10 250	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	-	-
Collector-Emitter Saturation Voltage (I_C = 2.0 mAdc, I_B = 0.2 mAdc)	$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 2.0 mAdc, I_B = 0.2 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc

2N1991 (SILICON)

For Specifications, See 2N1131 Data.

2N2042, 2N2043 (GERMANIUM)



CASE 31(1)
(TO-5)

PNP germanium transistors suitable for high-voltage audio switching and amplifier applications. Suitable for high-reliability projects.

All leads isolated from case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	105	Vdc
Collector-Emitter Voltage	V_{CES}	105	Vdc
Emitter-Base Voltage	V_{EB}	75	Vdc
Collector Current (Continuous)	I_C	200	mAdc
Operating Junction Temperature Range	T_J	-65 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +100	°C
Collector Dissipation, Ambient Derate above 25°C	P_D	200 2.67	mW mW/°C
Thermal Resistance (Junction to Ambient)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

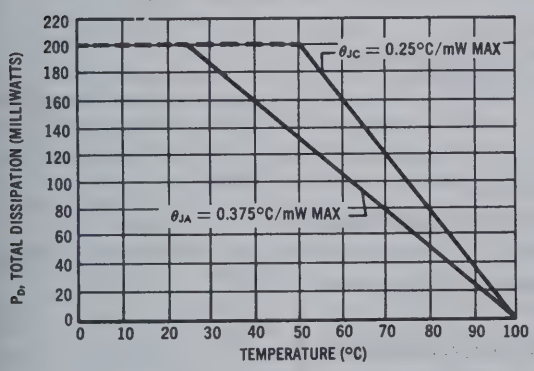
ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 105 V, I_E = 0)			–	25	
(V_{CB} = 2.5 V, I_E = 0)			–	10	
(V_{CB} = 105 V, I_E = 0, T_A = +71°C)			–	500	
Emitter-Base Cutoff Current		I_{EBO}			μAdc
(V_{EB} = 75 V, I_C = 0)			–	50	
(V_{EB} = 2.5 V, I_C = 0)			–	10	
Collector-Emitter Cutoff Current		I_{CER}			μAdc
(V_{CE} = 55 V, R_{BE} = 10 K)			–	600	
Collector-Emitter Cutoff Current		I_{CES}			mAdc
(V_{CE} = 105 V, V_{BE} = 0)			–	1.0	
DC Collector-Emitter Punch-Through Voltage		V_{pt}			Vdc
(V_{fl} = 1.0 V, VTVM R_{in} 10-12 megohm)			105	–	
DC Current Gain		h_{FE}			–
(I_C = 5 mA, V_{CE} = 0.35 V)	2N2042		20	50	
	2N2043		40	100	
Common Base, Small-Signal Input Impedance		h_{ib}			Ohms
(V_{CB} = 6 V, I_E = 1 mA, f = 1 kHz)			30	50	

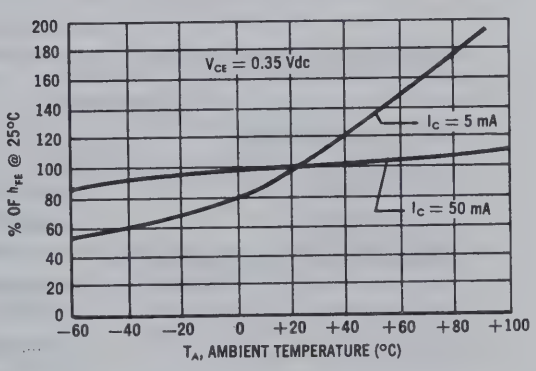
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
Common Base, Small-Signal Output Admittance (V_{CB} = 6 V, I_E = 1 mA, f = 1 kHz)		h_{ob}	0.1	1.0	μmho
Common Emitter, Small-Signal Current Transfer Ratio (V_{CE} = 6 V, I_C = 1 mA, f = 1 kHz)	2N2042 2N2043	h_{fe}	20 45	80 180	–
Base-Emitter Saturation Voltage (I_C = 5 mA, I_B = 0.25 mA)		$V_{BE(sat)}$	–	0.30	Vdc
Collector-Emitter Saturation Voltage (I_C = 5 mA, I_B = 0.25 mA) (I_C = 100 mA, I_B = 10 mA)		$V_{CE(sat)}$	– –	0.25 0.75	Vdc
Collector Output Capacitance (V_{CB} = 6 V, I_E = 0)		C_{ob}	–	25	pF
Common-Base, Small-Signal Forward Current Transfer Ratio Cutoff Frequency (V_{CB} = 6 V, I_E = 1 mA)	2N2042 2N2043	$f_{\alpha b}$	0.50 0.75	– –	MHz

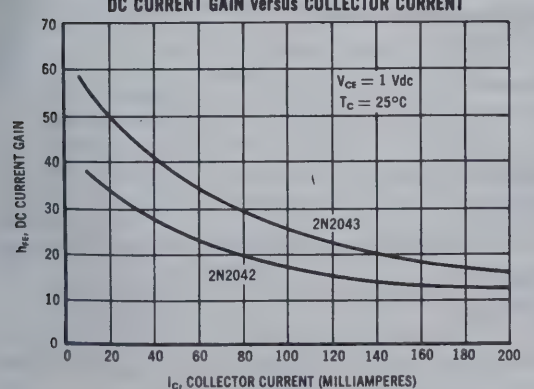
POWER-TEMPERATURE DERATING CURVE



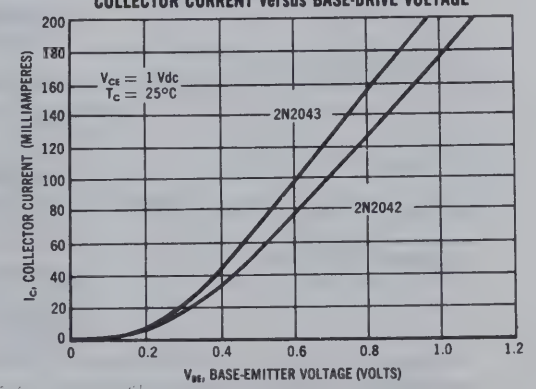
LARGE SIGNAL CURRENT GAIN versus TEMPERATURE



DC CURRENT GAIN versus COLLECTOR CURRENT



COLLECTOR CURRENT versus BASE-DRIVE VOLTAGE

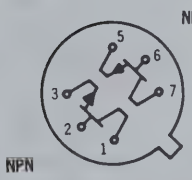


2N2060, A
2N2223, A
2N2480, A

NPN silicon annular Star dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.



CASE 32C



PINS 4 AND 8 OMITTED
Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	2N2060 2N2060A 2N2223 2N2223A	2N2480	2N280A	Unit
Collector-Emitter Voltage	V_{CEO}	60	40	40	Vdc
Collector-Emitter Voltage	V_{CER}	80	-	-	Vdc
Collector-Base Voltage	V_{CB}	100	75	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0	5.0	5.0	Vdc
Collector Current	I_C	◄——— 500 ———►			mAdc
Operating Junction Temperature	T_J	◄——— 200 ———►			°C
Storage Temperature Range	T_{stg}	◄——— -65 to +200 ———►			°C
		One Side	Both Sides		
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	0.6 3.43		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.6 9.1	3.0 17.2		Watts mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage*		BV_{CEO}*			Vdc
(I_C = 20 mAdc, I_B = 0)	2N2480, 2N2480A		40	-	
(I_C = 30 mAdc, I_B = 0)	2N2060, 2N2060A, 2N2223, 2N2223A		60	-	
Collector-Emitter Breakdown Voltage*		BV_{CER}*			Vdc
(I_C = 100 mAdc, $R_{BE} \leq$ 10 ohms)	2N2060, 2N2060A, 2N2223, 2N2223A		80	-	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	2N2060, 2N2060A, 2N2223, 2N2223A		100	-	
	2N2480		75	-	
	2N2480A		80	-	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 100 μAdc, I_C = 0)	2N2060, 2N2060A, 2N2223, 2N2223A		7.0	-	
	2N2480, 2N2480A		5.0	-	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N2480, 2N2480A		-	15	
(V_{CB} = 60 Vdc, I_E = 0)	2N2480		-	0.050	
	2N2480A		-	0.020	
(V_{CB} = 80 Vdc, I_E = 0)	2N2060, 2N2060A		-	0.002	
	2N2223, 2N2223A		-	0.010	
(V_{CB} = 80 Vdc, I_E = 0, T_A = 150°C)	2N2060, 2N2060A		-	10	
	2N2223, 2N2223A		-	15	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{BE} = 5.0 Vdc, I_C = 0)	2N2060, 2N2060A		-	2.0	
	2N2223, 2N2223A		-	10	
	2N2480		-	50	
	2N2480A		-	20	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		25	75	
	2N2223, 2N2223A		15	-	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		30	90	
	2N2223, 2N2223A		25	150	
	2N2480		20	-	
	2N2480A		35	-	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		40	120	
	2N2480		30	350	
	2N2480A		50	200	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)*	2N2060, 2N2060A		50	150	
	2N2223, 2N2223A		50	200	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N2060A		-	0.6	
	2N2060, 2N2223, 2N2223A, 2N2480A		-	1.2	
	2N2480		-	1.3	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A		-	0.9	
	2N2480		-	1.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product		f_T			MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N2223, 2N2223A, 2N2480, 2N2480A		50	-	
	2N2060, 2N2060A		60	-	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N2060, 2N2060A, 2N2223, 2N2223A		-	15	
	2N2480A		-	18	
	2N2480		-	20	
Input Capacitance		C_{ib}			pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A		-	85	
Input Impedance		h_{ie}			ohms
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A		1000	4000	
	2N2480A		1000	5000	
Input Impedance		h_{ib}			ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A, 2N2223, 2N2223A		20	30	
	2N2480A		20	35	
Voltage Feedback Ratio		h_{rb}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2223, 2N2223A		-	3.0	
Small-Signal Current Gain		h_{fe}			-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A		50	150	
	2N2223, 2N2223A		40	120	
	2N2480A		50	300	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A, 2N2480A		4.0	16	
Output Admittance		h_{ob}			μmhos
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2223, 2N2223A		-	0.5	
Noise Figure		NF			dB
(I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 510 ohms, f = 1.0 kHz, BW = 1.0 Hz)	2N2480, 2N2480A		-	8.0	
(I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 510 ohms, f = 1.0 kHz, BW = 200 Hz)	2N2060, 2N2060A		-	8.0	
(I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz, BW = 15.7 kHz†)			-	8.0	

†Amplifier: 3.0 dB points at 25 Hz and 10 kHz with a roll-off of 6.0 dB per octave.

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
MATCHING CHARACTERISTICS					
DC Current Gain Ratio**		h_{FE1}/h_{FE2}**			-
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A, 2N2223A		0.9	1.0	
	2N2223, 2N2480, 2N2480A		0.8	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		0.9	1.0	
	2N2480, 2N2480A		0.8	1.0	
Base Voltage Differential		$\lvert V_{BE1}-V_{BE2}\rvert$			mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060A		-	3.0	
	2N2060, 2N2223A, 2N2480A		-	5.0	
	2N2480		-	10	
	2N2223		-	15	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A, 2N2480A		-	5.0	
	2N2480		-	10	
Base Voltage Differential Change		$\Delta(V_{BE1}-V_{BE2})$			mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +25°C)	2N2060A		-	0.4	
	2N2060		-	0.8	
	2N2223, 2N2223A		-	2.0	
	2N2480, 2N2480A		-	1.2	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)	2N2060		-	1.0	
	2N2060A		-	0.5	
	2N2223, 2N2223A		-	2.5	
	2N2480, 2N2480A		-	1.5	

**The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2075 thru 2N2082 (GERMANIUM)
2N2075A thru 2N2082A



PNP germanium power transistors for high-power applications in high-reliability equipment.

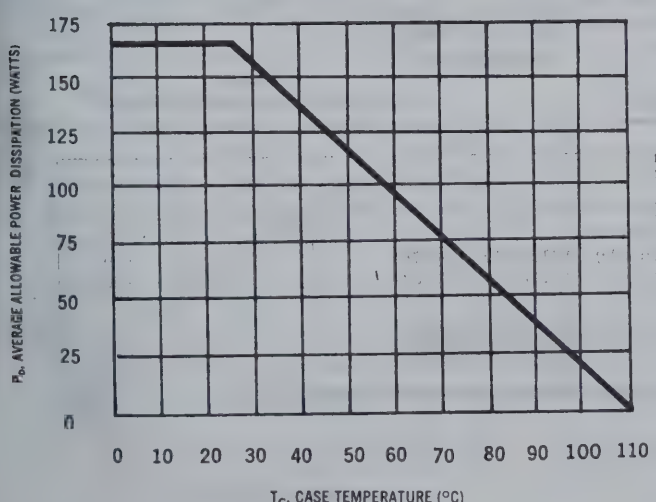
CASE 5
(TO-36)

MAXIMUM RATINGS

Rating	Symbol	2N2078 2N2082	2N2077 2N2081	2N2076 2N2080	2N2075 2N2079	Unit
Collector-Emitter Voltage	V_{CEO}	25	45	55	65	Vdc
Collector-Emitter Voltage	V_{CES}	40	50	70	80	Vdc
Collector-Base Voltage	V_{CB}	40	50	70	80	Vdc
Emitter-Base Voltage	V_{EB}	20	25	35	40	Vdc
Collector Current	I_C	15				Adc
Total Device Dissipation @ $T_C = 25°C$	P_D	170				Watts
Operating Junction Temperature Range	T_J	-65 to +110				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	°C/W



POWER-TEMPERATURE DERATING CURVE

The maximum average power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

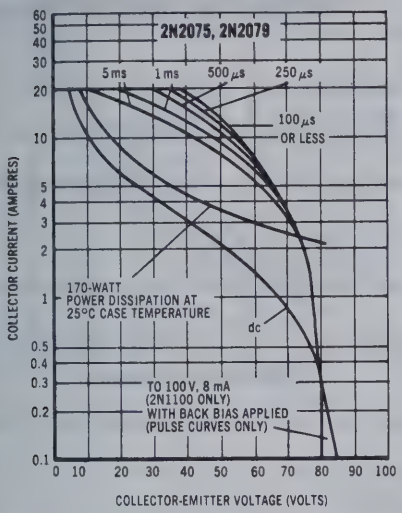
$$\text{allowable } P_D = \frac{110° - T_C}{0.5}$$

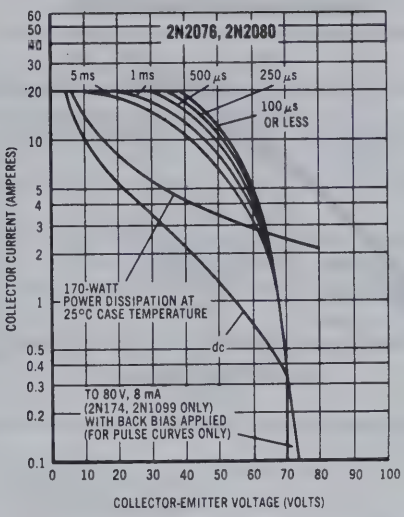
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

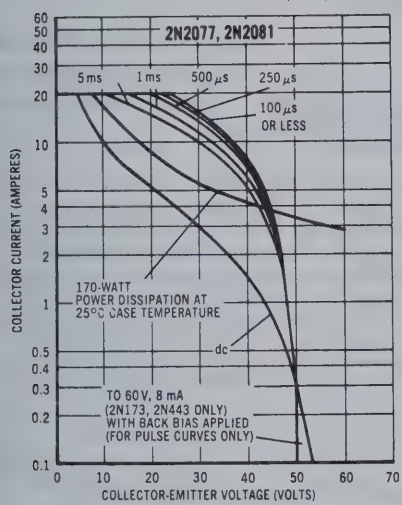
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 Adc, I_B = 0)	2N2078, 2N2082	BV_{CEO}	25	-	Vdc
	2N2077, 2N2081		45	-	
	2N2076, 2N2080		55	-	
	2N2075, 2N2079		65	-	
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc, V_{BE} = 0)	2N2078, 2N2082	BV_{CES}	40	-	Vdc
	2N2077, 2N2081		50	-	
	2N2076, 2N2080		70	-	
	2N2075, 2N2079		80	-	
Floating Potential (V_{CB} = 40 Vdc, I_E = 0)	2N2078, 2N2082	V_{EBF}	-	1.0	Vdc
(V_{CB} = 50 Vdc, I_E = 0)	2N2077, 2N2081		-	1.0	
(V_{CB} = 70 Vdc, I_E = 0)	2N2076, 2N2080		-	1.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N2075, 2N2079		-	1.0	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	0.2	mAdc
(V_{CB} = $V_{CB(max)}$, V_{EB} = 1.5 Vdc)			-	4.0	
(V_{CB} = $V_{CB(max)}$, I_E = 0, T_C = +71°C)			-	15	
Emitter Cutoff Current (V_{BE} = $V_{BE(max)}$, I_C = 0)		I_{EBO}	-	4.0	mAdc
(V_{BE} = $V_{BE(max)}$, I_C = 0, T_C = +71°C)			-	15	
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.2 Adc, V_{CE} = 2.0 Vdc)	2N2075 thru 2N2078	h_{FE}	25	100	-
	2N2079 thru 2N2082		40	160	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N2075 thru 2N2078		20	40	
	2N2079 thru 2N2082		35	70	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc, T_C = -55°C)	2N2075 thru 2N2078		15	-	
	2N2079 thru 2N2082		25	-	
(I_C = 12 Adc, V_{CE} = 2.0 Vdc)	2N2075 thru 2N2078		8	-	
	2N2079 thru 2N2082		12	-	
Collector-Emitter Saturation Voltage (I_C = 13 Adc, I_B = 2.0 Adc)	2N2075 & 76, 2N2079 & 80	$V_{CE(sat)}$	-	0.7	Vdc
	2N2077 & 78, 2N2081 & 82		-	0.9	
Base-Emitter On Voltage (I_C = 5.0 Adc, V_{CE} = 12 Vdc)		$V_{BE(on)}$	-	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Common-Emitter Cutoff Frequency (I_C = 5.0 Adc, V_{CE} = 6.0 Vdc)		$f_{\alpha e}$	5.0	-	kHz
Rise Time (V_{CE} = 12 Vdc, $I_{C(on)}$ = 12 Adc, I_B = 2.0 Adc)	2N2075 thru 2N2078	t_r	Typ		μs
	2N2079 thru 2N2082		9.0		
			6.0		
Fall Time (V_{BE} = 6.0 Vdc, $I_{C(off)}$ = 0, R_{BE} = 10 ohms)	2N2075 thru 2N2078	t_f	12		μs
	2N2079 thru 2N2082		13		

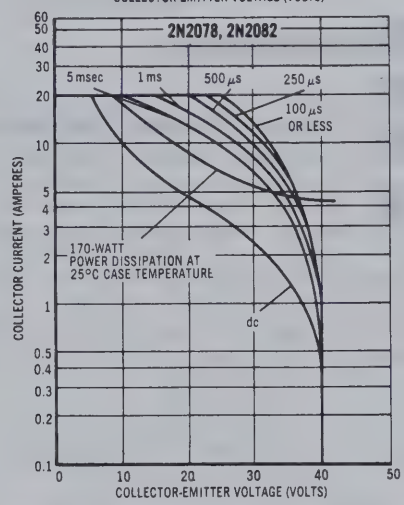
*To avoid excessive heating of collector junction, perform this test with a sweep method.

SAFE OPERATING AREAS





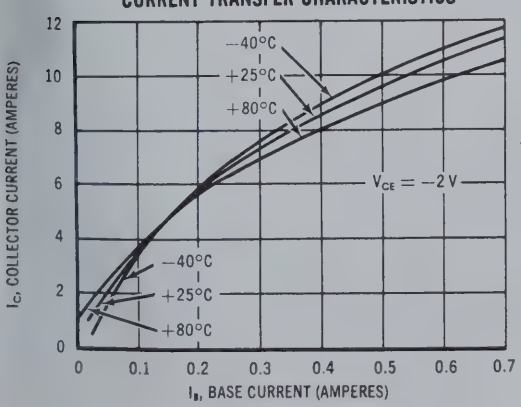




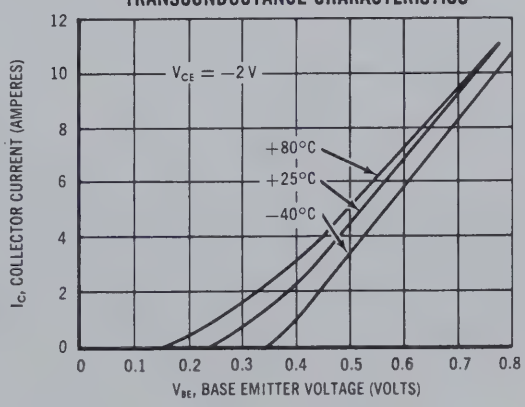
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N2075-2N2078

CURRENT TRANSFER CHARACTERISTICS

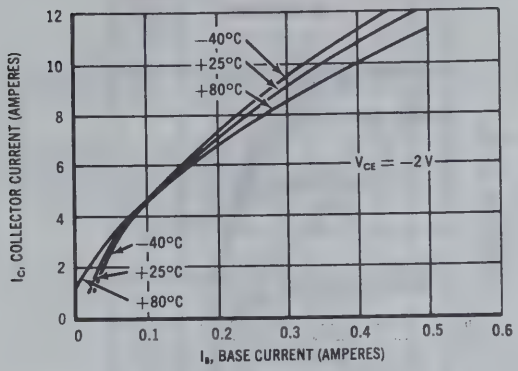


TRANSCONDUCTANCE CHARACTERISTICS

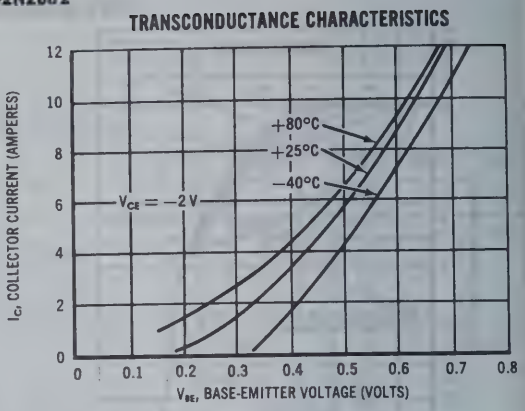


2N2079-2N2082

CURRENT TRANSFER CHARACTERISTICS



TRANSCONDUCTANCE CHARACTERISTICS

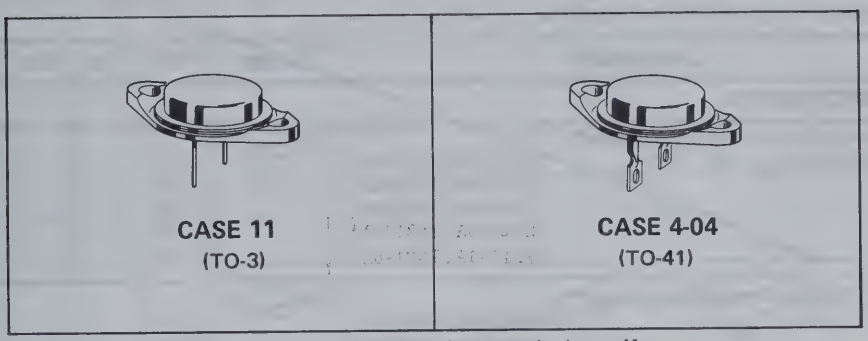


2N2096 (GERMANIUM)
2N2097
2N2099
2N2100

For Specifications, See 2N1204 Data.

2N2137 thru 2N2146 (GERMANIUM)
2N2137A thru 2N2146A

PNP germanium industrial power transistors for driver applications in high reliability equipment.



CASE 11
(TO-3)

CASE 4-04
(TO-41)

For units with solder lugs attached, specify devices MP2137,A etc. (TO-41 package)

MAXIMUM RATINGS

Apply also to standard, non-A series

Rating	Symbol	2N2137A 2N2142A	2N2138A 2N2143A	2N2139A 2N2144A	2N2140A 2N2145A	2N2141A 2N2146A	Unit
Collector-Base Voltage	V_{CB}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEO}	20	30	45	60	65	Vdc
Emitter-Base Voltage	V_{EB}	15	25	30	40	45	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	70 0.833					Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110					°C

ELECTRICAL CHARACTERISTICS

*Characteristics apply also to corresponding, non-A type numbers.

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage** (I_C = 500 mAdc, I_B = 0)	2N2137A, 2N2142A*	BV_{CEO}**	20	-	-	Vdc
	2N2138A, 2N2143A*		30	-	-	
	2N2139A, 2N2144A*		45	-	-	
	2N2140A, 2N2145A*		60	-	-	
	2N2141A, 2N2146A*		65			
Collector-Emitter Breakdown Voltage** (I_C = 300 mAdc, V_{BE} = 0)	2N2137A, 2N2142A*	BV_{CES}**	30	-	-	Vdc
	2N2138A, 2N2143A*		45	-	-	
	2N2139A, 2N2144A*		60	-	-	
	2N2140A, 2N2145A*		75	-	-	
	2N2141A, 2N2146A*		90	-	-	
Floating Potential (V_{CB} = 30 Vdc, I_E = 0)	2N2137A, 2N2142A*	V_{EBF}	-	-	1.0	Vdc
(V_{CB} = 45 Vdc, I_E = 0)	2N2138A, 2N2143A*		-	-	1.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N2139A, 2N2144A*		-	-	1.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N2140A, 2N2145A*		-	-	1.0	
(V_{CB} = 90 Vdc, I_E = 0)	2N2141A, 2N2146A*		-	-	1.0	
Collector-Base Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	0.018	0.05	mAdc
(V_{CB} = $V_{CB(max)}$, I_C = 0, T_C = +71°C)			-	0.75	5.0	
Collector-Base Cutoff Current† (V_{CB} = $V_{CB(max)}$, I_E = 0)		I_{CBO1}	-	0.1	2.0	mAdc
Emitter-Base Cutoff Current (V_{BE} = $V_{BE(max)}$, I_C = 0)		I_{EBO}	-	0.08	2.0	mAdc
(V_{BE} = $V_{BE(max)}$, I_C = 0, T_C = +71°C)			-	0.5	5.0	
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)	2N2137A-2N2141A*	h_{FE1}	30	45	60	-
	2N2142A-2N2146A*		50	70	100	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N2137A-2N2141A*	h_{FE}	15	22	-	
	2N2142A-2N2146A*		25	33	-	
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 200 mAdc)		$V_{CE(sat)}$	-	0.12	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 200 mAdc)		$V_{BE(sat)}$	-	0.75	1.2	Vdc
DYNAMIC CHARACTERISTICS						
Common Emitter Cutoff Frequency (I_C = 2.0 Adc, V_{CE} = 6.0 Vdc)		$f_{\alpha e}$	12	20	-	kHz

**Sweep method: 1/2 cycle sine wave, 60 Hz .

FIGURE 1 — POWER TEMPERATURE DERATING CURVE

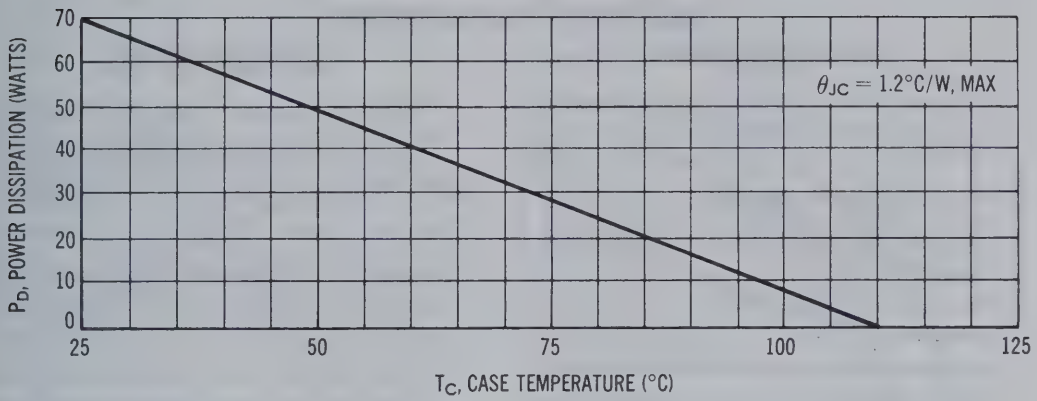
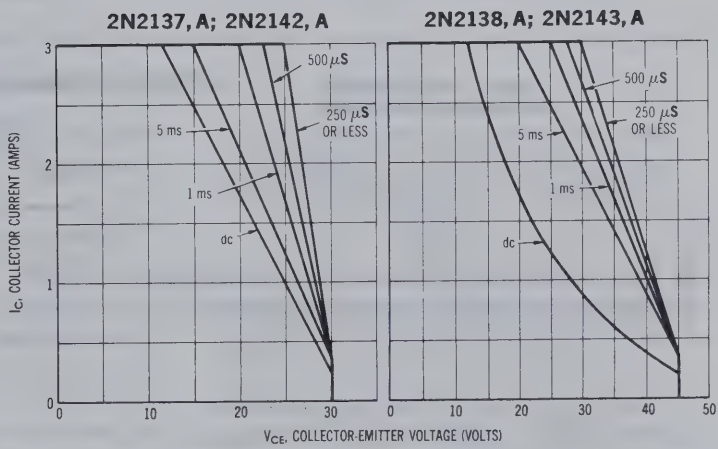
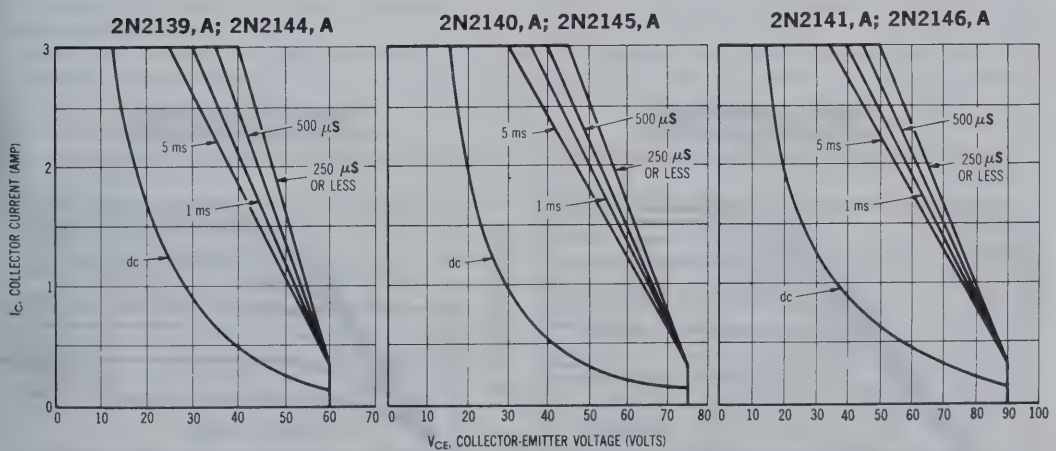


FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS

The active region safe operating area curves indicate I_C-V_{CE} limits to be observed in order to avoid secondary breakdown. (Secondary breakdown is independent of temperature and duty cycle.) These curves do not define operation in the avalanche region. To insure operation below the maximum junction temperature, power derating must be observed for both steady state and pulse conditions.





LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE (ALL TYPES)

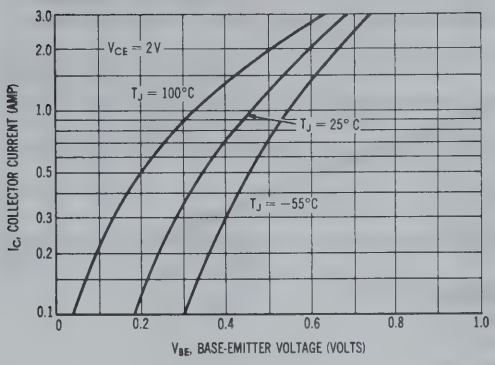


FIGURE 4 — INPUT ADMITTANCE (2N2137A-2N2141A, 2N2137-2N2141)

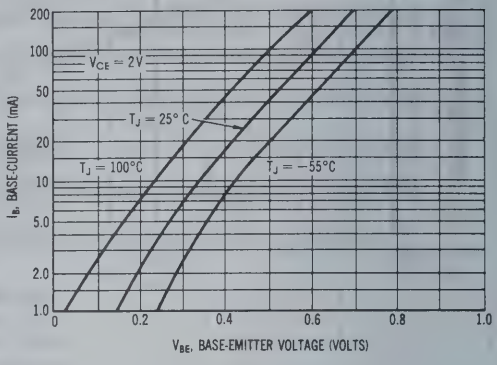


FIGURE 5 — INPUT ADMITTANCE (2N2142A-2N2146A, 2N2142-2N2146)

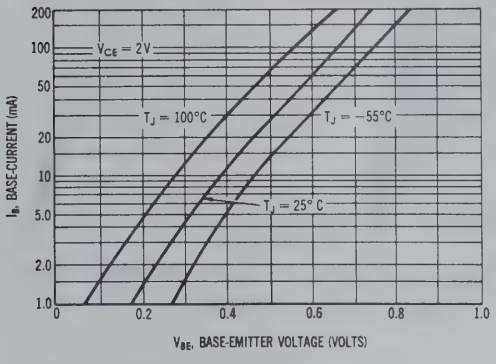


FIGURE 6 — NORMALIZED DC CURRENT GAIN (ALL TYPES)

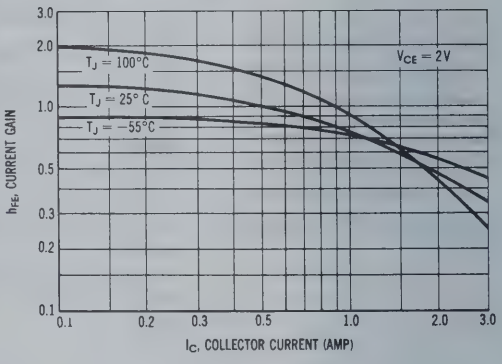


FIGURE 7 — SATURATION REGION (2N2137A-2N2141A, 2N2137-2N2141)

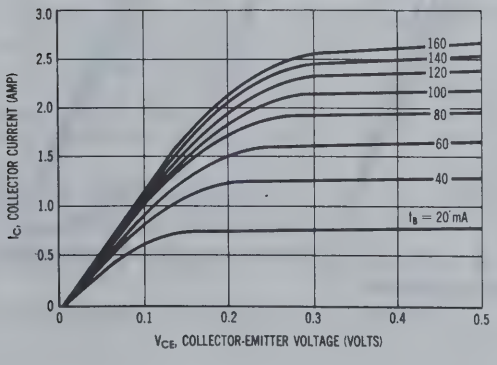
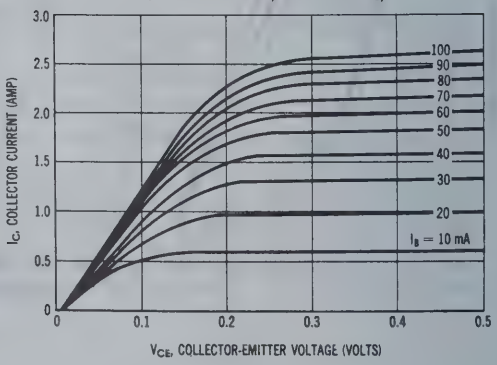
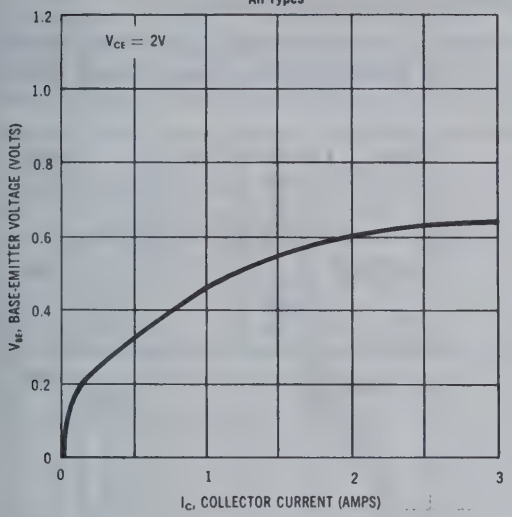


FIGURE 8 — SATURATION REGION (2N2142A-2N2146A, 2N2142-2N2146)

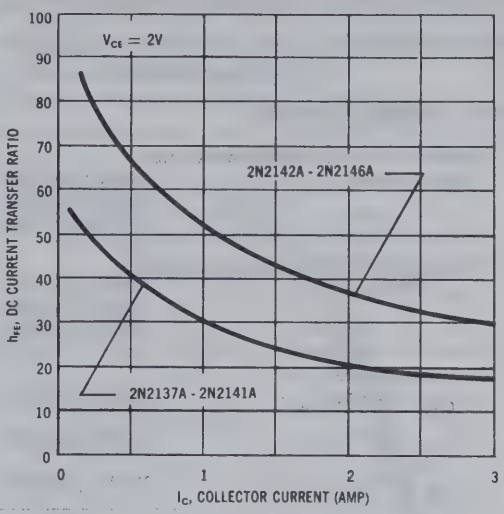


INPUT & TRANSFER CHARACTERISTICS

BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT
All Types



DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT



2N2152 thru 2N2154 (GERMANIUM)
2N2156 thru 2N2158

CASE 5
(TO-36)



PNP germanium power transistors for high-power, high-gain applications in high-reliability industrial equipment.

MAXIMUM RATINGS

Rating	Symbol	2N2152 2N2156	2N2153 2N2157	2N2154 2N2158	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	30	40	Vdc
Collector Current	I_C	30			Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	170 0.5			Watts $W/^oC$
Operating Junction Temperature Range	T_J	-65 to +110			^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^oC/W$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

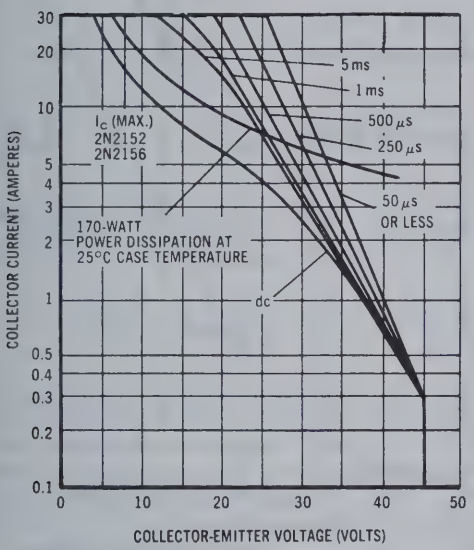
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1.0 Adc, I_B = 0)	2N2152, 2N2156	BV_{CEO}*	30	-	-	Vdc
	2N2153, 2N2157		45	-	-	
	2N2154, 2N2158		60	-	-	
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc, V_{BE} = 0)	2N2152, 2N2156	BV_{CES}*	45	-	-	Vdc
	2N2153, 2N2157		60	-	-	
	2N2154, 2N2158		75	-	-	
Floating Potential (V_{CB} = 45 Vdc, I_E = 0)	2N2152, 2N2156	V_{EBF}	-	-	1.0	Vdc
(V_{CB} = 60 Vdc, I_E = 0)	2N2153, 2N2157		-	-	1.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N2154, 2N2158		-	-	1.0	
Collector Cutoff Current (V_{CB} = 2V, I_E = 0)		I_{CBO}	-	0.08	0.2	mAdc
(V_{CB} = 45 Vdc, I_E = 0)	2N2152, 2N2156		-	0.9	4.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N2153, 2N2157		-	0.9	4.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N2154, 2N2158		-	0.9	4.0	
(V_{CB} = $V_{CB(max)}$, I_E = 0, T_C = 71°C)			-	4.0	15	
Emitter Cutoff Current (V_{BE} = 25 Vdc, I_C = 0)		I_{EBO}	-	0.2	4.0	mAdc
(V_{BE} = 30 Vdc, I_C = 0)			-	0.2	4.0	
(V_{BE} = 40 Vdc, I_C = 0)			-	0.2	4.0	
(V_{BE} = $V_{EB(max)}$, I_C = 0, T_C = 71°C)			-	2.7	15	
ON CHARACTERISTICS						
DC Current Gain (I_C = 5.0 Adc, V_{CB} = 2 Vdc)	2N2152, 2N2153, 2N2154	h_{FE}	50	75	100	
	2N2156, 2N2157, 2N2158		80	105	160	
(I_C = 15 Adc, V_{CB} = 2 Vdc)	2N2152, 2N2153, 2N2154		25	47	-	
	2N2156, 2N2157, 2N2158		40	63	-	
(I_C = 25 Adc, V_{CB} = 2 Vdc)			15	38	-	
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 500 mAdc)		$V_{CE(sat)}$	-	0.06	0.1	Vdc
(I_C = 25 Adc, I_B = 2 Adc)			-	0.2	0.3	
Base-Emitter On Voltage (I_C = 5.0 Adc, I_B = 500 mAdc)		$V_{BE(on)}$	-	0.65	1.0	Vdc
(I_C = 25 Adc, I_B = 2 Adc)			-	1.0	2.0	
SMALL SIGNAL CHARACTERISTICS						
Common-Emitter Cutoff Frequency (I_C = 5.0 Adc, V_{CE} = 6.0 Vdc)		$f_{\alpha e}$	2.0	2.7	-	kHz

*To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.

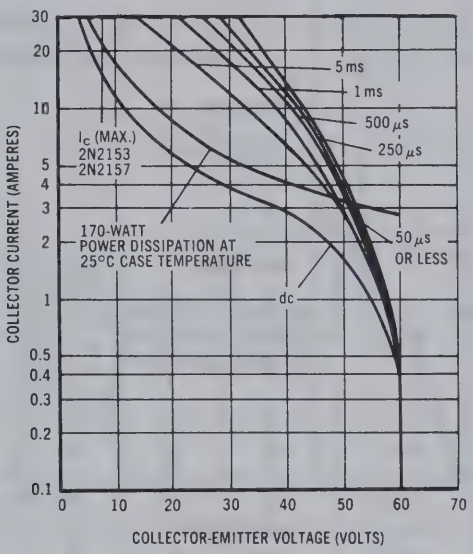
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

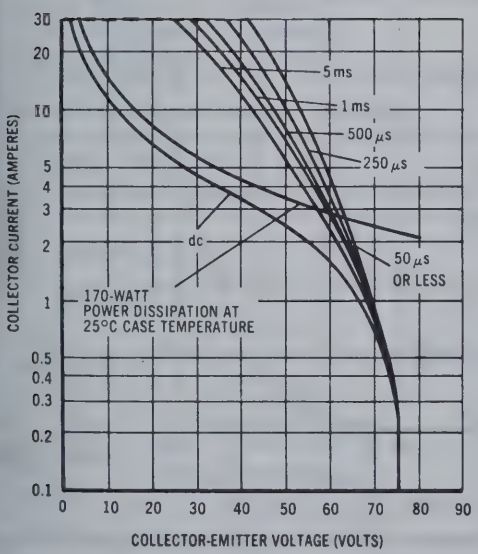
2N2152, 2N2156



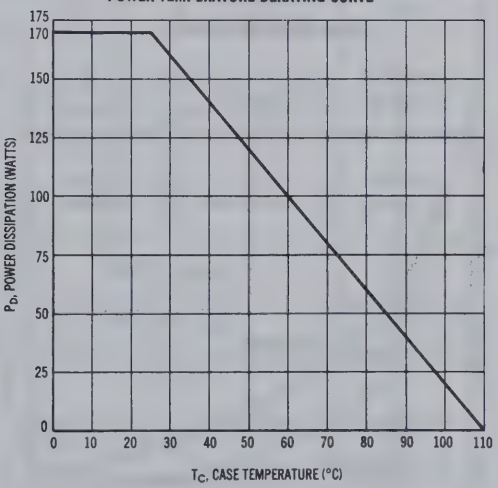
2N2153. 2N2157



2N2154, 2N2158



POWER-TEMPERATURE DERATING CURVE

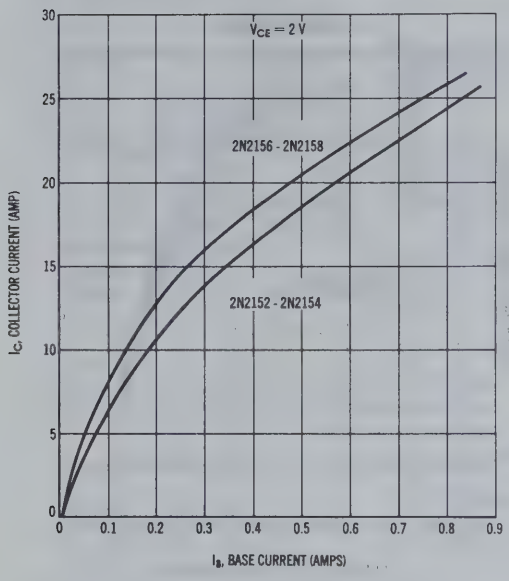


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

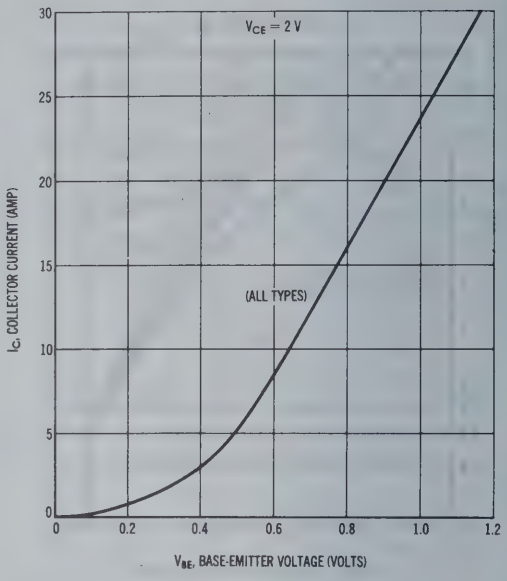
$$\text{allowable } P_D = \frac{110^{\circ} - T_C}{0.5}$$

TYPICAL INPUT AND TRANSFER CHARACTERISTICS

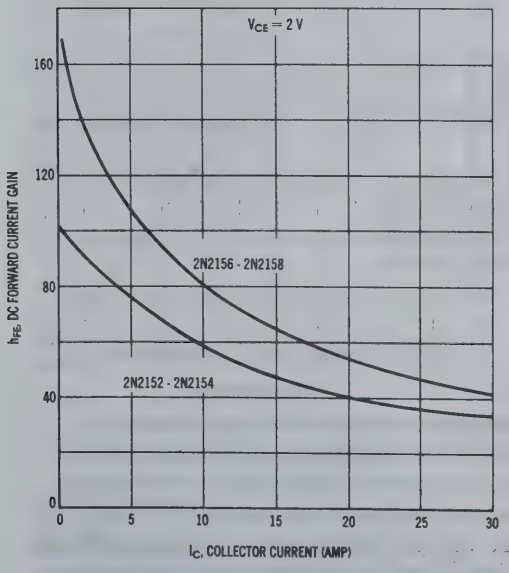
COLLECTOR CURRENT versus BASE CURRENT



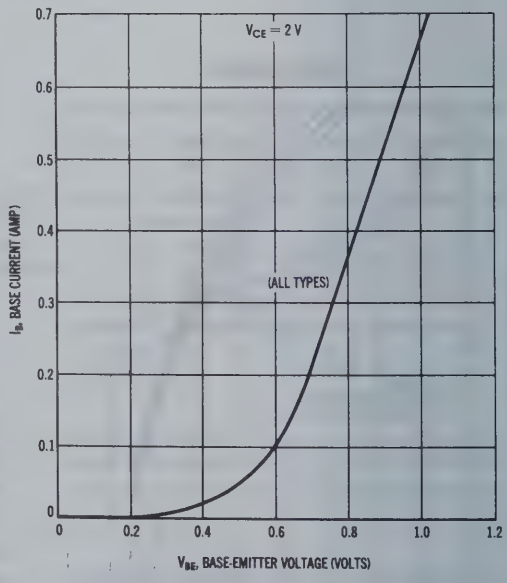
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



DC CURRENT GAIN versus COLLECTOR CURRENT



BASE CURRENT versus BASE-EMITTER VOLTAGE



2N2171 FOR SPECIFICATIONS, SEE 2N381 DATA.

2N2192, A, B thru 2N2195, A, B
(SILICON)



NPN silicon annular transistors for high-current switching and amplifier applications.

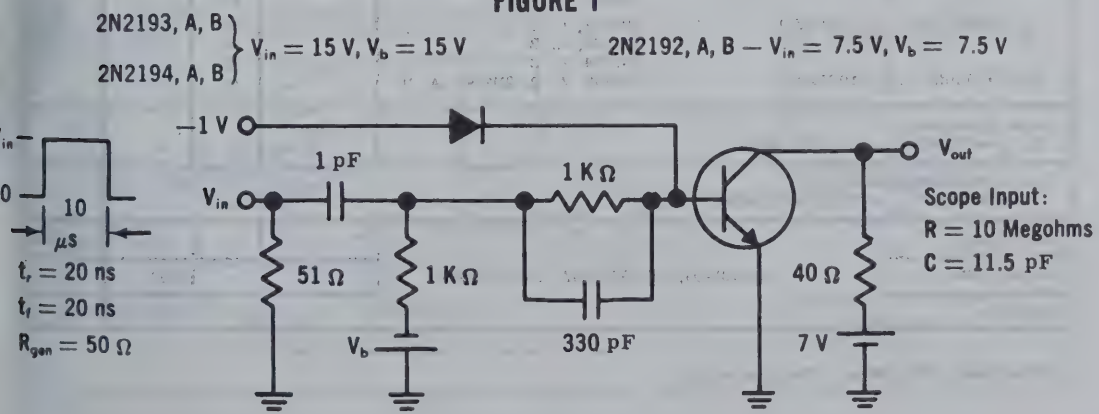
CASE 31
(TO-5)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N2192 2N2192A 2N2192B 2N2194 2N2194A 2N2194B	2N2193 2N2193A 2N2193B	2N2195 2N2195A 2N2195B	Unit
Collector-Base Voltage	V_{CB}	60	80	45	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	25	Vdc
Emitter-Base Voltage	V_{EB}	5	8	5	Vdc
Collector Current	I_C	1.0	1.0	1.0	Adc
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.8 4.56	0.8 4.56	0.6 3.43	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	← 2.8 → ← 16 →			Watts mW/°C
Junction Temperature, Operating	T_J	-65 to +200			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C

FIGURE 1



ELECTRICAL CHARACTERISTICS (at 25°C unless otherwise specified)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N2192, A, B, 2N2194, A, B	BV_{CBO}	60	-	Vdc
	2N2193, A. B		80	-	
	2N2195, A, B		45	.	
Collector Emitter-Open Base Sustain Voltage* (I_C = 25 mA pulsed, I_B = 0)	2N2192, A, B, 2N2194, A, B	$V_{CEO(sus)}$*	40	-	Vdc
	2N2193, A, B		50	-	
	2N2195, A, B		25	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N2192, A, B, 2N2194, A, B,	BV_{EBO}	5	-	Vdc
	2N2195, A, B		5	-	
	2N2193, A, B		8	-	
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	2N2192, A, B, 2N2194, A. B	I_{CBO}	-	.010	μAdc
	2N2195, A, B			.100	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N2192, A, B		-	15	
	2N2194, A, B		-	25	
	2N2195, A, B		-	50	
(V_{CB} = 60 Vdc, I_E = 0)	2N2193, A, B		-	.010	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	2N2193, A, B		-	25	
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)	2N2192, A, B, 2N2194, A, B	I_{EBO}	-	.050	μAdc
	2N2195, A, B		-	.100	
(V_{EB} = 5 Vdc, I_C = 0)	2N2193, A, B		-	.050	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	2N2192 thru 2N2195	$V_{CE(sat)}$	-	0.35	Vdc
	2N2192A thru 2N2195A		-	0.25	
	2N2192B thru 2N2195B		-	0.18	
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	-	1.3	Vdc
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2192, A, B, 2N2193, A, B	h_{FE}*	15	-	-
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2192, A, B		75	-	
	2N2193, A, B		30	-	
	2N2194, A, B		15	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N2192, A, B		35	-	
	2N2193, A, B		20	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N2192, A, B		100	300	
	2N2193, A, B		40	120	
	2N2194, A, B		20	60	
	2N2195, A, B		20	-	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N2192, A, B		70	-	
	2N2193, A, B		30	-	
	2N2194, A, B		15	-	
	2N2195, A, B		10	-	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N2192, A, B		35	-	
	2N2193, A, B		20	-	
	2N2194, A, B		12	-	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)	2N2192, A, B, 2N2193. A, B		15	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	20	pF
Small Signal Current Gain (I_C = 50 mA, V_{CE} = 10 V, f = 20 MHz)		h_{fe}	2.5	-	-
Rise Time	2N2192-94, 2N2192A-94A, 2N2192B-94B	t_r	-	70	ns
Storage Time		t_s	-	150	ns
Fall Time		t_f	-	50	ns

*Pulse Test: PW ≤ 300 μs Duty Cycle ≤ 2%

2N2212

PNP GERMANIUM POWER TRANSISTORS

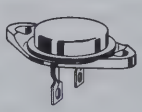
. . . designed for high-current switching applications requiring low saturation voltages, short switching times and good collector-emitter sustaining capability.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltage —
  $V_{CE(SAT)}$ = 0.5 Vdc (Max) @I_C = 5.0 Adc

10 AMPERE

PNP ADE GERMANIUM POWER TRANSISTORS

120 VOLTS
102 WATTS



MAXIMUM RATINGS

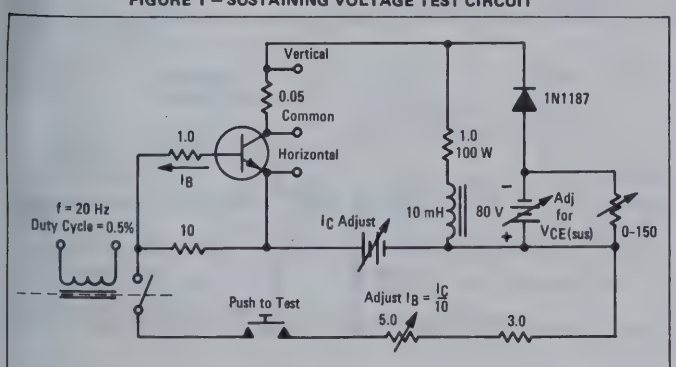
Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CER}	120	Vdc
*Collector-Base Voltage	V_{CB}	120	Vdc
*Emitter-Base Voltage	V_{EB}	1.5	Vdc
*Collector Current - Continuous	I_C	10	Adc
*Base Current - Continuous	I_B	3.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	102 1.2	Watts W/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

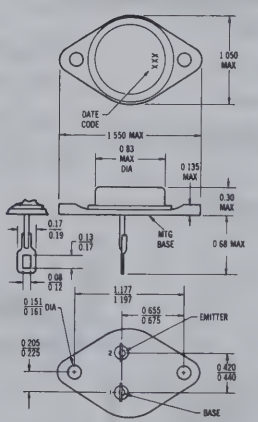
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	θ_{JC}	0.83	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT





Collector Connected to Case

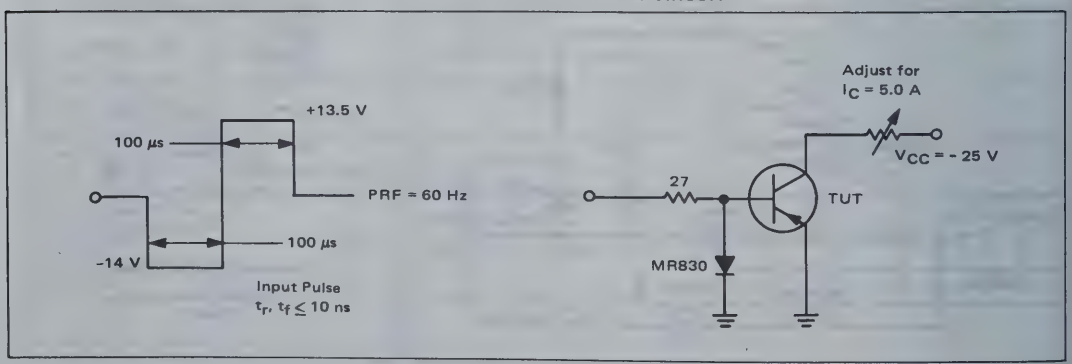
CASE 4-04
(TO-41)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	60	-	Vdc
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 5.0 Adc, I_B = 0)	$V_{CE(sus)}$	60	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 120 Vdc, R_{BE} = 100 Ohms)	I_{CER}	-	50	mAdc
*Collector Cutoff Current (V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	I_{CEX}	-	20	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	I_{CBO}	-	200	μAdc
*(V_{CB} = 100 Vdc, I_E = 0)		-	2.0	mAdc
Emitter Cutoff Current (V_{EB} = 0.75 Vdc, I_C = 0)	I_{EBO}	-	25	mAdc
ON CHARACTERISTICS				
*DC Current Gain (I_C = 0.6 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	50	200	-
(I_C = 1.2 Adc, V_{CE} = 1.0 Vdc)		60	200	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		50	120	
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)	$V_{CE(sat)}$	-	0.5	Vdc
*Base-Emitter On Voltage (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	-	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
*Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)	h_{fe}	15	-	-
SWITCHING CHARACTERISTICS				
Rise Time	(I_C = 5.0 Adc, I_{B1} = 0.5 Adc, I_{B2} = 0.5 Adc) (See Figure 2)	t_r	-	7.0 μs
Storage Time		t_s	-	10 μs
Fall Time		t_f	-	8.0 μs

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



2N2218, A, 2N2219, A 2N2221, A (SILICON)
2N2222, A, 2N5581, 2N5582

NPN SILICON ANNULAR HERMETIC TRANSISTORS

. . . widely used "Industry Standard" transistors for applications as medium-speed switches and as amplifiers from audio to VHF frequencies.

- DC Current Gain Specified – 1.0 to 500 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ @ I_C = 500 mAdc
  = 1.6 Vdc (Max) – Non-A Suffix
  = 1.0 Vdc (Max) – A-Suffix
- High Current-Gain–Bandwidth Product –
  f_T = 250 MHz (Min) @ I_C = 20 mAdc – All Types Except
  = 300 MHz (Min) @ I_C = 20 mAdc – 2N2219A, 2N2222A, 2N5582
- Complements to PNP 2N2904,A thru 2N2907,A
- JAN/JANTX Available for 2N2218,A Series

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS

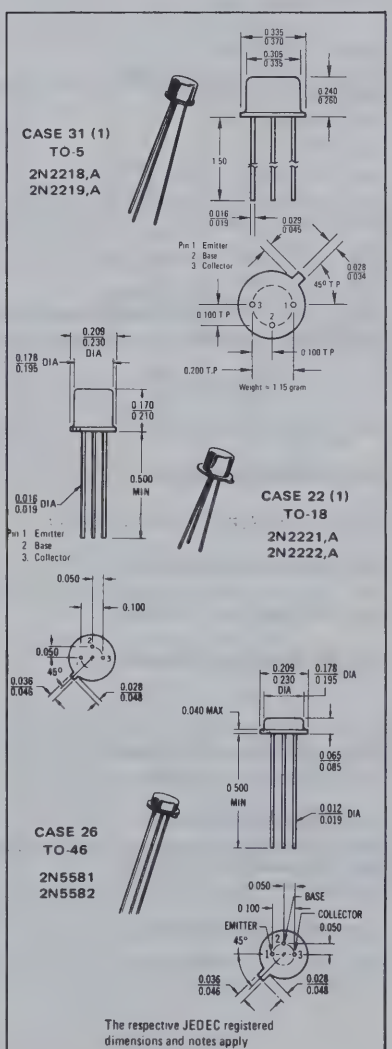
SELECTION GUIDE

Device Type	Characteristic: BV_{CEO} I_C = 10 mAdc Volts	Characteristic: h_{FE} I_C = 150 mAdc Min/Max	Characteristic: h_{FE} I_C = 500 mAdc Min	Package
2N2218 2N2219	30	40/120 100/300	20 30	TO-5
2N2221 2N2222	30	40/120 100/300	20 30	TO-18
2N5581 2N5582	40	40/120 100/300	25 40	TO-46
2N2218A 2N2219A	40	40/120 100/300	25 40	TO-5
2N2221A 2N2222A	40	40/120 100/300	25 40	TO-18

*MAXIMUM RATINGS

Rating	Symbol	2N2218 2N2219 2N2221 2N2222	2N2218A 2N2219A 2N2221A 2N2222A	2N5581 2N5582	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	40	Vdc
Collector-Base Voltage	V_{CB}	60	75	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	6.0	Vdc
Collector Current – Continuous	I_C	800	800	800**	mAdc
		2N2218,A 2N2219,A	2N2221,A 2N2222,A	2N5581 2N5582	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 5.33	0.5 3.33	0.5 3.33	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 20	1.8 12	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← –65 to +200 →			°C

*Indicates JEDEC Registered Data.
**Motorola Guarantees this Data in Addition to JEDEC Registered Data.



The respective JEDEC registered dimensions and notes apply

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	Non-A Suffix	BV_{CEO}	30	–	Vdc
	A-Suffix, 2N5581,2N5582		40	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	Non-A Suffix	BV_{CBO}	60	–	Vdc
	A-Suffix, 2N5581,2N5582		75	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	Non-A Suffix	BV_{EBO}	5.0	–	Vdc
	A-Suffix, 2N5581,2N5582		6.0	–	
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	A-Suffix, 2N5581,2N5582	I_{CEX}	–	10	nAdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 50 Vdc, I_E = 0)	Non-A Suffix		–	0.01	
(V_{CB} = 60 Vdc, I_E = 0)	A-Suffix, 2N5581,2N5582		–	0.01	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	Non-A Suffix		–	10	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	A-Suffix, 2N5581,2N5582		–	10	
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	A-Suffix, 2N5581,2N5582	I_{EBO}	–	10	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	A-Suffix	I_{BL}	–	20	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2218,A,2N2221,A,2N5581(1)		20	–	
	2N2219,A,2N2222,A,2N5582(1)		35	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2218,A,2N2221,A,2N5581		25	–	
	2N2219,A,2N2222,A,2N5582		50	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2218,A,2N2221,A,2N5581(1)		35	–	
	2N2219,A,2N2222,A,2N5582(1)		75	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N2218A,2N2221A,2N5581		15	–	
	2N2219A,2N2222A,2N5582		35	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2218,A,2N2221,A,2N5581		40	120	
	2N2219,A,2N2222,A,2N5582		100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N2218A,2N2221A,2N5581		20	–	
	2N2219A,2N2222A,2N5582		50	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2218,2N2221		20	–	
	2N2219,2N2222		30	–	
	2N2218A,2N2221A,2N5581		25	–	
	2N2219A,2N2222A,2N5582		40	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		–	0.4	
	A-Suffix, 2N5581,2N5582		–	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		–	1.6	
	A-Suffix, 2N5581,2N5582		–	1.0	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		0.6	2.0	
	A-Suffix, 2N5581,2N5582		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		–	2.6	
	A-Suffix, 2N5581,2N5582		–	2.0	

***ELECTRICAL CHARACTERISTICS** (Continued)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	All Types, Except 2N2219A,2N2222A,2N5582	f_T	 250 300	 – –	MHz
Output Capacitance(3) (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	8.0	pF
Input Capacitance(3) (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	Non-A Suffix A-Suffix, 2N5581,2N5582	C_{ib}	 – –	 30 25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{ie}	 1.0 2.0	 3.5 8.0	k ohms
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		0.2 0.25	1.0 1.25	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{re}	 – –	 5.0 8.0	X 10^{-4}
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		– –	2.5 4.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{fe}	 30 50	 150 300	–
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		50 75	300 375	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{oe}	 3.0 5.0	 15 35	μmhos
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		10 25	100 200	
Collector-Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	A-Suffix, 2N5581,2N5582	$r_b'C_c$	–	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)	2N2219A,2N2222A	NF	–	4.0	dB
SWITCHING CHARACTERISTICS (A-Suffix, 2N5581 and 2N5582)					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 14)	t_d	–	10	ns
Rise Time		t_r	–	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 15)	t_s	–	225	ns
Fall Time		t_f	–	60	ns
Active Region Time Constant** (I_C = 150 mAdc, V_{CE} = 30 Vdc)		T_A	–	2.5	ns

*Indicates JEDEC Registered Data.

**Motorola Guarantees this Data in Addition to JEDEC Registered Data.

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

(3)2N5581 and 2N5582 are Listed C_{cb} and C_{eb} for these conditions and values.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

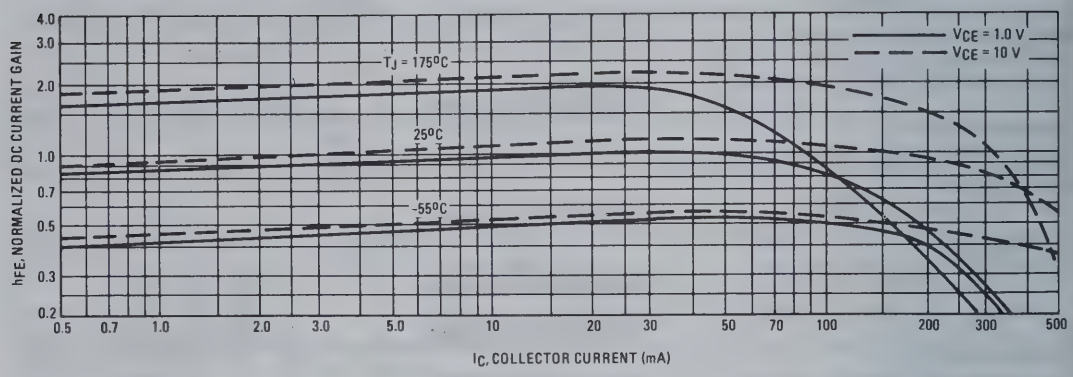
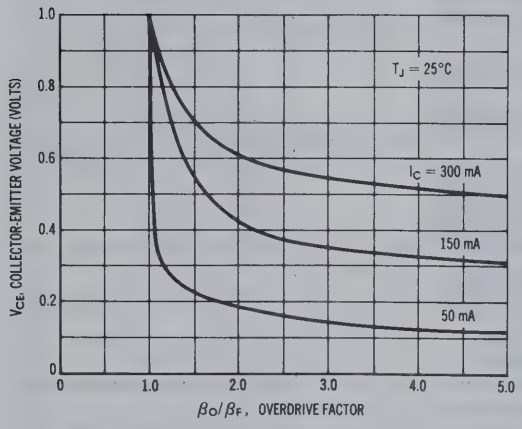


FIGURE 2 – COLLECTOR CHARACTERISTICS IN SATURATION REGION



This graph shows the effect of base current on collector current. β_o (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_f (forced gain) is the ratio of I_c/I_{B} in a circuit.

EXAMPLE: For type 2N2219, estimate a base current (I_B) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at I_c = 150 mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.62 of h_{FE} @ 10 volts. Using the guaranteed minimum gain of 100 @ 150 mA and 10 V, β_o = 62 and substituting values in the overdrive equation, we find:

$$\frac{\beta_o}{\beta_f} = \frac{h_{FE} @ 1.0\,V}{I_c/I_B} \qquad 2.5 = \frac{62}{150/I_B} \qquad I_B \approx 6.0 \text{ mA}$$

FIGURE 3 – "ON" VOLTAGES

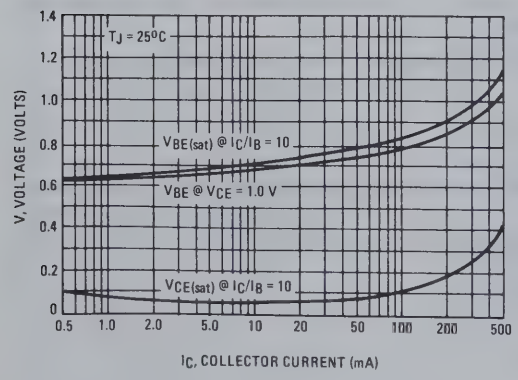
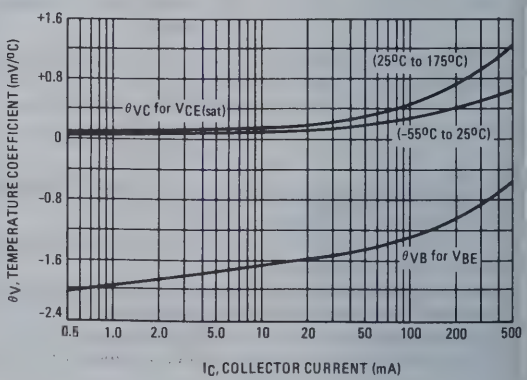


FIGURE 4 – TEMPERATURE COEFFICIENTS



NOISE FIGURE

V_{CE} = 10 V, T_A = 25°C

FIGURE 5 – FREQUENCY EFFECTS

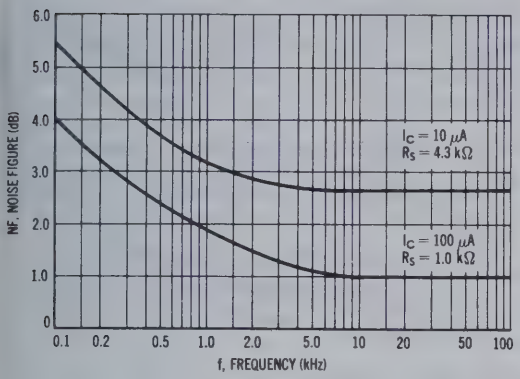
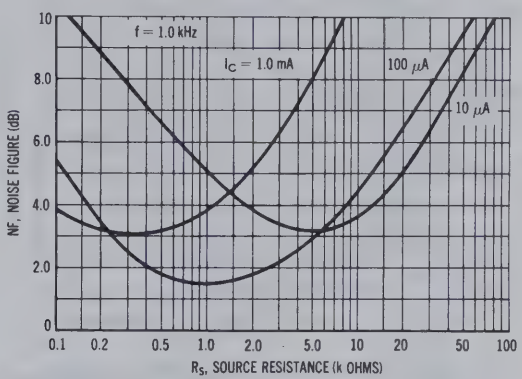


FIGURE 6 – SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 7 – INPUT IMPEDANCE

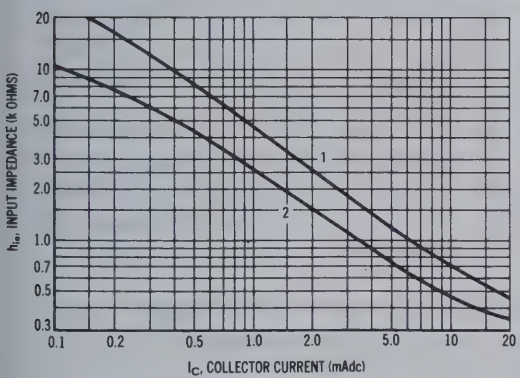


FIGURE 8 – VOLTAGE FEEDBACK RATIO

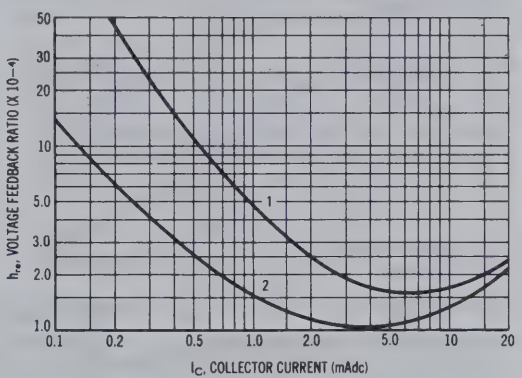


FIGURE 9 – CURRENT GAIN

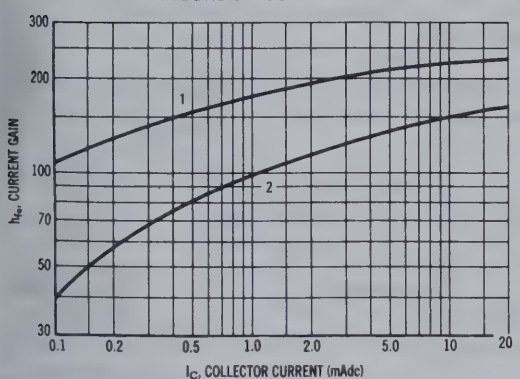
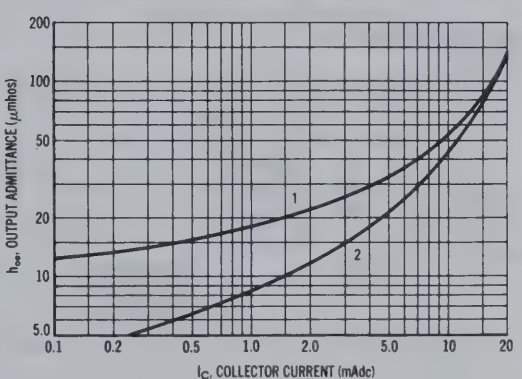


FIGURE 10 – OUTPUT ADMITTANCE



SWITCHING TIME CHARACTERISTICS

FIGURE 11 – TURN-ON TIME

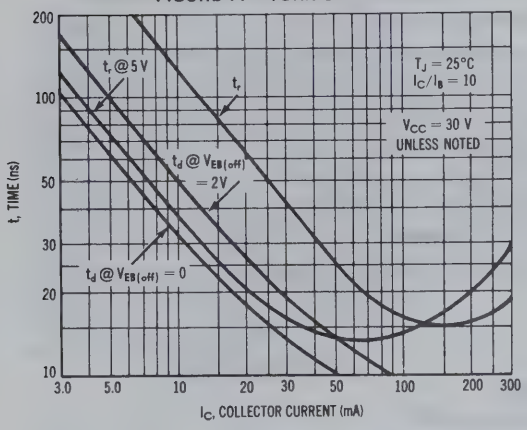


FIGURE 12 – CHARGE DATA

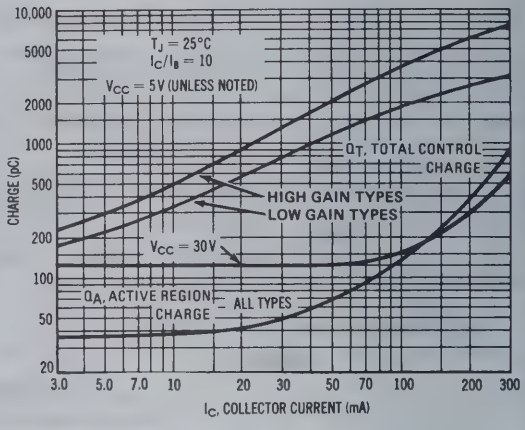
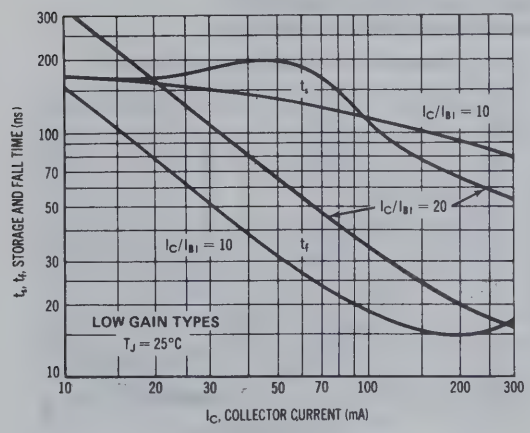


FIGURE 13 – TURN OFF BEHAVIOR



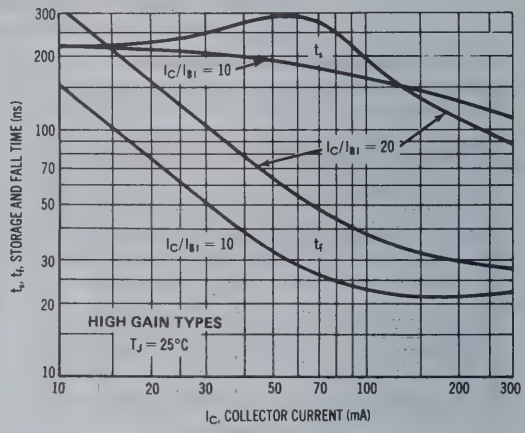


FIGURE 14 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

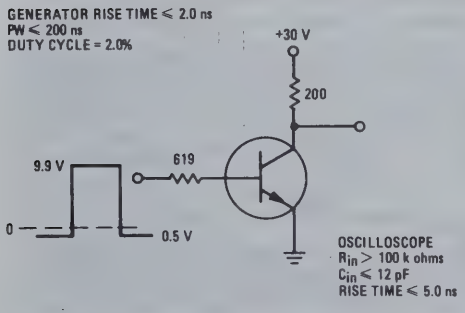


FIGURE 15 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT

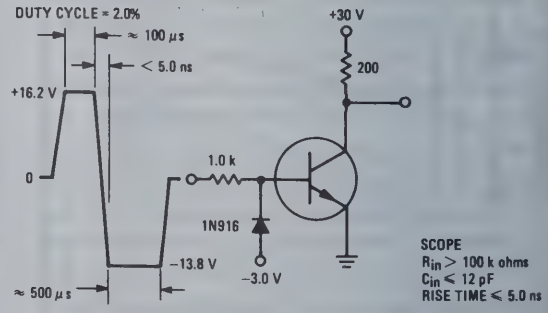


FIGURE 16 – CURRENT-GAIN–BANDWIDTH PRODUCT AND COLLECTOR-BASE TIME CONSTANT DATA

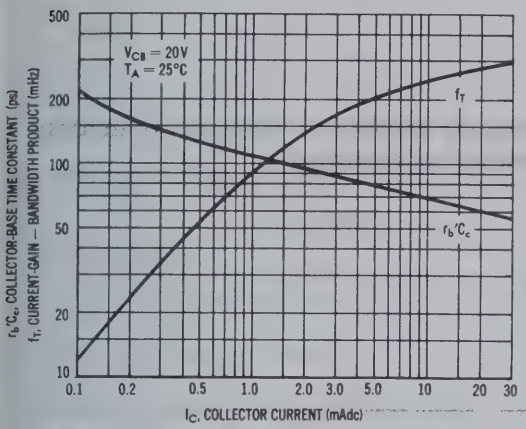


FIGURE 17 – CAPACITANCES

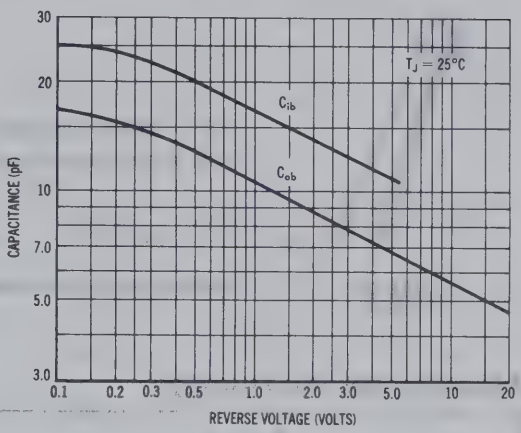
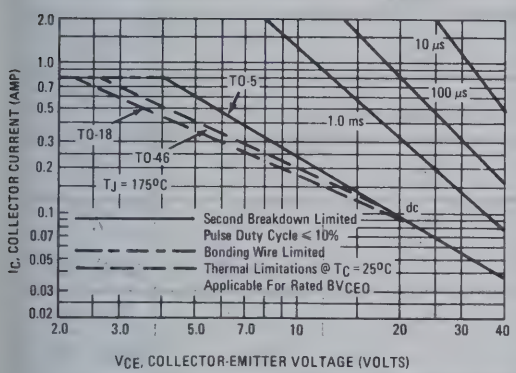


FIGURE 18 – ACTIVE-REGION SAFE OPERATING AREAS

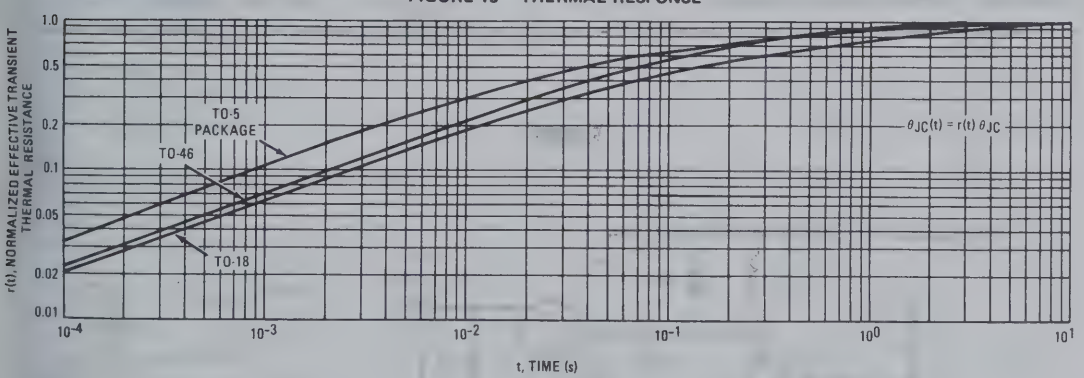


This graph shows the maximum I_C-V_{CE} limits of the device both from the standpoint of thermal dissipation (at 25°C case temperature), and secondary breakdown. For case temperatures other than 25°C, the thermal dissipation curve must be modified in accordance with the derating factor in the Maximum Ratings table.

To avoid possible device failure, the collector load line must fall below the limits indicated by the applicable curve. Thus, for certain operating conditions the device is thermally limited, and for others it is limited by secondary breakdown.

For pulse applications, the maximum I_C-V_{CE} product indicated by the dc thermal limits can be exceeded. Pulse thermal limits may be calculated by using the transient thermal resistance curve of Figure 19.

FIGURE 19 – THERMAL RESPONSE



2N2223, A

For Specifications, See 2N2060 Data.

2N2224 (SILICON)



NPN silicon annular transistor designed primarily for high speed switching applications.

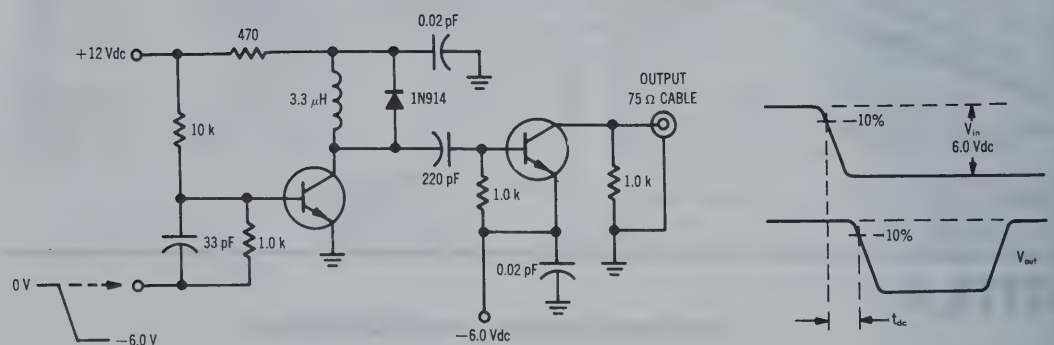
CASE 31
(TO-5)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current-Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 5.33	W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 20	Watts mW/°C
Operating Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	65	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector-Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = +150°C)	I_{CBO}	- -	0.01 10	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 20 25 35 40	 - - 115 120	-
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$*	-	0.4	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$*	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz) (I_C = 80 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	 250 160	 - -	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{ob}	-	8.0	pF
Circuit Delay (Figure 1) (T_A = 25°C)	t_{dc}	-	15	ns
Circuit Delay - Total Change (Figure 1) (T_A = +10°C to T_A = +25°C)	Δt_{dc}	-	15	ns

*Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%

2N2242 (SILICON)



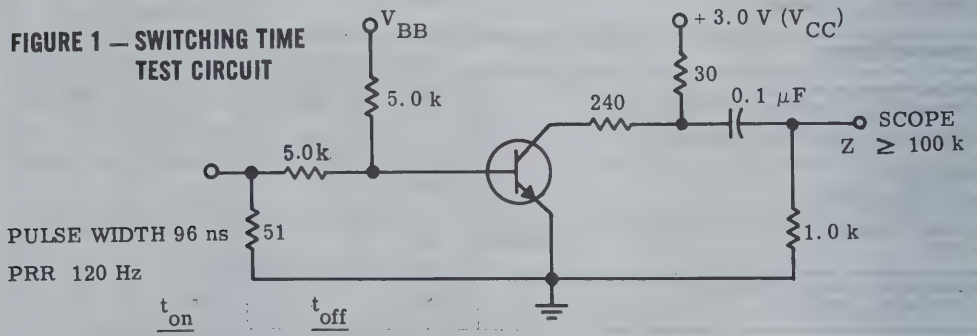
CASE 22
(TO-18)

NPN silicon annular transistors designed for high-speed, low-power saturated switching applications.

MAXIMUM RATINGS

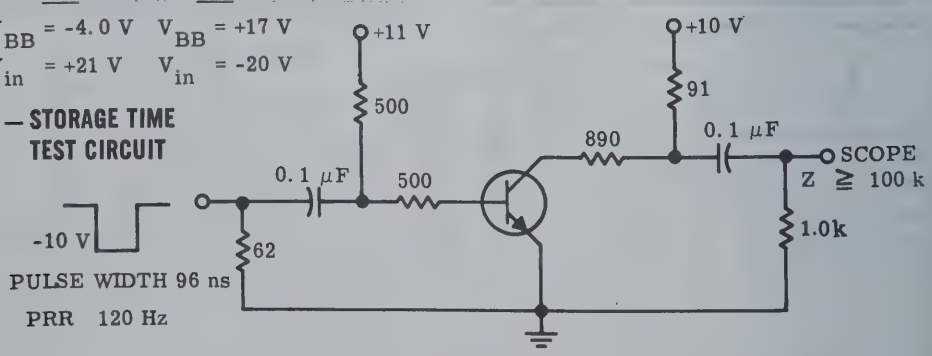
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	225	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.0	mWatts mW/°C
Junction Temperature — Operating	T_J	-65 to +200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



t_{on}	t_{off}
V_{BB} = -4.0 V	V_{BB} = +17 V
V_{in} = +21 V	V_{in} = -20 V

FIGURE 2 — STORAGE TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_E = 0)	BV_{CEO}*	15	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, R_{BE} = ≤ 10 ohms)	BV_{CER}*	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 125°C)	I_{CEX}	-	10	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	0.1 15	μAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)	I_{EBO}	-	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)	h_{FE}*	40 20	120 -	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = -55 to +125°C)	$V_{CE(sat)}$	- -	0.7 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 125°C)	$V_{BE(sat)}$	- -	1.5 0.8	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	6.0	pF
Turn-On Time (Figure 1) (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = +2.0 Vdc, I_{B1} = 3.0 mAdc, I_C = 10 mAdc)	t_{on}	-	30	ns
Turn-Off Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{off}		50	ns
Storage Time (Figure 2) (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	-	25	ns

* Pulse Test: Pulse Wdith = 300 μs; Duty Cycle = ≤ 2%

2N2256, 2N2257 (SILICON)
2N2258 (GERMANIUM)
2N2259 (GERMANIUM)



CASE 22
(TO-18)

NPN silicon and PNP germanium mesa complementary transistors for high-speed non-saturated switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N2256 2N2257	2N2258 2N2259	Unit
Collector-Emitter Voltage	V_{CEO}	7	7	Vdc
Collector-Base Voltage	V_{CB}	7	7	Vdc
Emitter-Base Voltage	V_{EB}	1	1	Vdc
Collector Current-Continuous	I_C	100	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	300	150	mW
Derate above 25^oC		2	2	$mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$	P_D	1000	300	mW
Derate above 25^oC		6.67	4	$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	-65 to +100	^oC

TRANSISTOR SELECTION CHART

TYPE	TYPE		h_{FE} @ I_C = 25 mA	
	NPN	PNP	20	40
2N2256	X		X	
2N2257	X			X
2N2258		X	X	
2N2259		X		X

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		BV_{CES}	7	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	7	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	1	-	-	Vdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	3	10	μAdc
(V_{CB} = 6 Vdc, I_E = 0, T_A = 65°C)			-	30	100	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N2256, 2N2258		17	30	-	
	2N2257, 2N2259		40	50	-	
(I_C = 25 mAdc, V_{CE} = 1 Vdc)	2N2256, 2N2258		20	35	-	
	2N2257, 2N2259		40	55	-	
Base-Emitter On Voltage		$V_{BE(on)}$				Vdc
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N2256, 2N2257		-	0.70	0.8	
	2N2258, 2N2259		-	0.35	0.5	
(I_C = 25 mAdc, V_{CE} = 1 Vdc)	2N2256, 2N2257		-	0.8	0.9	
	2N2258, 2N2259		-	0.45	0.6	
Conduction Threshold Base-Emitter Voltage* (I_C = 200 μAdc, V_{CE} = 1 Vdc)	2N2256, 2N2257	V_T	0.5	-	-	Vdc
	2N2258, 2N2259		0.1	-	-	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	2N2258, 2N2259	f_T	250	320	-	MHz
(I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	2N2256, 2N2257		250	320	-	
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 4 MHz)	2N2256, 2N2257	C_{ob}	-	4	5	pF
	2N2258, 2N2259		-	4	8	
Base Resistance (I_E = 5 mAdc, V_{CB} = 2 Vdc, f = 300 MHz)		r'_b				Ohms
	2N2256, 2N2257		-	50	100	
	2N2258, 2N2259		-	75	125	
Turn-On Time		t_{on}				ns
	2N2256, 2N2257 See Fig. 1		-	3	7	
	2N2258, 2N2259 See Fig. 2		-	4	8	
Turn-Off Time		t_{off}				ns
	2N2256, 2N2257 See Fig. 1		-	4	7	
	2N2258, 2N2259 See Fig. 2		-	3	7	

*Base-to-emitter forward bias voltage at which transistor will be at the threshold of conduction; i.e. that base-to-emitter voltage at which the collector current is less than or equal to the specified amount under a given collector-to-emitter voltage condition.

FIGURE 1 — NPN SWITCHING TIME TEST CIRCUIT

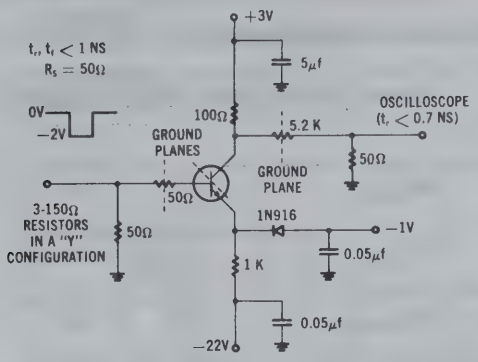


FIGURE 2 — PNP SWITCHING TIME TEST CIRCUIT

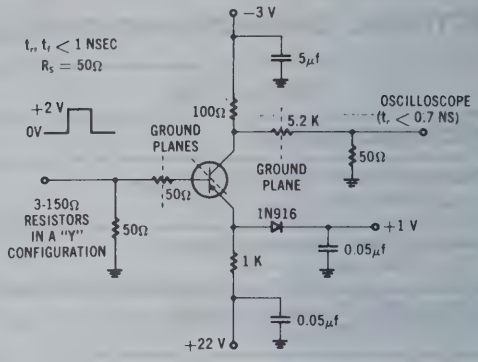


FIGURE 3 — CASCADE COMPLEMENTARY GATE

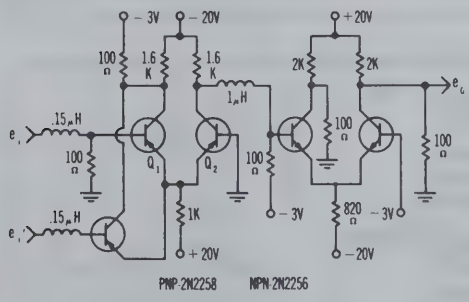


FIGURE 4 —CURRENT MODE INVERTER FOR USE WITH DIODE LOGIC PROPAGATION DELAY TIME 10 ns

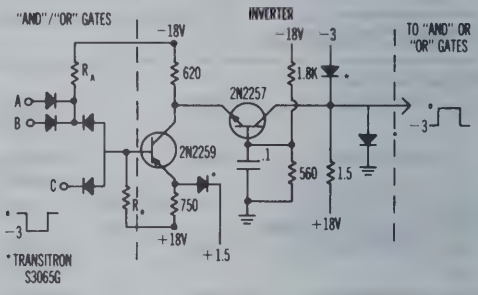


FIGURE 5 — CURRENT GAIN CHARACTERISTICS

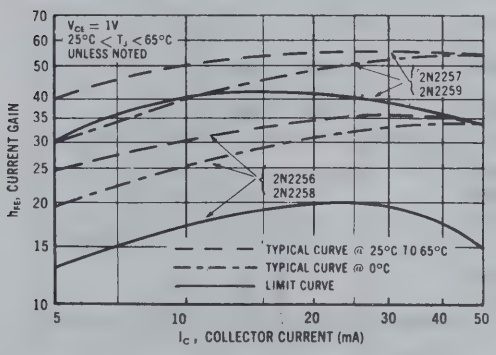
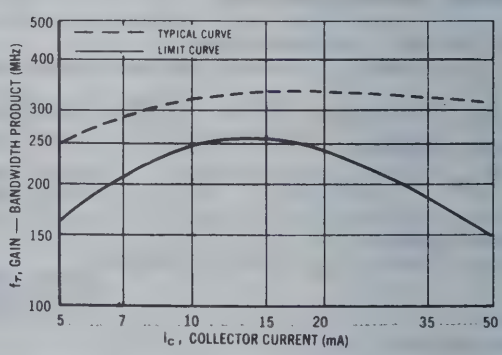
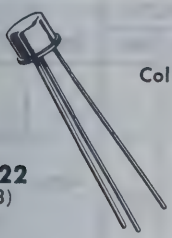


FIGURE 6 — CURRENT GAIN-BANDWITH PRODUCT CHARACTERISTICS



2N2273 (GERMANIUM)
JAN 2N2273



Collector connected to case

CASE 22
(TO-18)

High-frequency germanium PNP transistor, designed for military and high-reliability industrial as well as commercial VHF amplifier applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Volts
Collector-Emitter Voltage	V_{CES}	25	Volts
Collector-Emitter Voltage	V_{CEO}	15	Volts
Emitter-Base Voltage	V_{EB}	1.0	Volt
Collector Current	I_C	100	mA
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	150 2	mW mW/°C
Junction Operating & Storage Temperature Range	T_J, T_{stg}	-65 to +100	°C

TABLE I — GROUP A INSPECTION ($T_A = 25°C$ unless otherwise noted)
BOTH TYPES (LTPD applies to JAN 2N2273 only)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 1						
Visual and Mechanical Examination	2071	—	—	—	—	5
SUBGROUP 2						
Collector-Base Cutoff Current (V_{CB} = 12 Vdc, I_E = 0)	3036 Condition D	I_{CBO}	—	10	μAdc	5
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	3001 Condition D	BV_{CBO}	25	—	Vdc	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	3026 Condition D	BV_{EBO}	1.0	—	Vdc	
Forward Current Transfer Ratio* (I_C = 1 mAdc, V_{CE} = 10 Vdc)	3076	h_{FE}*	20	75	—	
Collector-Emitter Breakdown Voltage (I_C = 200 μAdc, V_{BE} = 0)	3011 Condition C	BV_{CES}	25	—	Vdc	
Small-Signal Forward Current Transfer Ratio (I_C = 1 mAdc, V_{CE} = 6 Vdc, f = 10 MHz)	3306	h_{fe}	20	28	dB	

* Applies to MIL unit only

TABLE I — GROUP A INSPECTION (continued)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 3						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	3236	C_{ob}	—	3.5	pF	10
Base Spreading Resistance (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 250 MHz)	3266	r_b'	—	250	ohms	
Small-Signal Forward Current Transfer Ratio* (I_C = 1 mAdc, V_{CE} = 6 Vdc, f = 100 MHz)	3306	h_{fe}*	2.5	—	—	
Noise Figure* (V_{CB} = 10 Vdc, I_C = 1 mAdc, f = 10 MHz, R_G = 50 ohms)	3246	NF*	—	12	dB	
STANDARD UNIT ONLY						
Emitter-Base Leakage Current (V_{EB} = 0.5 Vdc, I_C = 0)		I_{EBO}	—	100	μAdc	
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CEO}	15	—	Vdc	
Forward Current Transfer Ratio (I_C = 1 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	150	—	—
Real Part of Small-Signal Short-Circuit Input Impedance (V_{CE} = 10 Vdc, I_C = 1 mAdc, f = 250 MHz)		$Re(h_{ie})$	50	250	ohms	
Power Gain (See Figure 1) (V_{CE} = 9 Vdc, I_C = 1 mAdc, f = 30 MHz)		G_{PE}	10	30	dB	

* Applies to MIL unit only

TABLE II — GROUP B INSPECTION — JAN 2N2273 only

(T_A = 25°C unless otherwise noted)

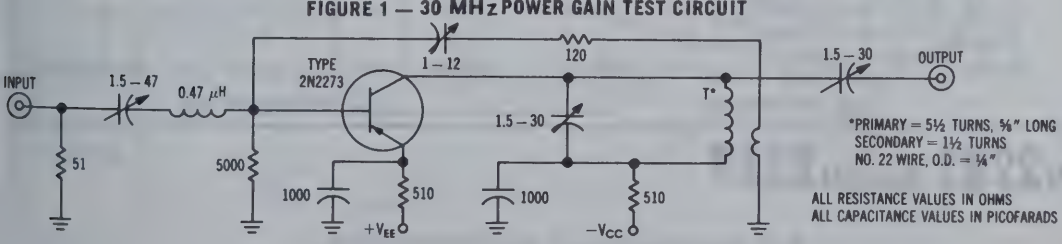
Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 1						
Physical Dimensions	2066	—	—	—	—	10
SUBGROUP 2						
Solderability	2026	—	—	—	—	10
Temperature Cycling (T_{high} = 100^{+3}_{-0}°C; 10 cycles)	1051 Condition B	—	—	—	—	
Thermal Shock (Glass Strain)	1056 Condition A	—	—	—	—	
Moisture Resistance	1021	—	—	—	—	
End Points: (Subgroups 2, 3, 5, 6, 7)						
Collector-Base Cutoff Current (V_{CB} = 12 Vdc, I_E = 0)	3036 Condition D	I_{CBO}	—	20	μAdc	
DC Forward Current Transfer Ratio (I_C = 1 mAdc, V_{CE} = 10 Vdc)	3076	h_{FE}	15	—	—	

TABLE II — GROUP B INSPECTION (continued)

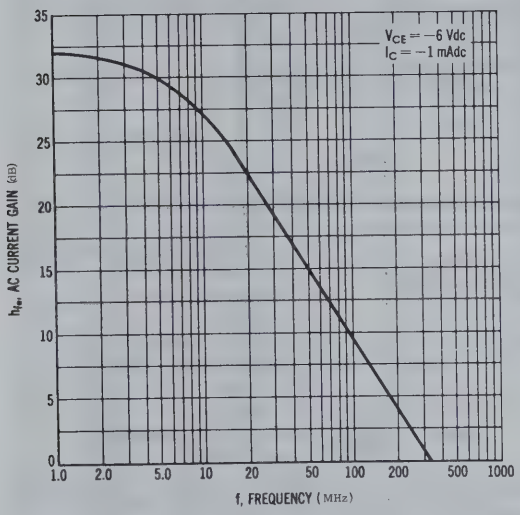
Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 3						
Shock (500 G, 1 msec, 5 blows each orientation: Y_1, Y_2, X_1 and Z_1)	2016 Nonoperating	—	—	—	—	10
Vibration, Variable Frequency (10 G)	2056	—	—	—	—	
Constant Accelerating (10,000 G)	2006	—	—	—	—	
End Points: Same as Subgroup 2						
SUBGROUP 4						
Lead Fatigue (Note 1)	2036 Condition E	--	--	—	—	10
SUBGROUP 5						
High Temperature Operation (Note 2) ($T_A = 70^{+3}_{-0}°C$)		—	—	—	—	10
Collector-Base Cutoff Current (V_{CB} = 12 Vdc, I_E = 0)	3036	I_{CBO}	—	100	μAdc	
Low Temperature Operation (Note 2) ($T_A = -55 \pm 3°C$)		—	—	—	—	
Forward Current Transfer Ratio (V_{CE} = 10 Vdc, I_C = 1 mAdc)	3076	h_{FE}	8	—	—	
Salt Atmosphere (Corrosion)	1041	—	—	—	--	
End Points: Same as Subgroup 2						
SUBGROUP 6						
High Temperature Life ($T_A = 100^{+5}_{-0}°C$)	1031 (Nonoperating)	—	—	—	—	$\lambda = 10$
End Points: Same as Subgroup 2						
SUBGROUP 7						
Steady State Operation Life (V_{CB} = 10 Vdc, P_C = 60 mW, $T_A = 55^{+3}_{-0}°C$)	1026	—	—	—	—	$\lambda = 10$
End Points: Same as Subgroup 2						

Note 1. Rejects from prior electrical tests from the same lot may be used for this test.
Note 2. Test measurement shall be made after thermal equilibrium has been reached at the temperature specified.

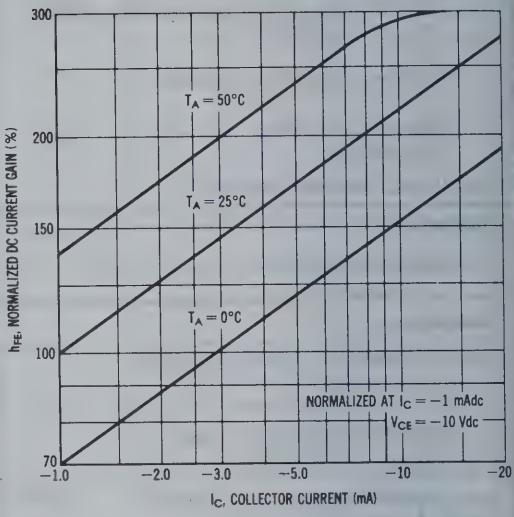
FIGURE 1 — 30 MHz POWER GAIN TEST CIRCUIT



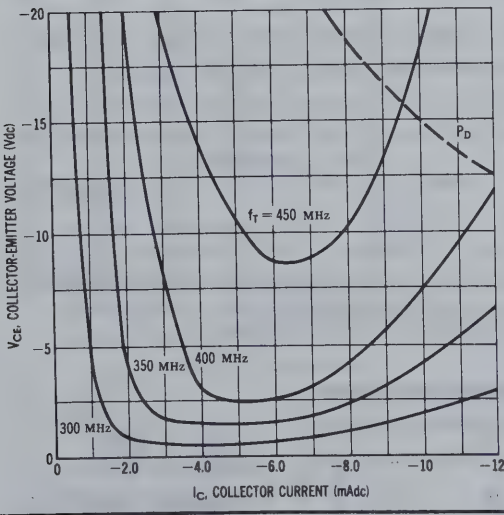
AC CURRENT GAIN versus FREQUENCY



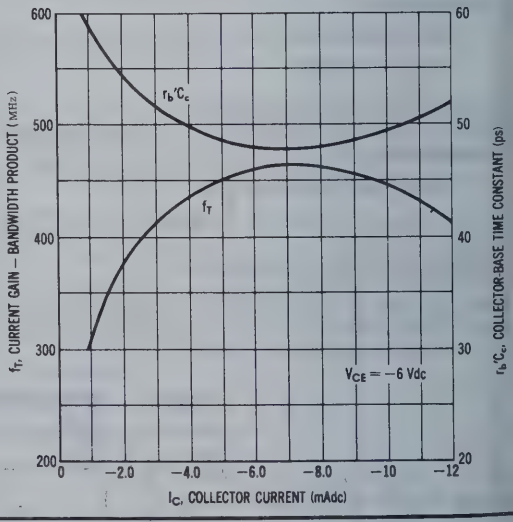
VARIATION IN DC GAIN versus COLLECTOR CURRENT



CONTOURS OF CURRENT GAIN — BANDWIDTH PRODUCT



f_T AND $r_b'C_c$ versus COLLECTOR CURRENT



2N2285 thru 2N2287

For Specifications, See 2N1651 Data.

2N2288 2N2289
2N2290

PNP GERMANIUM POWER SWITCHING TRANSISTORS

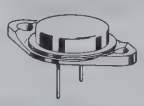
. . . designed for fast-switching applications requiring low saturation voltage and excellent collector-emitter sustaining voltage capability.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages –
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 5.0 Adc
  $V_{BE(sat)}$ = 1.0 Vdc (Max) @ I_C = 5.0 Adc

10 AMPERE

PNP ADE GERMANIUM POWER TRANSISTORS

40-120 VOLTS
70 WATTS



MAXIMUM RATINGS

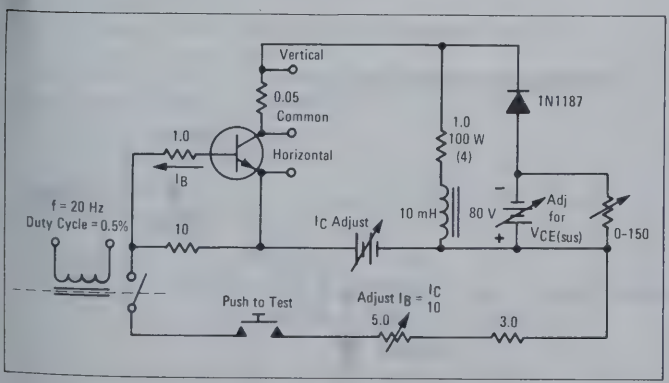
Rating	Symbol	2N2288	2N2289	2N2290	Unit
*Collector-Emitter Voltage (R_{BE} = 100 Ohms)	V_{CER}	40	80	120	Vdc
*Collector-Base Voltage	V_{CB}	40	80	120	Vdc
*Emitter-Base Voltage	V_{EB}	0.75			Vdc
*Collector Current - Continuous	I_C	10			Adc
Base Current - Continuous	I_B	3.0			Adc
Total Device Dissipation @ T_C = 25°C *Derate above 25°C	P_D	70 0.833			Watts W/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			°C

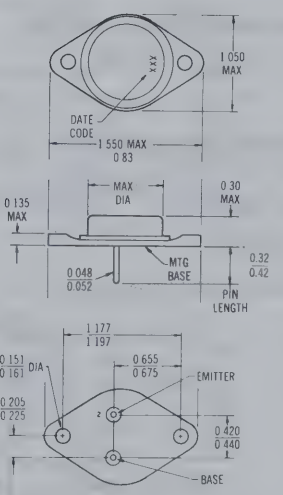
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.2	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT





Collector Connected to Case

CASE 11A
(TO-3)

Except Pin Diameter

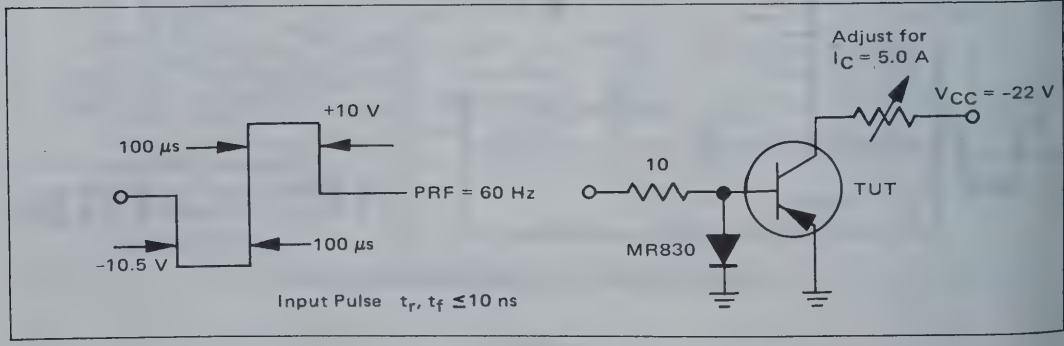
2N2288, 2N2289, 2N2290 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	2N2288	BV_{CEO}	30	-	Vdc
	2N2289		50	-	
	2N2290		70	-	
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 5.0 Adc)	2N2288	$V_{CE(sus)}$	30	-	Vdc
	2N2289		50	-	
	2N2290		70	-	
*Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, R_{BE} = 100 Ohms)	2N2288	BV_{CER}	40	-	Vdc
	2N2289		80	-	
	2N2290		120	-	
*Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	2N2288	I_{CEO}	-	50	mAdc
(V_{CE} = 25 Vdc, I_B = 0)	2N2289		-	50	
(V_{CE} = 35 Vdc, I_B = 0)	2N2290		-	50	
*Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C, +0, -3.0°C)	2N2288	I_{CEX}	-	35	mAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C, +0, -3.0°C)	2N2289		-	35	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C, +0, -3.0°C)	2N2290		-	35	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	All Types	I_{CBO}	-	200	μAdc
*(V_{CB} = 40 Vdc, I_E = 0)	2N2288		-	5.0	mAdc
*(V_{CB} = 80 Vdc, I_E = 0)	2N2289		-	5.0	
*(V_{CB} = 120 Vdc, I_E = 0)	2N2290		-	5.0	
Emitter Cutoff Current (V_{EB} = 0.75 Vdc, I_C = 0)		I_{EBO}	-	25	mAdc
ON CHARACTERISTICS					
*DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)		h_{FE}	20	-	-
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			20	60	
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{CE(sat)}$	-	0.5	Vdc
*Base-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{BE(sat)}$	-	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
*Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 14 Vdc, f = 1.0 kHz)		h_{fe}	25	100	-
(I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)			15	-	
SWITCHING CHARACTERISTICS					
Rise Time	I_C = 5.0 Adc, I_{B1} = I_{B2} = 1.0 Adc) (See Figure 2)	t_r	-	5.0	μs
Storage Time		t_s	-	7.0	μs
Fall Time		t_f	-	8.0	μs

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



2N2291 2N2292 2N2293

PNP GERMANIUM POWER SWITCHING TRANSISTORS

. . . designed for fast switching applications requiring low saturation voltage and excellent collector-emitter sustaining voltage capability.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages –
  $V_{CE(sat)}$ = 0.5 Vdc @ I_C = 5.0 Adc
  $V_{BE(sat)}$ = 1.0 Vdc @ I_C = 5.0 Adc

10 AMPERE

PNP ADE GERMANIUM POWER TRANSISTORS

40-120 VOLTS
70 WATTS



MAXIMUM RATINGS

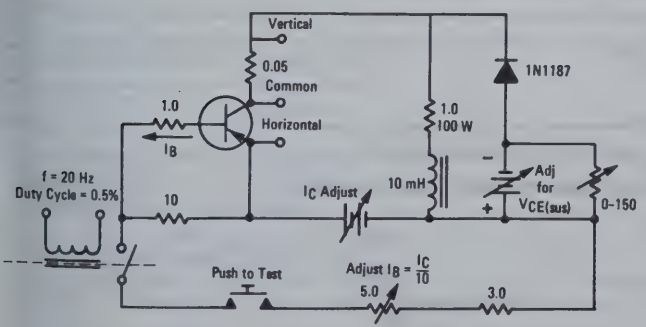
Rating	Symbol	2N2291	2N2292	2N2293	Unit
*Collector-Emitter Voltage	V_{CEO}	30	50	70	Vdc
*Collector-Base Voltage	V_{CB}	40	80	120	Vdc
*Emitter-Base Voltage	V_{EB}	1.5			Vdc
*Collector Current - Continuous	I_C	10			Adc
*Base Current - Continuous	I_B	3.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	70 0.83			Watts W/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			°C

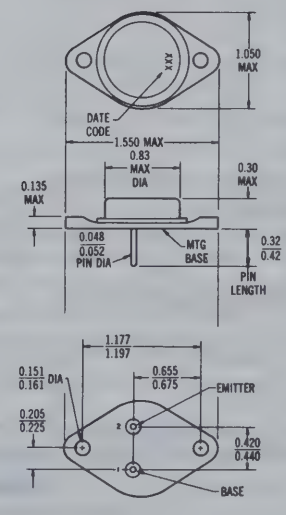
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.2	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT





Collector Connected to Case

CASE 11A
(TO-3)

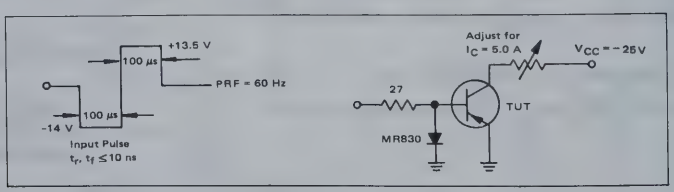
Except Pin Diameter

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	2N2291	BV_{CEO}	30	-	Vdc
	2N2292		50	-	
	2N2293		70	-	
*Collector-Emitter Sustaining Voltage (See Figure 1) *(I_C = 500 mAdc)	2N2291	$V_{CE(sus)}$	30	-	Vdc
	2N2292		50	-	
	2N2293		70	-	
**(I_C = 5.0 Adc)	2N2291		25	-	
	2N2292		50	-	
	2N2293		70	-	
*Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, R_{BE} = 100 ohms)	2N2291	BV_{CER}	40	-	Vdc
	2N2292		80	-	
	2N2293		120	-	
*Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	2N2291	I_{CEO}	-	50	mAdc
(V_{CE} = 25 Vdc, I_B = 0)	2N2292		-	50	
(V_{CE} = 35 Vdc, I_B = 0)	2N2293		-	50	
*Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C)	2N2291	I_{CEX}	-	35	mAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C)	2N2292		-	35	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C)	2N2293		-	35	
Collector Cutoff Current *(V_{CB} = -2.0 Vdc, I_E = 0)	All Types	I_{CBO}	-	200	μAdc
*(V_{CB} = 40 Vdc, I_E = 0)	2N2291		-	5.0	mAdc
*(V_{CB} = 80 Vdc, I_E = 0)	2N2292		-	5.0	
*(V_{CB} = 120 Vdc, I_E = 0)	2N2293		-	5.0	
Emitter Cutoff Current (V_{EB} = 1.5 Vdc, I_C = 0)		I_{EBO}	-	50	mAdc
ON CHARACTERISTICS					
*DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)		h_{FE}	40	-	-
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			50	120	
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{CE(sat)}$	-	0.5	Vdc
*Base-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{BE(sat)}$	-	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
*Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 14 Vdc, f = 1.0 kHz)		h_{fe}	50	200	-
(I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)			15	-	
SWITCHING CHARACTERISTICS					
Rise Time	(I_C = 5.0 Adc, I_{B1} = I_{B2} = 0.5 Adc) (See Figure 2)	t_r	-	7.0	μs
Storage Time		t_s	-	10	μs
Fall Time		t_f	-	8.0	μs

*Indicates JEDEC Registered Data.
**Motorola guarantees this data in addition to the JEDEC Registered Data Shown.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



2N2303 (SILICON)

For Specifications, See 2N722 Data.

2N2322 thru 2N2326 (SILICON)



CASE 31(2)
(TO-5)

All-diffused PNPN thyristors designed for gating operation in mA/μA signal or detection circuits.

MAXIMUM RATINGS* (T_J = 125°C unless otherwise noted, R_{GK} = 1000 ohms)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1)	$V_{RXM(rep)}$		Volts
2N2322		25	
2N2323		50	
2N2324		100	
2N2325		150	
2N2326		200	
Non-Repetitive Peak Reverse Blocking Voltage (t < 5.0 ms)	$V_{RXM(non-rep)}$		Volts
2N2322		40	
2N2323		75	
2N2324		150	
2N2325		225	
2N2326		300	
Forward Current RMS (All Conduction Angles)	I_f	1.6	Amp
Peak Surge Current (One-Half Cycle, 60 Hz) No Repetition Until Thermal Equilibrium is Restored	$I_{FM(surge)}$	15	Amp
Peak Gate Power — Forward	P_{GFM}	0.1	Watt
Average Gate Power — Forward	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current — Forward	I_{GFM}	0.1	Amp
Peak Gate Voltage — Forward	V_{GFM}	6.0	Volts
Reverse	V_{GRM}	6.0	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Lead Solder Temperature (> 1/16" from case, 10 sec. max)	-	+230	°C

* JEDEC Registered Values

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Characteristic	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1)	V_{FXM}			Volts
2N2322		25*	-	
2N2323		50*	-	
2N2324		100*	-	
2N2325		150*	-	
2N2326		200*	-	
Peak Reverse Blocking Current (Rated V_{RXM}, T_J = 125°C)	I_{RXM}	-	100*	µA
Peak Forward Blocking Current (Rated V_{FXM}, T_J = 125°C)	I_{FXM}	-	100*	µA
Forward "On" Voltage (I_F = 1.0 A Peak)	V_F	-	1.5	Volts
(I_F = 3.14 A Peak, T_C = 85°C)		-	2.0*	
Gate Trigger Current (Note 2) (Anode Voltage = 6.0 Vdc, R_L = 100 ohms)	I_{GT}	-	200	µA
(Anode Voltage = 6.0 Vdc, R_L = 100 ohms, T_C = -65°C)		-	350*	
Gate Trigger Voltage (Anode Voltage = 6.0 V, R_L = 100 ohms)	V_{GT}	-	0.8	Volts
(Anode Voltage = 6.0 V, R_L = 100 ohms, T_C = -65°C)		-	1.0*	
(Anode Voltage = Rated V_{FXM}, R_L = 100 ohms, T_J = 125°C)		0.1*	-	
Holding Current (Anode Voltage = 6.0 V)	I_{HX}	-	2.0	mA
(Anode Voltage = 6.0 V, T_C = -65°C)		-	3.0*	
(Anode Voltage = 6.0 V, T_C = 125°C)		0.15*	-	
Turn-On Time	t_{on}	Circuit dependent, consult manufacturer		
Turn-Off Time	t_{off}			

* JEDEC Registered Values

Notes: 1. V_{RXM} and V_{FXM} can be applied for all types on a continuous dc basis without incurring damage.

2. R_{GK} current is not included in measurement.

Thyristor devices shall not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

Thyristor devices shall not have a positive bias applied to the gate concurrently with a negative potential applied to the anode.

FIGURE 1 — CASE TEMPERATURE vs CURRENT

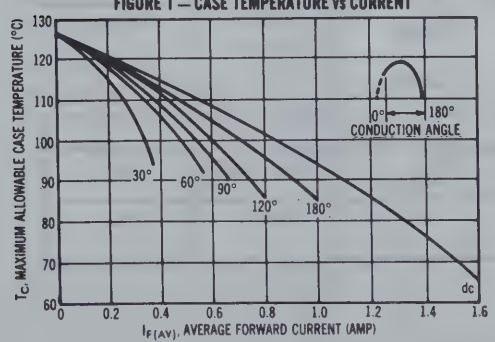
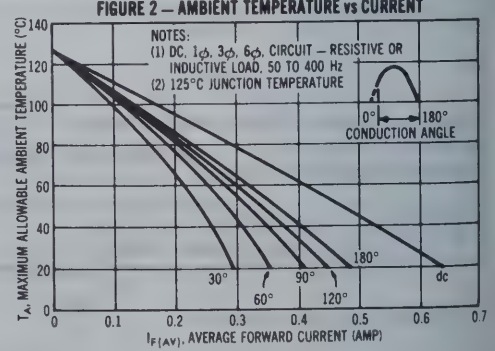
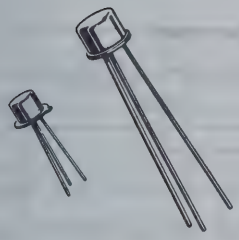


FIGURE 2 — AMBIENT TEMPERATURE vs CURRENT



2N2330 (SILICON)
2N2331



NPN silicon annular Star transistors for low-level DC/AC chopper applications.

CASE 22 (TO-18) 2N2331

CASE 31 (TO-5) 2N2330

Collector connected to case

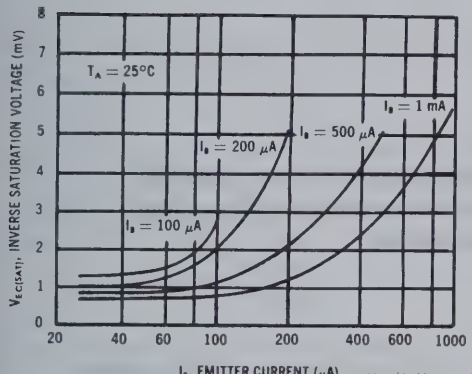
MAXIMUM RATINGS

Rating	Symbol	2N2330 (TO-5)	2N2331 (TO-18)	Unit
Collector-Emitter Voltage	V_{CEO}	20	20	Vdc
Collector-Base Voltage	V_{CB}	30	30	Vdc
Emitter-Base Voltage	V_{EB}	5	5	Vdc
Collector Current	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	0.8	0.5	Watt
Derate above 25^oC		5.33	3.33	$mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$	P_D	3	1.8	Watts
Derate above 25^oC		20	12	$mW/^oC$
Operating Junction Temperature Range	T_J	-65 to +175		^oC
Storage Temperature Range	T_{stg}	-65 to +200		^oC

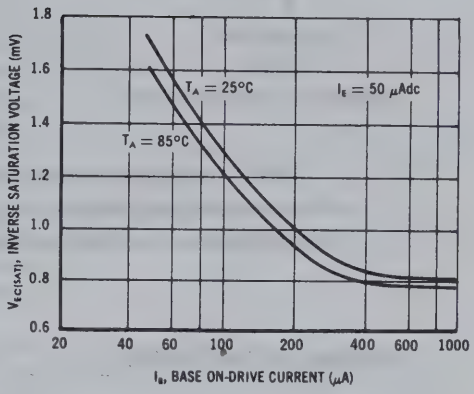
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5	-	Vdc
Collector Cutoff Current (V_{CB} = 4.5 Vdc, I_E = 0)	I_{CBO}	-	1.0	nAdc
Emitter Cutoff Current (V_{BE} = 4.5 Vdc)	I_{EBO}	-	5.0	nAdc
Offset Current (V_{BC} = 2 Vdc, V_{CE} = 0, T_A = 25°C)	$I_{(off)}$	-	1	nAdc
(V_{BC} = 2 Vdc, V_{CE} = 0, T_A = 85°C)		-	10	
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc)	h_{FE}	50	-	-
Offset Voltage (I_B = 200 μAdc, I_E = 0)	$V_{(off)}$	-	0.75	mVdc
Inverse Saturation Voltage (I_B = 200 μAdc, I_E = 50 μAdc)	$V_{EC(sat)}$	-	3.0	mVdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 1 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	f_T	100	-	MHz
Output Capacitance (V_{CB} = 2 Vdc, I_E = 0)	C_{ob}	-	10	pF
Input Capacitance (V_{BE} = 2 Vdc, I_C = 0)	C_{ib}	-	20	pF

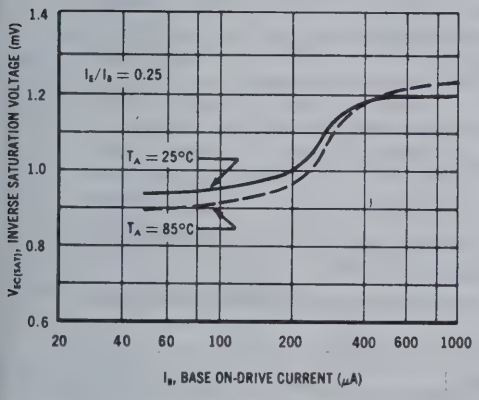
INVERSE SATURATION VOLTAGE versus EMITTER CURRENT



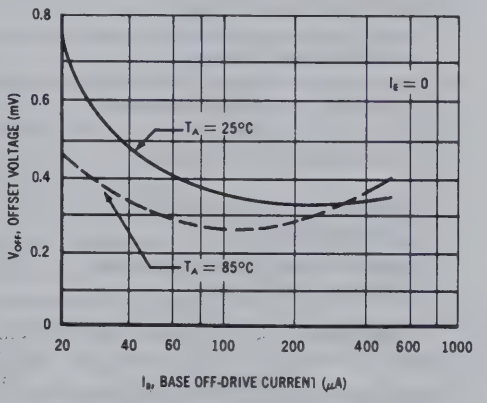
INVERSE SATURATION VOLTAGE versus BASE CURRENT



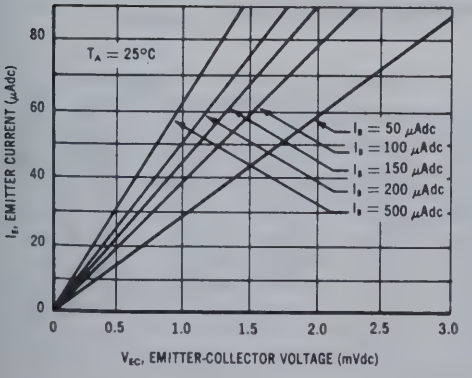
INVERSE SATURATION VOLTAGE versus BASE CURRENT



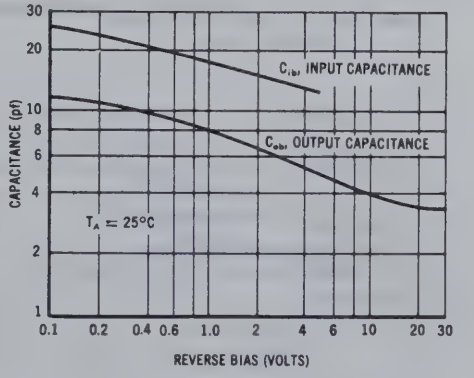
OFFSET VOLTAGE versus BASE CURRENT



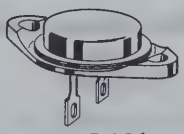
INVERSE SATURATION CHARACTERISTICS



OUTPUT CAPACITANCE versus COLLECTOR-BASE VOLTAGE and INPUT CAPACITANCE versus EMITTER-BASE VOLTAGE



2N2357 thru 2N2359 (Germanium)



CASE 161
(TO-41)
Collector Connected to Case

PNP Germanium power transistors designed for very high-current switching applications requiring low saturation voltages, fast switching times and good safe operating area.

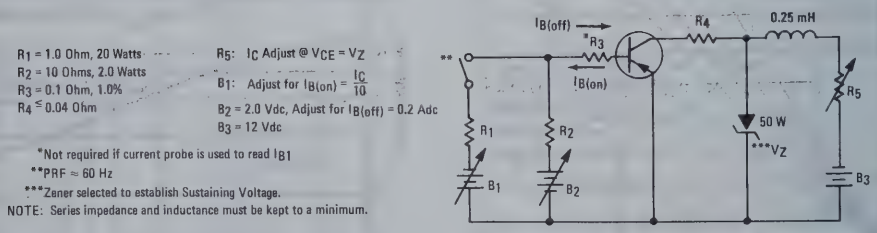
MAXIMUM RATINGS

Rating	Symbol	2N2357	2N2358	2N2359	Unit
Collector-Emitter Voltage	V_{CEO}	30	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	100	120	Vdc
Emitter-Base Voltage	V_{EB}	← 2.5 →			Vdc
Collector Current - Continuous	I_C	← 50 →			Adc
Base Current - Continuous	I_B	← 10 →			Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	← 170 2.0 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +110 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	°C/W

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT



2N2357 thru 2N2359 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	2N2357	BV_{CEO}	30	-	-	Vdc
	2N2358		60	-	-	
	2N2359		80	-	-	
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 50 Adc)	2N2357	$V_{CE(sus)}$	35	-	-	Vdc
	2N2358		40	-	-	
	2N2359		45	-	-	
Collector -Emitter Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 0	2N2357	I_{CES}	-	-	50	mAdc
(V_{CE} = 100 Vdc, V_{BE} = 0)	2N2358		-	-	50	
(V_{CE} = 120 Vdc, V_{BE} = 0)	2N2359		-	-	50	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	-	200	μAdc
Collector-Emitter Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N2357	I_{CEX}	-	-	5.0	mAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N2358		-	-	5.0	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N2359		-	-	5.0	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C) (+0, -3.0°C)	2N2357		-	-	35	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C) (+0, -3.0°C)	2N2358		-	-	35	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C) (+0, -3.0°C)	2N2359		-	-	35	
Emitter Cutoff Current (V_{EB} = 2.5 Vdc, I_C = 0)		I_{EBO}	-	-	50	mAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 20 Adc, V_{CE} = 1.5 Vdc)		h_{FE}	30	-	90	-
(I_C = 50 Adc, V_{CE} = 1.5 Vdc)			15	-	-	
Collector-Emitter Saturation Voltage (I_C = 50 Adc, I_B = 5.0 Adc)		$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 50 Adc, I_B = 5.0 Adc)		$V_{BE(sat)}$	-	-	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)		h_{fe}	20	-	-	-
SWITCHING CHARACTERISTICS						
Rise Time	(V_{CC} = -28 Vdc, I_C = 50 Adc, I_{B1} = 5.0 Adc, I_{B2} = 3.0 Adc) (See Figure 3)	t_r	-	12	-	μs
Storage Time		t_s	-	5.0	-	μs
Fall Time		t_f	-	6.0	-	μs

FIGURE 2 – SWITCHING TIMES

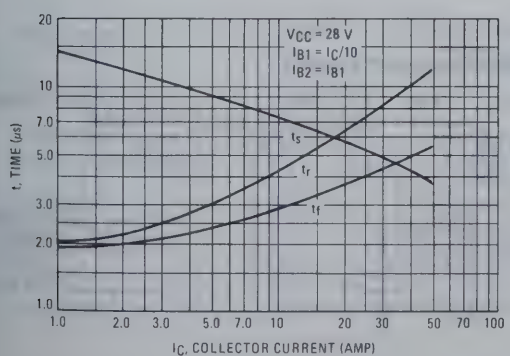
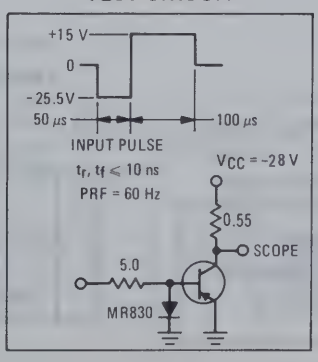
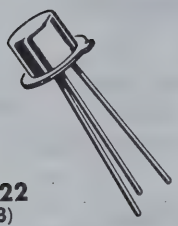


FIGURE 3 – SWITCHING TIME TEST CIRCUIT



2N2368 (SILICON)



CASE 22
(TO-18)

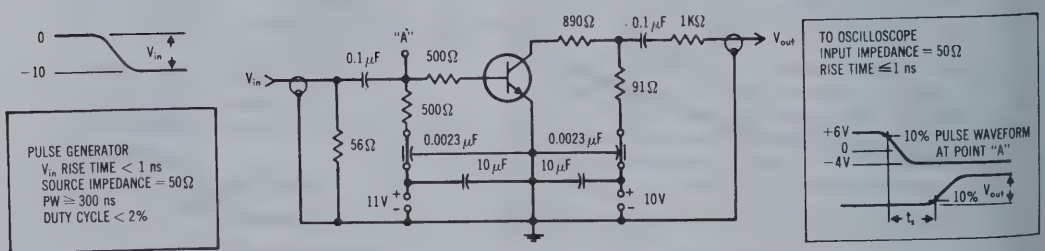
NPN silicon annular transistor designed for high-speed, low-level, saturated-switching application.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Device Dissipation@ $T_A = 25^oC$	P_D	0.36	Watt
Derate above 25^oC		2.06	$mW/^oC$
Total Device Dissipation@ $T_C = 25^oC$	P_D	1.2	Watt
Derate above 25^oC		6.85	$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

FIGURE 1 — STORAGE TIME TEST CIRCUIT

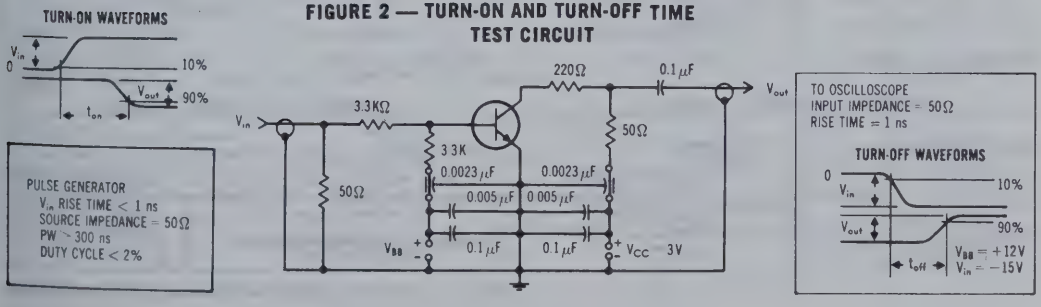


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	15	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.4 30	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}*	20 10 10	60 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	0.85	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	4	pF
Storage Time (Figure 1) (I_C = I_{B1} = 10 mAdc, I_{B2} = -10 mAdc)	t_s	—	10	ns
Turn-On Time (Figure 2) (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = -1.5 mAdc)	t_{on}	—	12	ns
Turn-Off Time (Figure 2) (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = -1.5 mAdc)	t_{off}	—	15	ns

*Pulse Test: Pulse Width = 300 μs; Duty Cycle ≤ 2%

FIGURE 2 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT



2N2369 (SILICON)
2N3227



CASE 22
(TO-18)

NPN silicon annular transistors for low-current, high-speed switching applications.

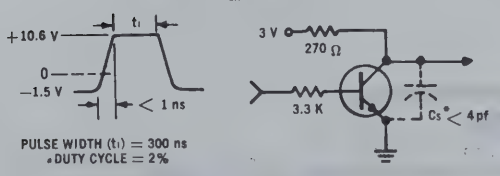
Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage 2N2369 2N3227	V_{CEO}	15 20	Vdc
Emitter-Base Voltage 2N2369 2N3227	V_{EB}	4.5 6.0	Vdc
Collector Current (10 μsec pulse)	$I_{C(Peak)}$	500	mA
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	 0.36 2.06	 Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	 1.2 6.85	 Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

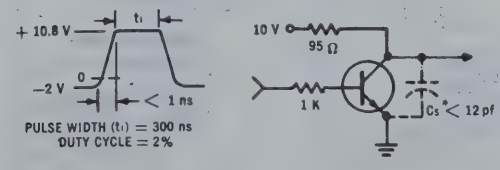
SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — t_{on} CIRCUIT — 10 mA



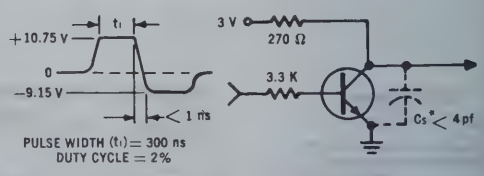
PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2%

FIGURE 2 — t_{on} CIRCUIT — 100 mA



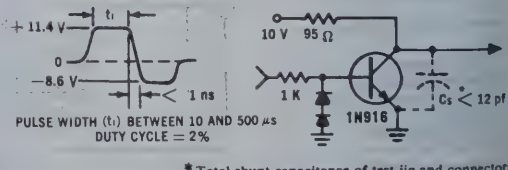
PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2%

FIGURE 3 — t_{off} CIRCUIT — 10 mA



PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2%

FIGURE 4 — t_{off} CIRCUIT — 100 mA



PULSE WIDTH (t_1) BETWEEN 10 AND 500 μs
DUTY CYCLE = 2%

* Total shunt capacitance of test jig and connectors.

ELECTRICAL CHARACTERISTICS

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector Cutoff Current			I_{CBO}			μAdc
(V_{CB} = 20 Vdc)	2N2369			—	0.4	
	2N3227			—	0.2	
(V_{CB} = 20 Vdc, T_A = 150°C)	2N2369			—	30	
	2N3227			—	50	
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3 Vdc)	2N3227		I_{CEX}	—	0.2	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3 Vdc)	2N3227		I_{BL}	—	0.5	μAdc
Collector-Base Breakdown Voltage (I_C = 10μ Adc, I_B = 0)			BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10μ Adc, I_C = 0)	2N2369		BV_{EBO}	4.5	—	Vdc
	2N3227			6.0	—	
Collector-Emitter Breakdown Voltage * (I_C = 10 mAdc)	2N2369		BV_{CEO}*	15	—	Vdc
	2N3227			20	—	
Collector-Emitter Voltage (I_C = 10μ Adc, I_B = 0)			BV_{CES}	40	—	Vdc
Collector-Emitter Saturation Voltage * (I_C = 10 mAdc, I_B = 1 mAdc)	Both Types	11,13	$V_{CE(sat)}$*	—	0.25	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3227			—	0.45	
Base-Emitter Saturation Voltage * (I_C = 10 mAdc, I_B = 1 mAdc)	Both Types	13	$V_{BE(sat)}$*	0.70	0.85	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3227			0.8	1.4	
DC Current Gain*			h_{FE}*			—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N2369			40	120	
	2N3227	12		100	300	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)	2N2369			20	—	
	2N3227	12		40	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3227	12		30	—	
(I_C = 100 mAdc, V_{CE} = 2 Vdc)	2N2369			20	—	
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)			h_{fe}	5	—	—
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)		5	C_{ob}	—	4	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 140 kHz)	2N3227		C_{ib}		4	pF
Storage Time (I_C = I_{B1} = I_{B2} = 10 mA)		10	t_s	—	13	ns
Turn-On Time (I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 3 V, $V_{EB(off)}$ = 1.5 Vdc)		1,6	t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mA, I_{B1} = 3 mA, I_{B2} = 1.5 mA, V_{CC} = 3 V)		3,6	t_{off}	—	18	ns
Total Control Charge (I_C = 10 mA, I_B = 1 mA, V_{CC} = 3 V)	2N3227	7,8	Q_T	—	50	pC
Delay Time	V_{CC}=10 V, $V_{EB(off)}$ = 2 Vdc,	2,6	t_d	—	5	ns
Rise Time	I_C = 100 mA, I_{B1}=10 mA	2N3227	t_r	—	18	ns
Storage Time	V_{CC}= 10 V	4,6	t_s	—	13	ns
Fall Time	I_C = 100 mA, I_{B1}= I_{B2} = 10 mA	2N3227	t_f	—	15	ns

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%

FIGURE 5 — JUNCTION CAPACITANCE VARIATIONS

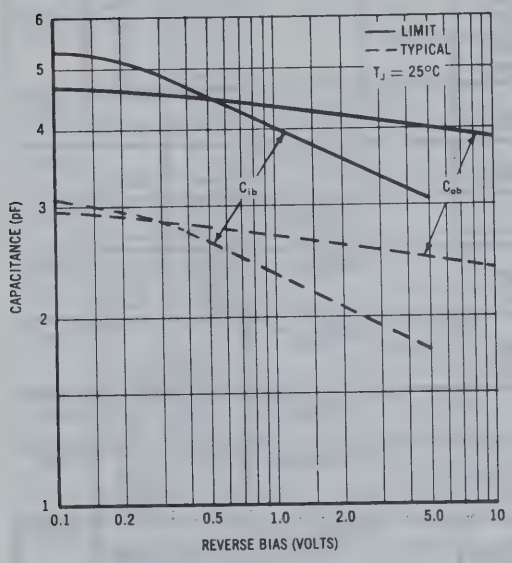


FIGURE 6 — TYPICAL SWITCHING TIMES

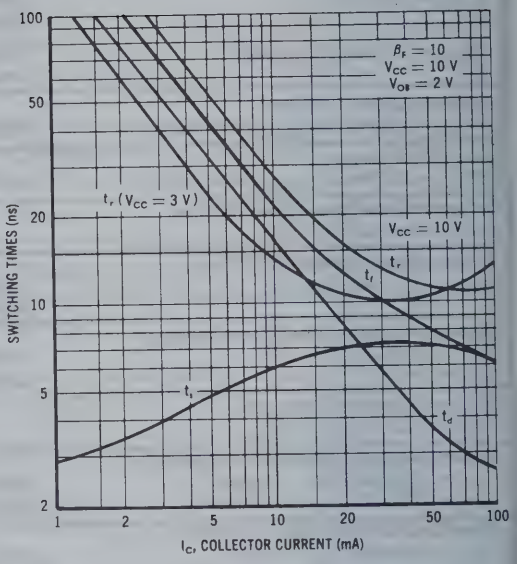


FIGURE 7 — MAXIMUM CHARGE DATA

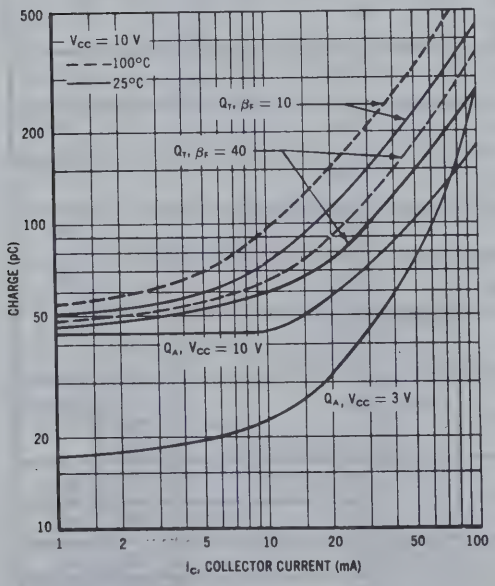


FIGURE 8 — Q_T TEST CIRCUIT

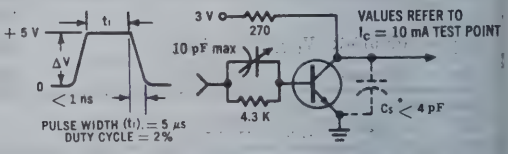
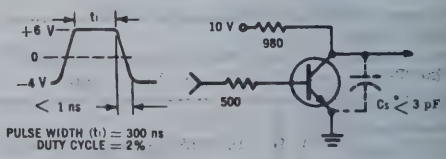


FIGURE 9 — TURN-OFF WAVE FORM



FIGURE 10 — STORAGE TIME EQUIVALENT TEST CIRCUIT



* Total shunt capacitance of test jig and connectors.

FIGURE 11 — MAXIMUM COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

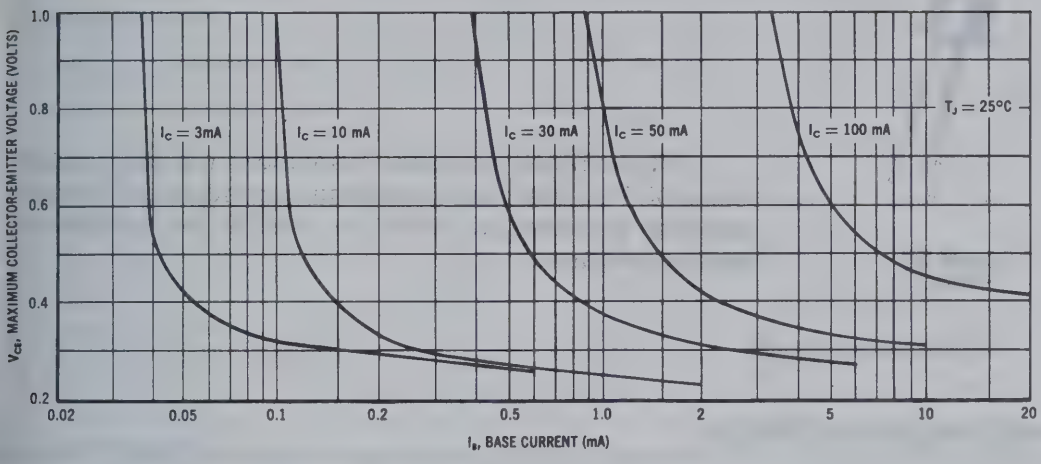


FIGURE 12 — MINIMUM CURRENT GAIN CHARACTERISTICS

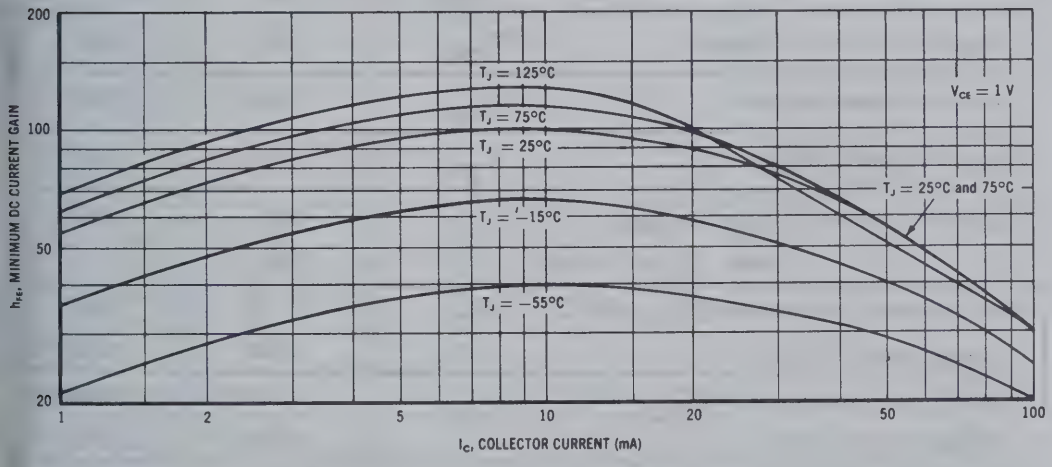


FIGURE 13 — SATURATION VOLTAGE LIMITS

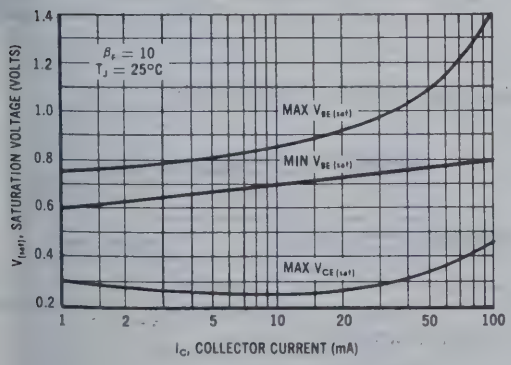
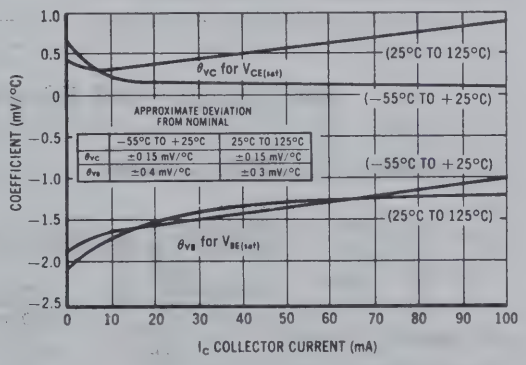


FIGURE 14 — TYPICAL TEMPERATURE COEFFICIENTS



2N2369A (SILICON)



CASE 22
(TO-18)

Collector connected to case

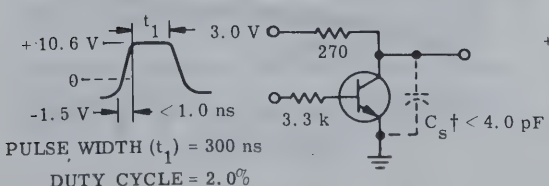
NPN silicon epitaxial transistor for high-speed range of 10 – 100 mAdc switching applications. Specifications provided at -55°C to +125°C for critical dc characteristics.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current — Continuous Peak (10 μs Pulse)	I_C	200 500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	Watts mW/°C
Operating Junction Temperature Range	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

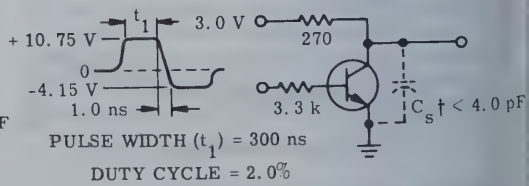
SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — t_{on} CIRCUIT — 10 mA



PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2.0%

FIGURE 2 — t_{off} CIRCUIT — 10 mA



PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2.0%

† Total shunt capacitance of test jig and connectors.

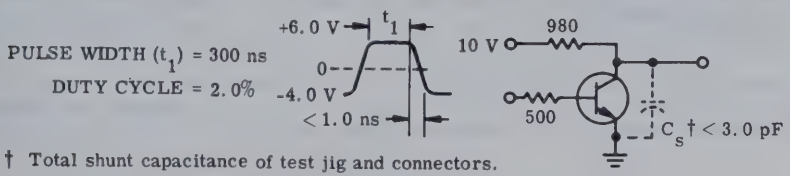
2N2369A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	-	BV_{CEO}*	15	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, I_B = 0)	-	BV_{CES}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	-	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	-	BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	-	I_{CES}	-	0.4	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	-	I_{CBO}	-	30	μAdc
Base Current (V_{CE} = 20 Vdc, V_{BE} = 0)	-	I_B	-	0.4	μAdc
ON CHARACTERISTICS					
DC Current Gain*	-	h_{FE}*			-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			-	120	
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc)			40	-	
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = -55°C)			20	-	
(I_C = 30 mAdc, V_{CE} = 0.4 Vdc)			30	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			20	-	
Collector-Emitter Saturation Voltage*	-	$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			-	0.20	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C)			-	0.30	
(I_C = 30 mAdc, I_B = 3.0 mAdc)			-	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)			-	0.50	
Base-Emitter Saturation Voltage*	-	$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			0.70	0.85	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C)			0.59	-	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = -55°C)			-	1.02	
(I_C = 30 mAdc, I_B = 3.0 mAdc)			-	1.15	
(I_C = 100 mAdc, I_B = 10 mAdc)			-	1.60	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	-	f_T	500	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	-	C_{ob}	-	4.0	pF
Turn-On Time (V_{CC} = 3.0 V, $V_{BE(off)}$ = 1.5 V, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	1	t_{on}	-	12	ns
Turn-Off Time (V_{CC} = 3.0 V, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	2	t_{off}	-	18	ns
Storage Time (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	3	t_s	-	13	ns

* Pulse Test: PW = 300 μs, Duty Cycle = 2.0%

FIGURE 3 — STORAGE TIME EQUIVALENT TEST CIRCUIT



† Total shunt capacitance of test jig and connectors.

2N2381 (GERMANIUM)
2N2382



PNP germanium epitaxial mesa transistors for high-speed, high-current switching applications.

Collector connected to case

CASE 31
(TO-5)

MAXIMUM RATINGS

Rating	Symbol	2N2381	2N2382	Unit
Collector-Emitter Voltage	V_{CEO}	15	20	Vdc
Collector-Base Voltage	V_{CB}	30	45	Vdc
Emitter-Base Voltage	V_{EB}	4	4	Vdc
Collector Current-Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	300 4		mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	750 10		mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		^oC

FIGURE 1 — ACTIVE REGION TIME CONSTANT

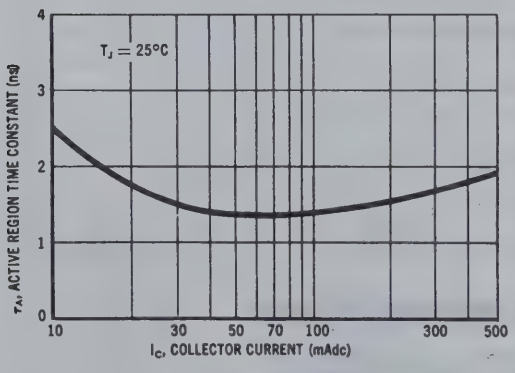
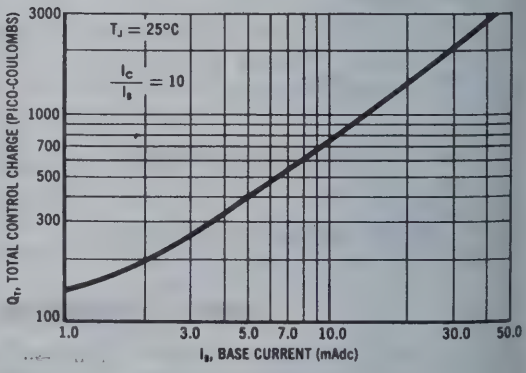


FIGURE 2 — TOTAL CONTROL CHARGE



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_E = 0) 2N2381		BV_{CEO}	15	-	-	Vdc
2N2382			20	-	-	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) 2N2381		BV_{CBO}	30	-	-	Vdc
2N2382			45	-	-	
Latch-Up Voltage 2N2381	7	LV_{CEX}	20	-	-	Vdc
2N2382			25	-	-	
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0) 2N2381		I_{CES}	-	-	100	μAdc
(V_{CE} = 45 Vdc, V_{BE} = 0) 2N2382			-	-	100	
Collector Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)		I_{CBO}	-	1.0	7	μAdc
(V_{CB} = 5 Vdc, I_E = 0, T_A = 85°C)			-	-	100	
(V_{CB} = 20 Vdc, I_E = 0) 2N2381			-	-	25	
2N2382			-	-	15	
Emitter Cutoff Current (V_{BE} = 0.5 Vdc, I_C = 0)		I_{EBO}	-	-	0.005	mAdc
(V_{BE} = 4 Vdc, I_C = 0)			-	-	1	
ON CHARACTERISTICS						
DC Current Gain (I_C = 200 mAdc, V_{CE} = 0.5 Vdc)	11	h_{FE}	40	-	-	-
(I_C = 400 mAdc, V_{CE} = 1.0 Vdc)			25	-	-	
Collector-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc)	8,10	$V_{CE(sat)}$	-	0.25	0.4	Vdc
(I_C = 400 mAdc, I_B = 40 mAdc)			-	0.4	0.7	
Base-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc)	9,10	$V_{BE(sat)}$	0.45	0.54	0.7	Vdc
(I_C = 400 mAdc, I_B = 40 mAdc)			-	0.71	0.9	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	-	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 4 MHz)	13	C_{ob}	-	3.5	6	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 4 MHz)	13	C_{ib}	-	8	15	pF
Delay Time	4	t_d	-	4.5	7	ns
Rise Time	4	t_r	-	8	15	ns
Storage Time	3,4	t_s	-	20	30	ns
Fall Time	4	t_f	-	8	15	ns
Active Region Time Constant	1,4	τ_A	-	1.6	3.0	ns

FIGURE 3 — STORAGE TIME VARIATIONS

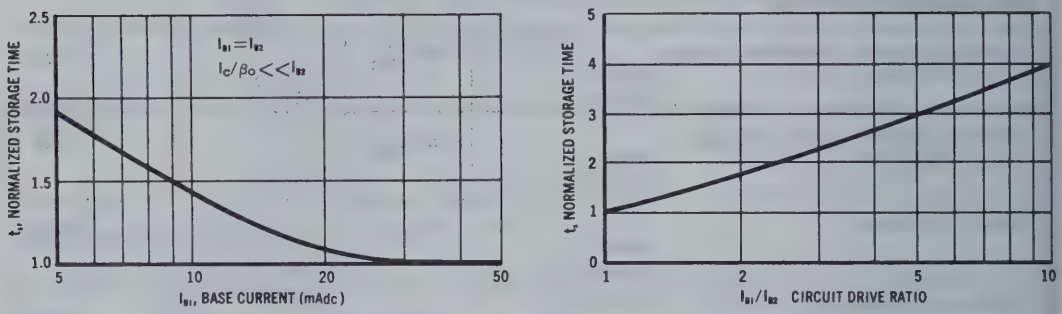


FIGURE 4 — SWITCHING TIME EQUATIONS & TEST CIRCUIT

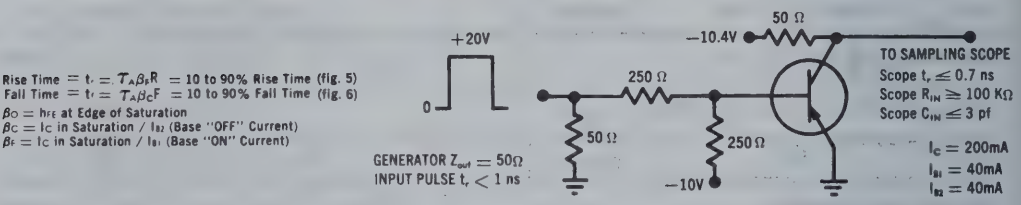


FIGURE 5 — RISE TIME FACTOR

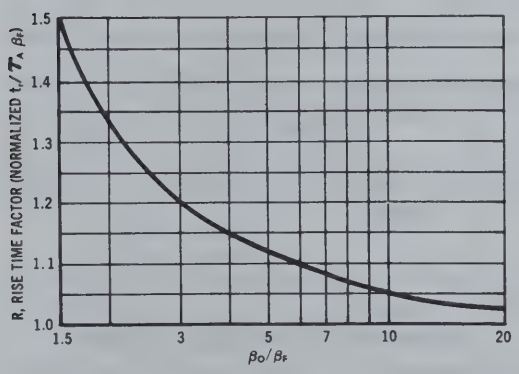


FIGURE 6 — FALL TIME FACTOR

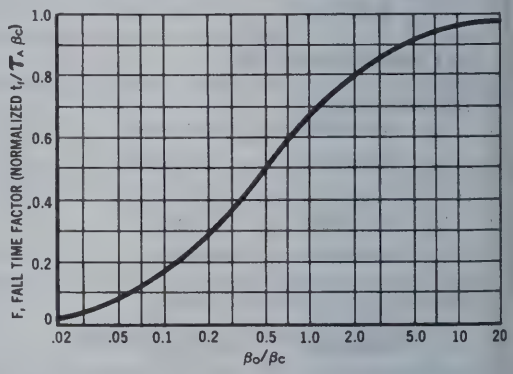


FIGURE 7 — COLLECTOR LATCH-UP VOLTAGE AND TEST CIRCUIT

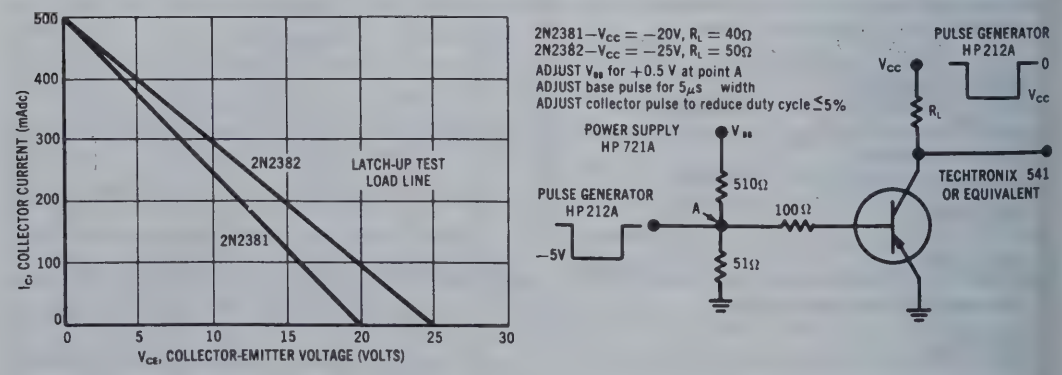


FIGURE 8 — COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT

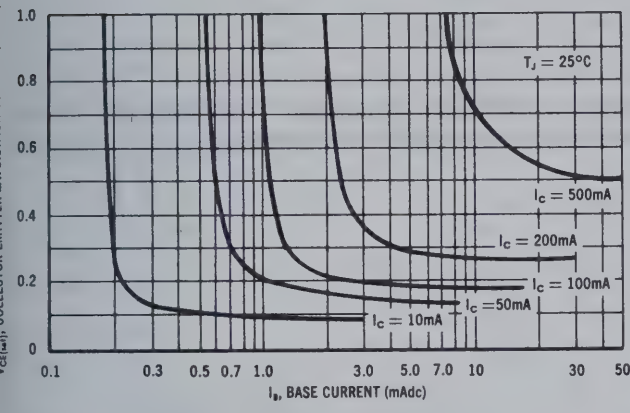


FIGURE 9 — BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

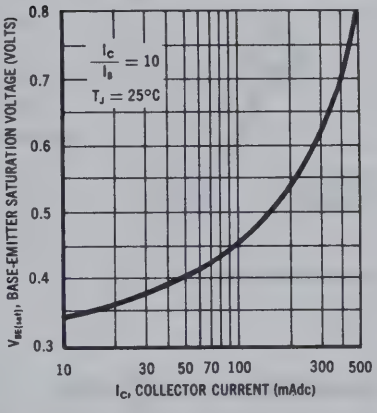


FIGURE 10 — TEMPERATURE COEFFICIENTS

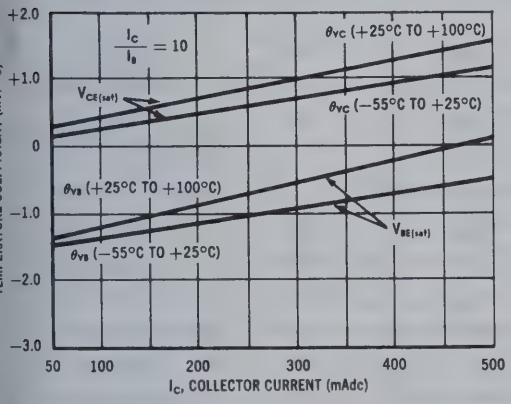


FIGURE 11 — NORMALIZED GAIN CHARACTERISTICS

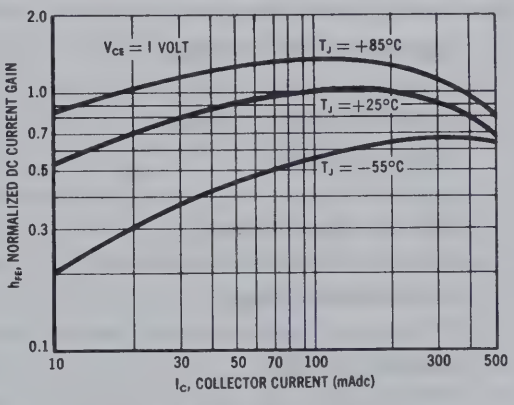


FIGURE 12 — LEAKAGE CHARACTERISTICS COMMON EMITTER

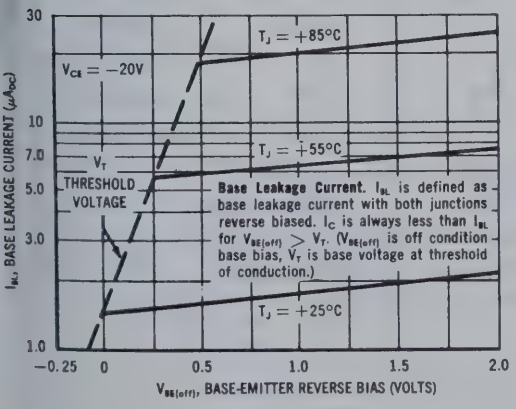
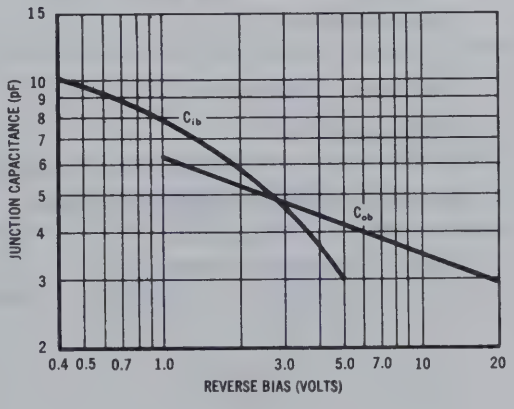


FIGURE 13 — JUNCTION CAPACITANCE versus REVERSE VOLTAGE



2N2405

For Specifications, See 2N1893 Data.

2N2410 (SILICON)



CASE 31
(TO-5)

Collector connected to case

NPN silicon annular transistor designed for high-speed, medium-power saturated switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Emitter Voltage R_{BE} = 10 ohms	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	800	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 4.57	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 14.3	Watts mW/°C
Operating Junction Temperature Range	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

2N2410 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, I_B = 0)	$BV_{CEO\ (sus)}$*	30	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, R_{BE} = 10 ohms)	BV_{CER}*	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector-Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0) (V_{CE} = 30 Vdc, V_{BE} = 0, T_A = 150°C)	I_{CES}	— —	0.3 350	μAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	0.3	μAdc
Emitter Cutoff Current (V_{BE} = 4 Vdc, I_C = 0)	I_{EBO}	—	0.3	μVdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 1 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	h_{FE}*	30 15 30 25	120 — 120 100	—
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$*	— —	0.45 1.3	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE\ (sat)}$*	— —	1.2 1.6	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	11	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1 MHz)	C_{ib}	—	50	pF
Turn-On Time (t_d + t_r) (I_C = 150 mAdc, Figure 1) (I_C = 500 mAdc, Figure 2)	t_{on}	— —	65 65	ns
Turn-Off Time (t_s + t_f) (I_C = 150 mAdc, Figure 1) (I_C = 500 mAdc, Figure 2)	t_{off}	— —	55 65	ns
Storage Time (I_C = 150 mAdc, Figure 1)	t_s	—	40	ns
Fall Time (I_C = 150 mAdc, Figure 1)	t_f	—	30	ns

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — I_c = 150 mA

$t_r \leq 1$ ns, PULSE WIDTH $\geq$ 300 ns

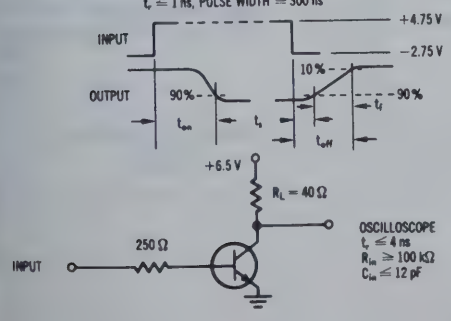
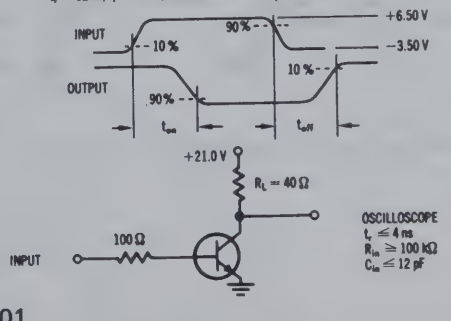


FIGURE 2 — I_c = 500mA

$t_r \leq$ 12 ns, $t_f \leq$ 12 ns, PULSE WIDTH = 1.5 μs ± 0.5 μs, PRR $\leq$ 500 Hz



2N2411 (SILICON)
2N2412

PNP SILICON ANNULAR TRANSISTORS

. . . designed for high-speed, low power, saturated switching applications.

- DC Current Gain Specified — 50 μAdc to 50 mAdc
- Fast Turn-On Time — t_{on} = 25 ns (Max)
- Fast Turn-Off Time — t_{off} = 100 ns (Max)

PNP SILICON SWITCHING TRANSISTORS

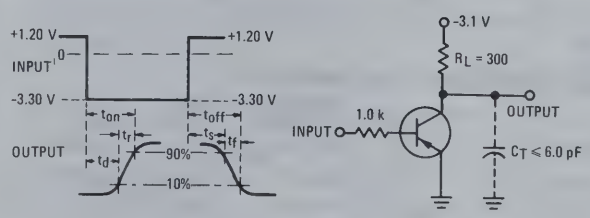


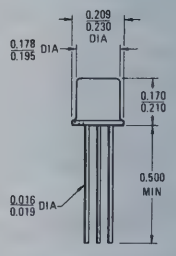
*MAXIMUM RATINGS

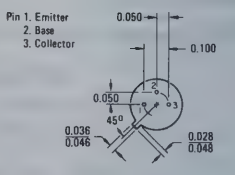
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.72	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT







Collector Connected to Case
CASE 22 (1)
(TO-18)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage[1] (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	20	–	Vdc
Collector Cutoff Current		I_{CES}			
(V_{CE} = 25 Vdc, V_{BE} = 0)			–	10	nAdc
(V_{CE} = 25 Vdc, V_{BE} = 0, T_A = +150°C)			–	10	μAdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)		I_{CBO}	–	10	nAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain[1]		h_{FE}			–
(I_C = 50 μAdc, V_{CE} = 0.5 Vdc)	2N2411		10	–	
	2N2412		20	–	
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc)	2N2411		20	60	
	2N2412		40	120	
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C)	2N2411		10	–	
	2N2412		20	–	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N2411		10	–	
	2N2412		20	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	0.7	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product[2] (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	140	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	5.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	–	8.0	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Time		t_{on}	–	25	ns
Delay Time		t_d	–	10	ns
Rise Time		t_r	–	20	ns
Turn-Off Time		t_{off}	–	100	ns
Storage Time		t_s	–	90	ns
Fall Time		t_f	–	20	ns

*Indicates JEDEC Registered Data.

[1]Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

[2]f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N2415 (GERMANIUM)
2N2416

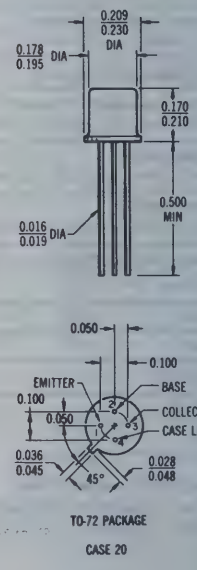
AMPLIFIER TRANSISTORS
GERMANIUM PNP
EPITAXIAL MESA
DIFFUSED BASE

GERMANIUM ULTRA-HIGH-FREQUENCY TRANSISTORS

. . . for very low-noise, high-gain amplifiers, oscillators, mixers, and frequency multipliers.

- High Maximum Frequency of Oscillation
  f_{max} = 2000 MHz typ
- Low Noise Figure
  NF = 3.0 dB max at 200 MHz (2N2415)
- High Maximum Available Gain
  MAG = 14 dB typ at 500 MHz for 2N2415
  MAG = 12.5 dB typ at 500 MHz for 2N2416
- High Breakdown Voltages
  BV_{CEO} = 25 Volts typ
  BV_{CEO} = 15 Volts typ
- Low Output Capacitance
  C_{ob} = 0.9 pF typ





TO-72 PACKAGE
CASE 20

MAXIMUM RATINGS*

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	0.3	Vdc
Collector Current	I_C	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	75 1.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	°C

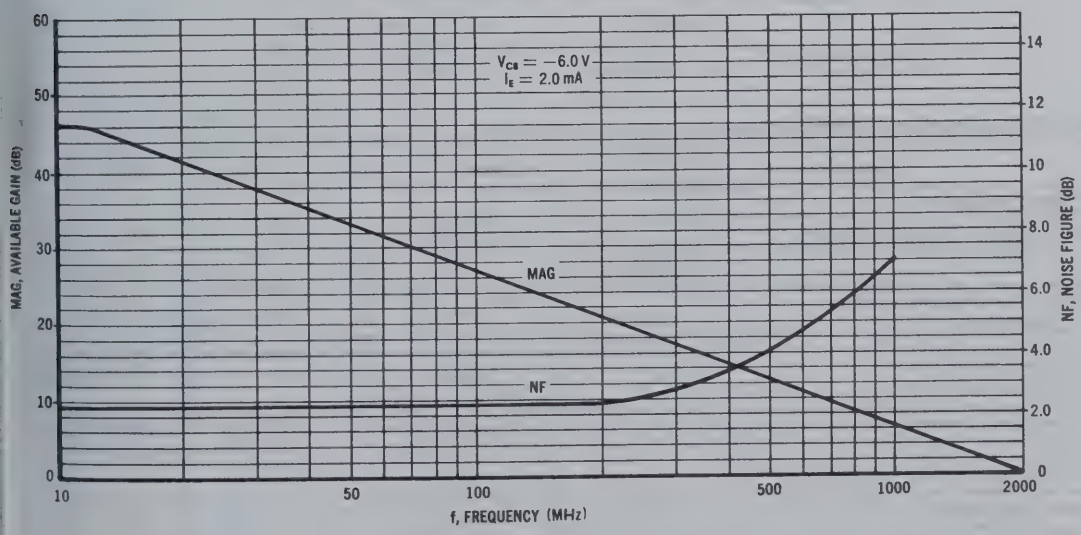
* The maximum rating is that value above which device operation may be impaired from the viewpoint of life or performance.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 2.0 mAdc, I_B = 0)		BV_{CEO}*	10	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	15	25	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	-	1.0	5.0	μAdc
Emitter Cutoff Current (V_{BE} = 0.3 Vdc, I_C = 0)		I_{EBO}	-	-	100	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc)	2N2415 2N2416	h_{FE}	10 8.0	- -	200 200	-
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz)	2N2415 2N2416	f_T	500 400	- -	- -	MHz
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	0.9	2.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	2N2415 2N2416	h_{fe}	15 10	- -	300 300	-
Collector-Base Time Constant** (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 79.8 MHz)	2N2415 2N2416	$r_b'C_c$**	- -	- -	8.0 10	ps
Noise Figure (V_{CB} = 6.0 Vdc, I_E = 1.5 mAdc, R_S = 75 ohms, f = 200 MHz)	2N2415 2N2416	NF	- -	2.4 3.4	3.0 4.0	dB
FUNCTIONAL TESTS						
Maximum Available Gain# (V_{CB} = 6.0 Vdc, I_E = 2.0 mAdc, f = 500 MHz)	2N2415 2N2416	MAG#	- -	14 12.5	- -	dB

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
** Direct Collector-Emitter header capacitance balanced out to give true device capability.
MAG calculated from f_{max} as determined from actual amplifier circuits.

TYPICAL MAG and NOISE FIGURE versus FREQUENCY

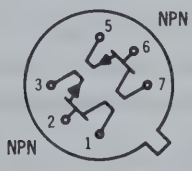


2N2453 (SILICON)
2N2453A



Dual NPN silicon transistors designed for differential amplifier applications.

CASE 32C



PINS 4 AND 8 OMITTED

Pin Connections, Bottom View

All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	2N2453	2N2453A	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J T_{stg}	-65 to +200		C
		One Side	Both Sides	
Power Dissipation @ T_A = 25°C	P_D	200	300	mW
Derate above 25°C		1.14	1.71	mW/°C
Power Dissipation @ T_C = 25°C	P_D	600	1200	mW
T_C = 100°C		350	700	mW
Derate above 25°C		3.43	6.86	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	2N2453	$BV_{CEO(sus)}$*	30	-	Vdc
	2N2453A		50	-	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N2453	BV_{CBO}	60	-	Vdc
	2N2453A		80	-	
Emitter Base Breakdown Voltage (I_E = 0.1 μAdc, I_C = 0)		BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	-	0.005	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			-	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	0.002	μAdc

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)		80	-	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)		40	-	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		150	600	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)		75	-	
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)	f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	5.0	-	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	-	6.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	150	600	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	5.0	30	μmhos
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	20	30	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	5.0	X 10^{-4}
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	0.2	μmho
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)	NF	-	7.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio**	h_{FE1}/h_{FE2}**			-
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc) 2N2453A		0.90	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		0.90	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +125°C)		0.85	1.0	
Base Voltage Differential	$\lvert V_{BE1}-V_{BE2}\rvert$			mVdc
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)		-	3.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		-	5.0	
Base Voltage Differential Gradient	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$			μV/°C
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +125°C) 2N2453		-	10	
2N2453A		-	5.0	

** Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2476 (SILICON)
2N2477



CASE 31
(TO-5)

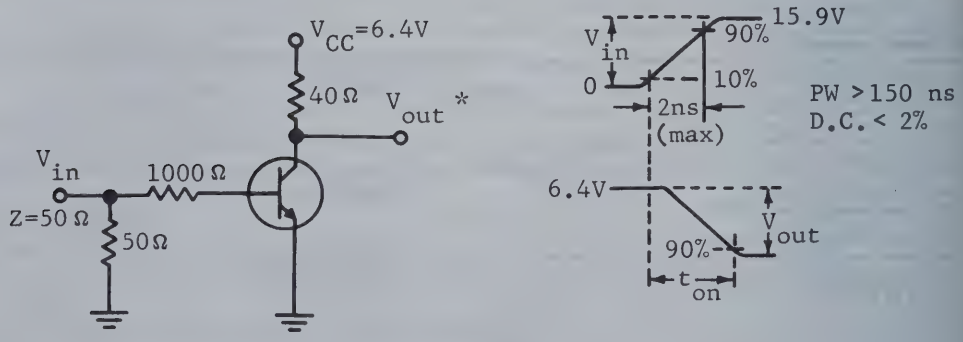
NPN silicon annular transistors designed for high speed, low-power saturated switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C	P_D	0.6	Watt
Derate above 25°C		3.4	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	2.0	Watts
Derate above 25°C		11.4	mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 — TURN-ON TIME TEST CIRCUIT



*Input and output waveforms monitored by means of an oscilloscope or other indicating device having a rise time<0.5 ns; input capacitance of probe < 2.5 pF with shunt resistance ≥ 1 megohm.

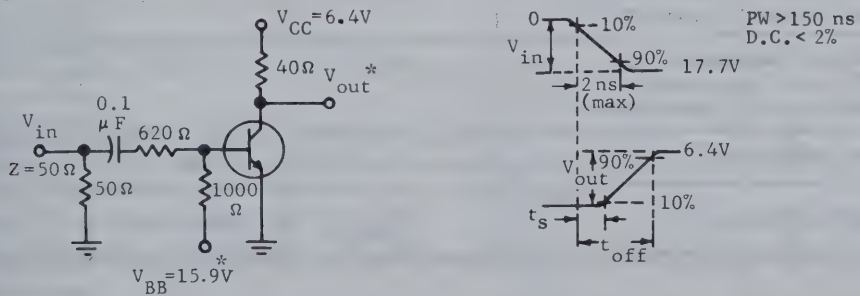
2N2476, 2N2477 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 50 mAdc, I_B = 0)		BV_{CEO}*	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	0.2	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)			-	200	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 150 mAdc, V_{CE} = 0.4 Vdc)	2N2476	h_{FE}	20	-	-
	2N2477		40	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 7.5 mAdc)	2N2476		-	0.4	
(I_C = 150 mAdc, I_B = 3.75 mAdc)	2N2477		-	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N2476		-	0.75	
	2N2477		-	0.65	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 7.5 mAdc)	2N2476		-	1.0	
(I_C = 150 mAdc, I_B = 3.75 mAdc)	2N2477		-	0.95	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	250	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	-	10	pF
Turn-On Time (Figure 1) (V_{CC} = 6.4 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)		t_{on}	-	25	ns
Turn-Off Time (Figure 2) (V_{CC} = 6.4 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)		t_{off}	-	45	ns
Storage Time (Figure 2) (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)		t_s	-	25	ns

* Pulse Test: pulse width ≤ 400 μs, duty cycle ≤ 3%.

FIGURE 2 — TURN-OFF TIME TEST CIRCUIT



*Input and output waveforms monitored by means of an oscilloscope or other indicating device having a rise time<0.5 ns; input capacitance of probe < 2.5 pF with shunt resistance ≥ 1 megohm.

2N2480, A

For Specifications, See 2N2060 Data.

2N2481 (SILICON)



CASE 22
(TO-18)

NPN silicon annular transistor for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

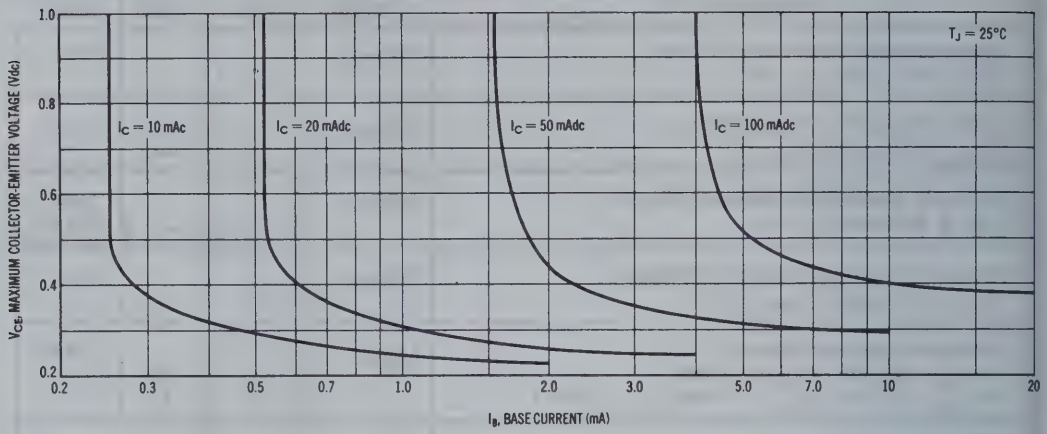
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Total Device Dissipation @ 25°C Ambient Temperature (Derate 2.06 mW/°C above 25°C)	P_D	0.36	Watt
Total Device Dissipation @ 25°C Case Temperature (Derate 6.9 mW/°C above 25°C)	P_D	1.2	Watts
Junction Temperature	T_J	200	°C
Storage Temperature	T_{stg}	-65 to + 200	°C

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

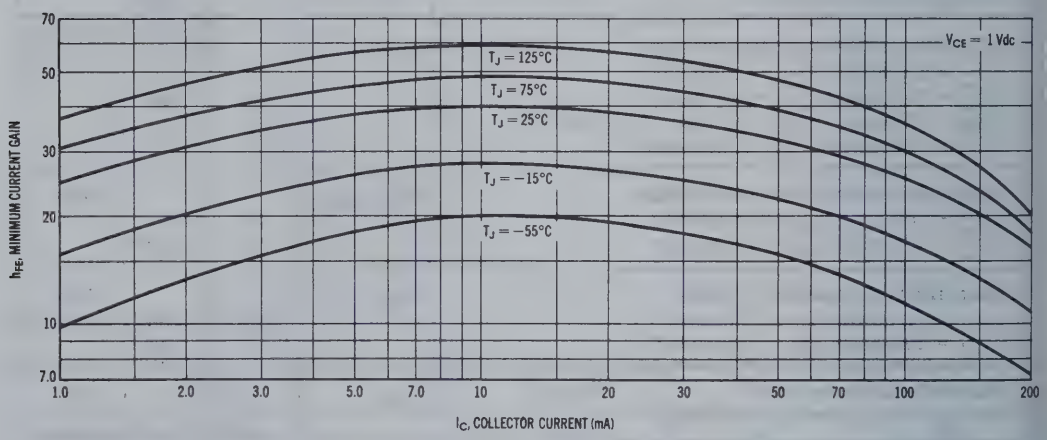
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	15	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 μAdc, V_{BE} = 0)	BV_{CES}	30	---	Vdc
Collector Leakage Current (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc) (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc, T_A = 150°C)	I_{CEX}	--- ---	.050 15	μAdc
Base Leakage Current (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc)	I_{BL}	---	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	---	100	nAdc
DC Forward Current Transfer Ratio (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)* (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)*	h_{FE}	 25 40 20 20	 --- 120 --- ---	---
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)*	V_{CE} (sat)	 --- ---	 0.25 0.40	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)*	V_{BE} (sat)	 0.7 ---	 0.82 1.25	Vdc
Output Capacitance (V_{CB} = 5 V, I_C = 0, f = 1 MHz)	C_{ob}	---	5	pF
Input Capacitance (V_{EB} = 0.5 V, f = 1 MHz)	C_{ib}	---	7	pF
Small-Signal Forward Current Transfer Ratio (V_{CE} = 10 V, I_C = 10 mA, f = 100 MHz)	h_{fe}	3	---	---
Small-Signal, Short-Circuit, Input Impedance (Real part) (I_C = 10 mA, V_{CE} = 10 V, f = 250 MHz)	$Re(h_{ie})$	---	60	ohms
Turn-On Time (I_C = 100 mA, I_{B1} = 10 mA, $V_{BE(off)}$ = 2 V) (I_C = 10 mA, I_{B1} = 1.0 mA, $V_{BE(off)}$ = 2 V)	t_{on}	--- ---	40 75	ns
Turn-Off Time (I_C = 100 mA, I_{B1} = 10 mA, I_{B2} = 5 mA) (I_C = 10 mA, I_{B1} = 1.0 mA, I_{B2} = 0.5 mA)	t_{off}	--- ---	55 45	ns
Storage Time (I_C = 10 mA, I_{B1} = 10 mA, I_{B2} = 10 mA)	t_s	---	20	ns

*Pulse width ≤ 300 μs, Duty Cycle ≤ 2%

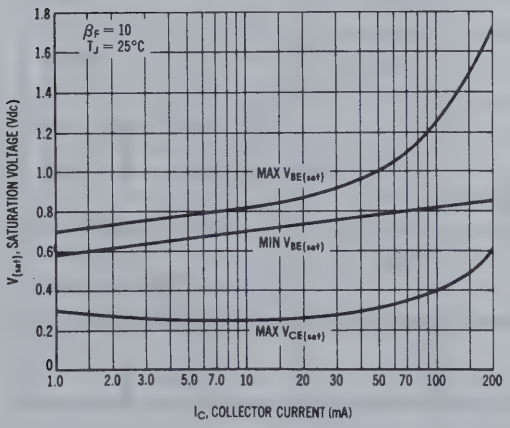
COLLECTOR SATURATION VOLTAGE CHARACTERISTICS



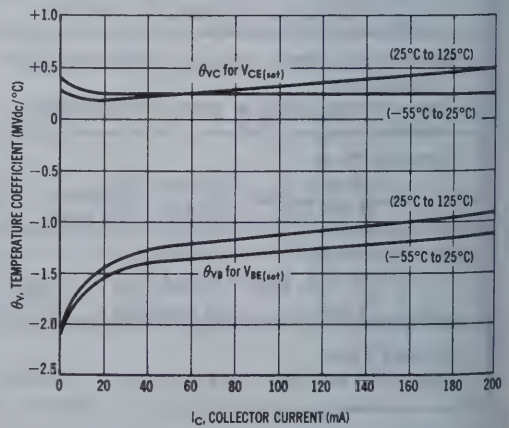
MINIMUM CURRENT GAIN CHARACTERISTICS



LIMITS OF SATURATION VOLTAGES

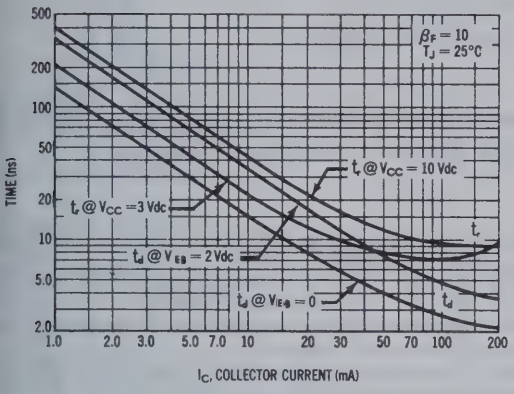


TYPICAL TEMPERATURE COEFFICIENTS

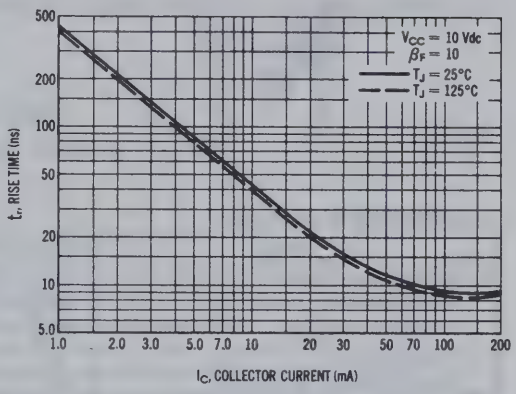


TYPICAL SWITCHING CHARACTERISTICS

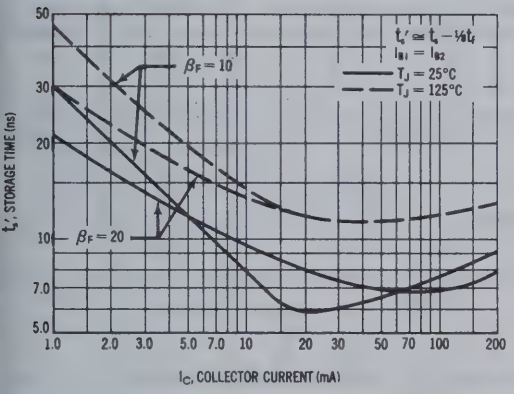
TURN-ON TIME VARIATIONS WITH VOLTAGE



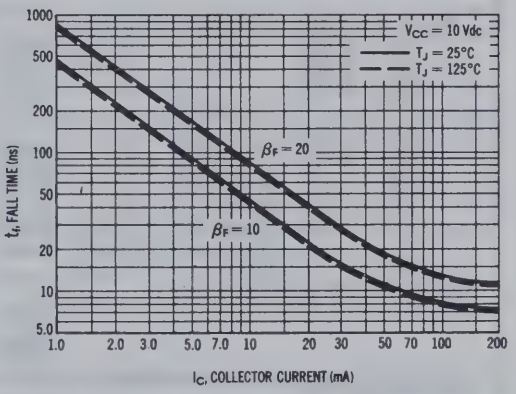
RISE TIME BEHAVIOR



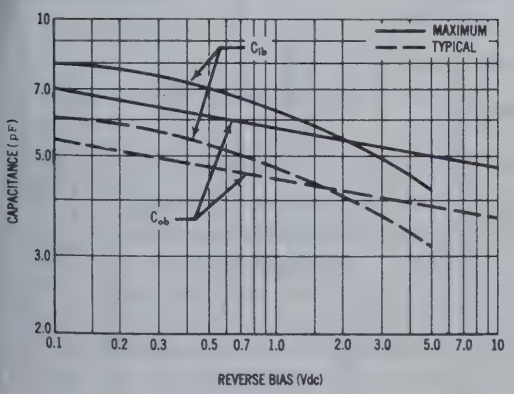
STORAGE TIME BEHAVIOR



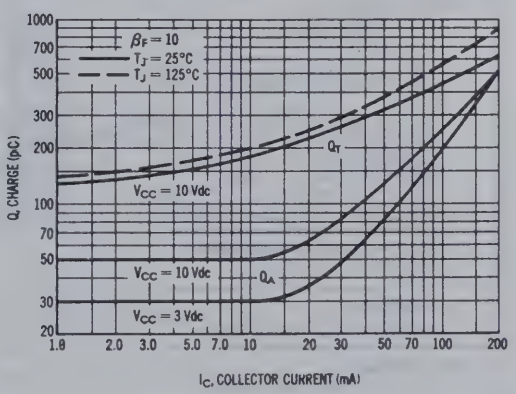
FALL TIME BEHAVIOR



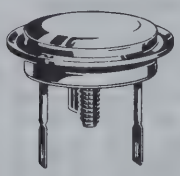
JUNCTION CAPACITANCE VARIATIONS



MAXIMUM CHARGE DATA



2N2490 thru 2N2493 (GERMANIUM)



CASE 5
(TO-36)

PNP germanium power transistors for general purpose power and switching applications.
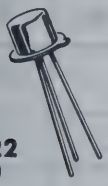
MAXIMUM RATINGS

Rating	Symbol	2N2490	2N2491	2N2492	2N2493	Unit
Collector-Base Voltage	V_{CB}	70	60	80	100	Volts
Collector-Emitter Voltage	V_{CES}	60	50	70	85	Volts
Emitter-Base Voltage	V_{EB}	40	30	60	80	Volts
Collector Current	I_C	15				Amp
Power Dissipation at $T_C = 25^oC$	P_D	170				Watts
Junction Temperature Range	T_J	-65 to +110				^oC

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = -2 Vdc)		I_{CBO}	—	0.2	mAdc
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = -40 Vdc)	2N2490		—	3.0	
(V_{EB} = -30 Vdc)	2N2491		—	3.0	
(V_{EB} = -60 Vdc)	2N2492		—	2.0	
(V_{EB} = -80 Vdc)	2N2493		—	3.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = -70 Vdc, V_{BE} = 1.5 Vdc)	2N2490		—	3.0	
(V_{CE} = -60 Vdc, V_{BE} = 1.5 Vdc)	2N2491		—	3.0	
(V_{CE} = -80 Vdc, V_{BE} = 1.5 Vdc)	2N2492		—	2.0	
(V_{CE} = -100 Vdc, V_{BE} = 1.5 Vdc)	2N2493		—	3.0	
(V_{CE} = -35 Vdc, V_{BE} = 1.5 Vdc, T_C = +100°C)	2N2490, 2N2491		—	35	
(V_{CE} = -40 Vdc, V_{BE} = 1.5 Vdc, T_C = +100°C)	2N2492		—	35	
(V_{CE} = -50 Vdc, V_{BE} = 1.5 Vdc, T_C = +100°C)	2N2493		—	35	
Collector-Emitter Breakdown Voltage (I_C = 1 A, I_B = 0)	2N2490	V_{CEO}	50	—	Volts
	2N2491		40	—	
	2N2492		65	—	
	2N2493		75	—	
Base-Emitter Voltage		V_{BE}			Vdc
(I_C = 5 Adc, V_{CE} = -2 Vdc)	2N2490, 2N2491		—	0.9	
	2N2492, 2N2493		—	0.8	
(I_C = 12 Adc, V_{CE} = -2 Vdc)			—	1.5	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 12 Adc, I_B = 2 Adc)	2N2490, 2N2491		—	0.7	
	2N2492, 2N2493		—	0.5	
DC Current Gain		h_{FE}			—
(I_C = 1 Adc, V_{CE} = -2 Vdc)	2N2490		45	—	
	2N2491		65	—	
	2N2492, 2N2493		50	—	
(I_C = 5 Adc, V_{CE} = -2 Vdc)	2N2490		20	40	
	2N2491		35	70	
	2N2492, 2N2493		25	50	
(I_C = 5 Adc, V_{CE} = -2 Vdc, T_A = -65°C)	2N2490		15	—	
	2N2491		25	—	
	2N2492, 2N2493		20	—	
(I_C = 12 Adc, V_{CE} = -2 Vdc)	2N2490		8	—	
	2N2491		12	—	
	2N2492, 2N2493		10		
Common Emitter Cutoff Frequency (I_C = 5A, V_{CE} = -6 V)		$f_{\alpha e}$	5.0	—	kHz
Turn-On Time (I_C = 5 A, I_{B1} = I_{B2} = 0.5 A)		t_{on}	—	25	μs
Turn-Off Time (I_C = 5 A, I_{B1} = I_{B2} = 0.5 A)		t_{off}	—	15	μs

2N2501 (SILICON)



CASE 22
(TO-18)

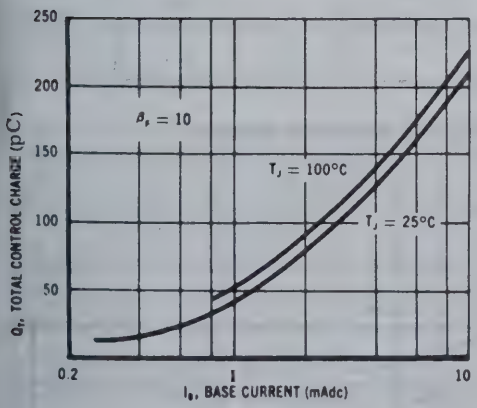
Collector connected to case

NPN silicon annular transistor for high-speed switching applications.

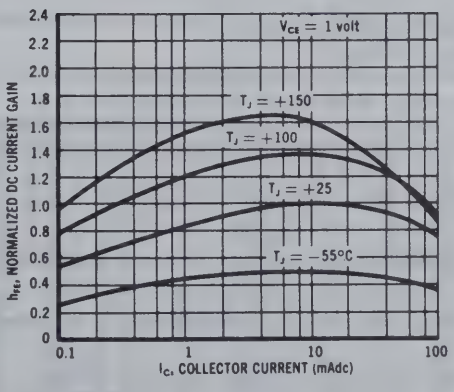
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EB}	6	Vdc
Total Device Dissipation @ 25°C Ambient Temperature (Derate 2.06 mW/°C above 25°C)	P_D	0.36	Watts
Junction Temperature	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C
Total Device Dissipation @ 25°C Case Temperature (Derate 6.9 mW/°C above 25°C)	P_D	1.2	Watts

TOTAL CONTROL CHARGE



NORMALIZED CURRENT GAIN CHARACTERISTICS



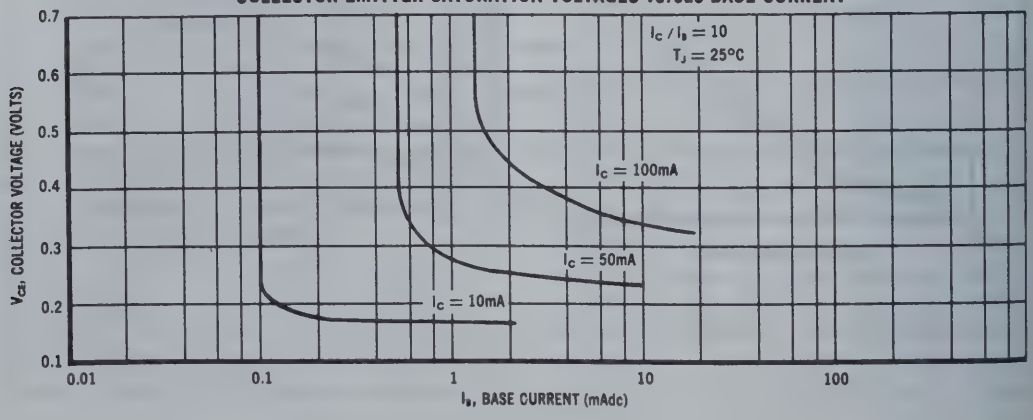
2N2501 (Continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

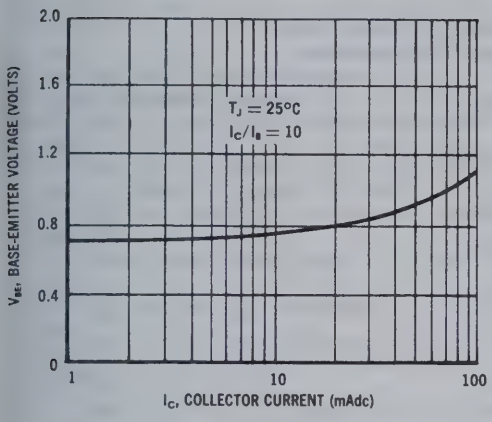
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0, Pulsed)	BV_{CEO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6	–	Vdc
Collector Leakage Current (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc)	I_{CEX}	–	25	nAdc
Base Leakage Current (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc) (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc, T_A = 150°C)	I_{BL}	– –	25 50	nAdc μAdc
DC Forward Current Transfer Ratio* (I_C = 100 μAdc, V_{CE} = 1 Vdc) (I_C = 1 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55°C) (I_C = 50 mAdc, V_{CE} = 1 Vdc) (I_C = 100 mAdc, V_{CE} = 1 Vdc) (I_C = 500 mAdc, V_{CE} = 5 Vdc)	h_{FE}	20 30 50 20 40 30 10	– – 150 – – – –	–
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	– – –	0.2 0.3 0.4	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	– – –	0.85 1.0 1.2	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	4	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	7	pF
Small Signal Forward Current Transfer Ratio (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 100 MHz)	h_{fe}	3.5	–	–
Current-Gain-Bandwidth Product (V_{CE} = 20 Vdc, I_C = 10 mAdc)	f_T	350	–	MHz
Charge Storage Time Constant (I_C = I_{B1} = I_{B2} = 10 mAdc)	τ_S	–	15	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1 mAdc)	Q_T	–	60	pC
Active Region Time Constant (I_C = 10 mAdc)	τ_A	–	2.5	ns

*Pulse Test: Pulse width ≤ 300 μs, duty cycle ≤ 2%

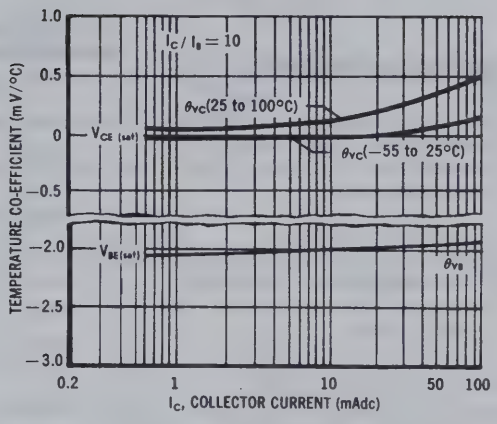
COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT



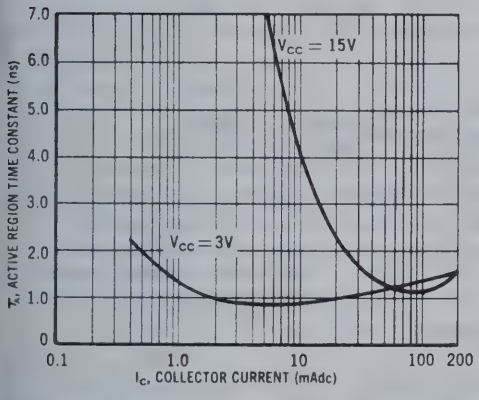
BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT



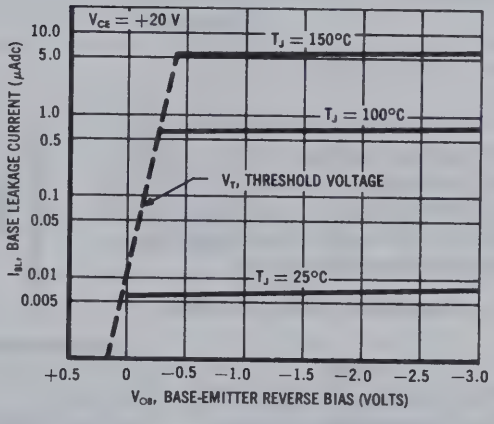
TEMPERATURE COEFFICIENTS



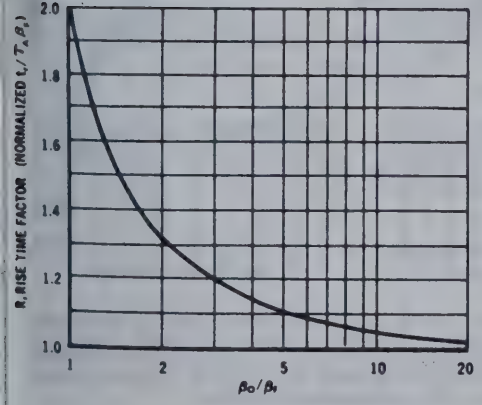
ACTIVE REGION TIME CONSTANT



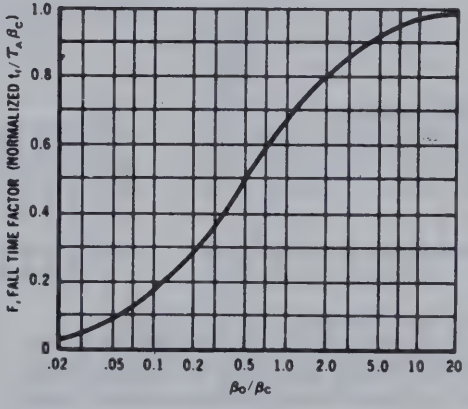
COMMON EMITTER DC LEAKAGE CHARACTERISTICS



RISE TIME FACTOR

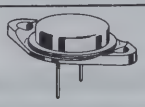


FALL TIME FACTOR

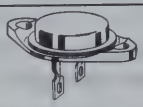


2N2526 (GERMANIUM)
2N2527
2N2528

PNIP germanium power transistors for high-voltage power switching applications.



CASE 11A
(TO-3 modified)



CASE 4-04
(TO-41)

For units with solder lugs attached, specify devices MP2526 etc. (TO-41 package)

MAXIMUM RATINGS

Rating	Symbol		2N2527	2N2528	Unit
Collector-Emitter Voltage	V_{CE}	80	120	160	Vdc
Collector-Base	V_{CB}	80	120	160	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current - Continuous	I_C	10			Adc
Base Current	I_B	5.0			Adc
Emitter Reverse Current (Surge 60 Hz Recurrent)	I_E	1.5			Adc
Total Device Dissipation @ $T_C = 25°C$	P_D	85			Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			°C

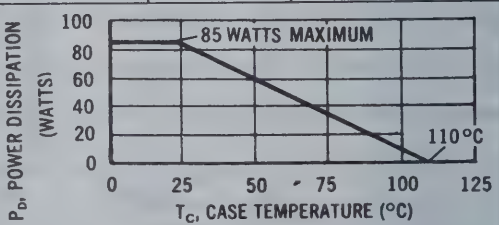
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

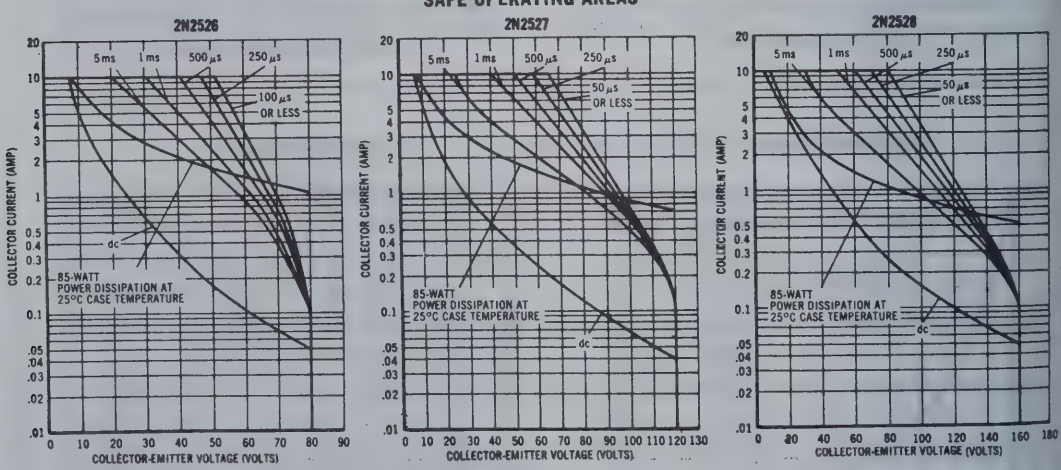
POWER-TEMPERATURE DERATING CURVE

The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 85 watts at a case temperature of 25°C and is 0 watts at 110°C with a linear relation between the two temperatures such that:

$$\text{Allowable } P_D = \frac{110° - T_C}{1.0} \text{ Watts}$$



SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N2526 thru 2N2528 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

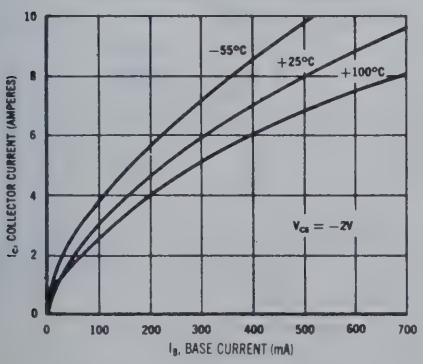
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	2N2526	$BV_{CEO(sus)}$*	80	-	-	Volts
	2N2527		120	-	-	
	2N2528		160	-	-	
Emitter-Base Breakdown Voltage (I_E = 50 mAdc, I_C = 0)		BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current*		I_{CEX}*				mAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C)	2N2526		-	-	35	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C)	2N2527		-	-	35	
(V_{CE} = 160 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C)	2N2528		-	-	35	
Collector-Emitter Cutoff Current		I_{CER}				mAdc
(V_{CE} = 80 Vdc, R_{BE} = 100 ohms)	2N2526		-	-	25	
(V_{CE} = 120 Vdc, R_{BE} = 100 ohms)	2N2527		-	-	25	
(V_{CE} = 160 Vdc, R_{BE} = 100 ohms)	2N2528		-	-	25	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 80 Vdc, I_E = 0)	2N2526		-	-	3.0	
(V_{CB} = 120 Vdc, I_E = 0)	2N2527		-	-	3.0	
(V_{CB} = 160 Vdc, I_E = 0)	2N2528		-	-	3.0	
(V_{CB} = 2.0 Vdc, I_E = 0)			-	-	150	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20	-	50	-
DC Transconductance (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		g_{FE}	4.0	6.0	-	mhos
Collector-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)		$V_{CE(sat)}$	-	0.5	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)		$V_{BE(sat)}$	-	0.8	1.2	Vdc
DYNAMIC CHARACTERISTICS						
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 12 Vdc, f = 30 kHz)		h_{fe}	10	15	-	-
Rise Time		t_r	-	5.5	-	μs
Storage Time		t_s	-	1.2	-	μs
Fall Time		t_f	-	2.0	-	μs

*To avoid excessive heating of collector junction, perform this test with a sweep method.

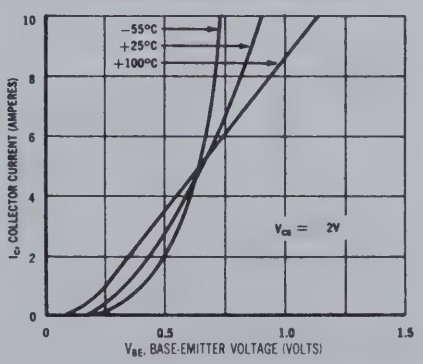
TYPICAL INPUT CHARACTERISTICS

ALL TYPES

COLLECTOR CURRENT versus BASE CURRENT



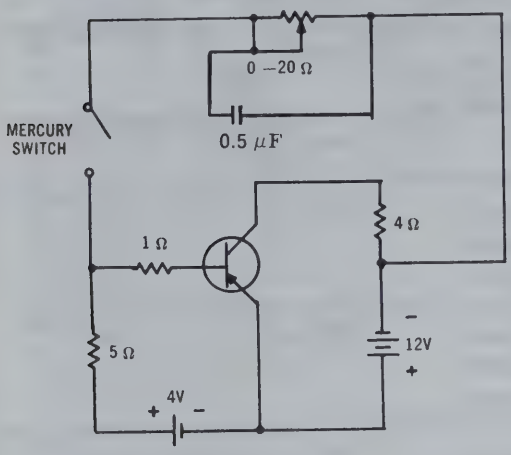
COLLECTOR CURRENT versus DRIVE VOLTAGE



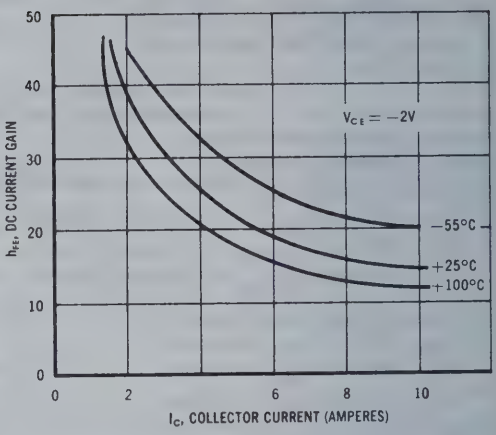
2N2526 thru 2N2528 (continued)

SWITCHING TEST CIRCUIT

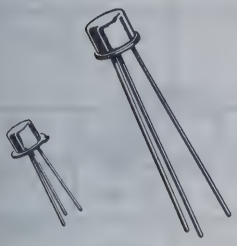
PULSE CONDITIONS ; $I_C = 3$ Adc, $I_B = 300$ mAdc



DC CURRENT GAIN versus COLLECTOR CURRENT



2N2537 thru 2N2540 (SILICON)



NPN silicon annular Star transistors for high-speed switching.

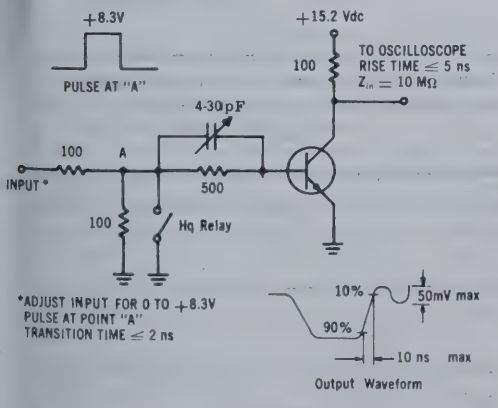
CASE 22 (TO-18)	CASE 31 (TO-5)
2N2539	2N2537
2N2540	2N2538

Collector connected to case

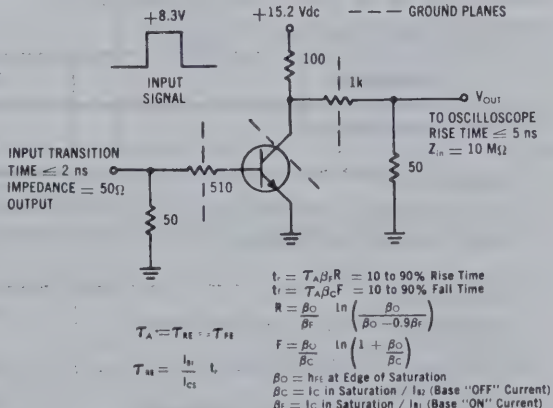
MAXIMUM RATINGS

Rating	Symbol	2N2537 2N2538 (TO-5)	2N2539 2N2540 (TO-18)	Unit
Collector-Base Voltage	V_{CB}	60	60	Vdc
Collector-Emitter Voltage	V_{CEO}	30	30	Vdc
Collector-Emitter Voltage	V_{CER}	40	40	Vdc
Emitter-Base Voltage	V_{EB}	5	5	Vdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	 3 17.2	 1.8 10.3	Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	 0.8 4.57	 0.5 2.86	Watts mW/°C
Junction Temperature	T_J	-65 to +200		°C
Storage Temperature	T_{stg}	-65 to +200		°C

TOTAL CONTROL CHARGE TEST CIRCUIT



ACTIVE REGION TIME CONSTANT TEST CIRCUIT



2N2537 thru 2N2540 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

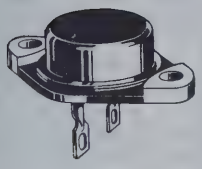
Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	– –	0.250 200	μAdc
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)	I_{EBO}	–	0.05	μAdc
Collector Cutoff Current (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc)	I_{CEX}	–	0.250	μAdc
Base Cutoff Current (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc) (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc, T_A = 150°C)	I_{BL}	– –	0.250 200	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed, I_B = 0)	BV_{CEO}	30	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed, $R_{BE} \leq 10\ \Omega$)	BV_{CER}	40	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5	–	Vdc
Collector Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	– –	0.45 1.6	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)* (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	– –	1.3 2.6	Vdc
DC Forward Current Transfer Ratio	h_{FE}			–
(I_C = 1 mAdc, V_{CE} = 10 Vdc) 2N2537, 2N2539		20	–	
2N2538, 2N2540		35	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc) 2N2537, 2N2539		30	–	
2N2538, 2N2540		50	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)* 2N2537, 2N2539		50	150	
2N2538, 2N2540		100	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)* 2N2537, 2N2539		20	–	
2N2538, 2N2540		30	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	8	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	25	pF
Small Signal Forward Current Transfer Ratio (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 MHz)	h_{fe}	2.5	–	–

*Pulse Test: Pulse width ≦ 300 μs, duty cycle ≦ 2%

SWITCHING CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Total Control Charge	Q_T	750	pC
Storage Time (I_C = I_{B1} = I_{B2} = 20 mAdc, V_{CC} = 5 V)	τ_S	20	ns
Active Region Time Constant	τ_A	2.0	ns
Turn-on Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, V_{CC} = 7 Vdc, R_L = 40 Ω)	t_{on}	40	ns
Turn-off Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, V_{CC} = 7 Vdc, R_L = 40 Ω)	t_{off}	40	ns

2N2573 thru 2N2579 (SILICON)



Industrial-type, silicon controlled rectifiers in a "diamond" package for applications requiring a high surge-current rating or low thermal resistance.

CASE 61 (TO-41) **CASE 54** (TO-3 Modified)

For units with pins (TO-3 Modified) specify devices MCR649AP-1(2N2573) thru MCR649AP-7(2N2579).

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*		Volts
2N2573		25	
2N2574		50	
2N2575		100	
2N2576		200	
2N2577		300	
2N2578		400	
2N2579		500	
Forward Current RMS (all conduction angles)	I_f	25	Amp
Circuit Fusing Considerations (T_J = -65° to +125°C, t ≦ 8.3 ms)	I^2t	275	A^2s
Peak Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)	$I_{FM(surge)}$	260	Amp
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2.0	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5.0	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*V_{ROM} for all types can be applied on a continuous dc basis without incurring damage.

V_{ROM} ratings apply for zero or negative gate voltage.

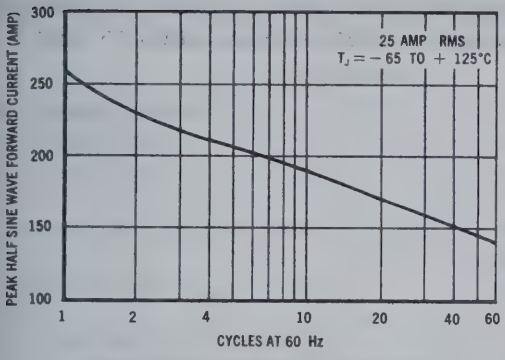
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C) 2N2573	V_{FOM}*	25	—	—	Volts
2N2574		50	—	—	
2N2575		100	—	—	
2N2576		200	—	—	
2N2577		300	—	—	
2N2578		400	—	—	
2N2579		500	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 125°C)	I_{FOM}	—	0.6	5.0	mA
Peak Reverse Blocking Current (Rated V_{ROM}, T_J = 125°C)	I_{ROM}	—	0.6	5.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 Ω)	I_{GT}	—	20	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 Ω)	V_{GT}	—	1.0	3.5	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 100Ω, T_J = 125°C)	V_{GNT}	0.3	—	3.5	
Forward On Voltage (I_F = 20 Adc)	V_F	—	1.1	1.4	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	20	—	mA
Turn-On Time (t_d + t_r) (I_G = 50 mA, I_F = 10A)	t_{on}	—	1.0	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A, dv/dt = 20 V/μs, T_J = 125°C) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)	t_{off}	—	30	—	μs
Forward Voltage Application Rate (Gate Open, T_J = 125°C)	dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	1.5	°C/W

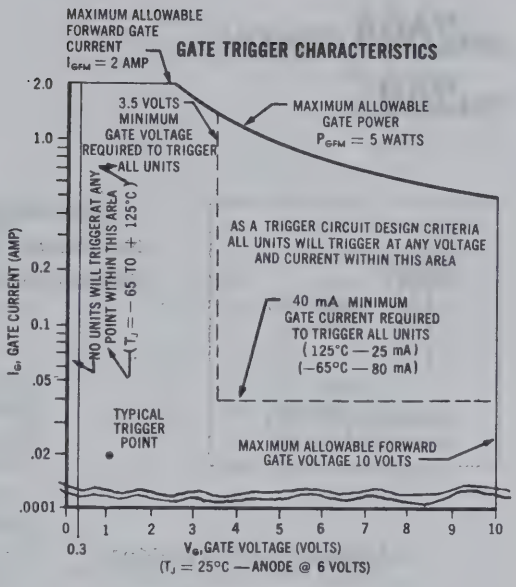
*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage.

V_{FOM} ratings apply for zero or negative gate voltage.

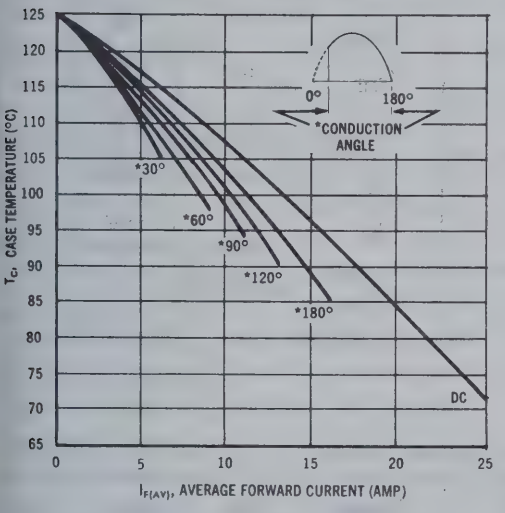
MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT



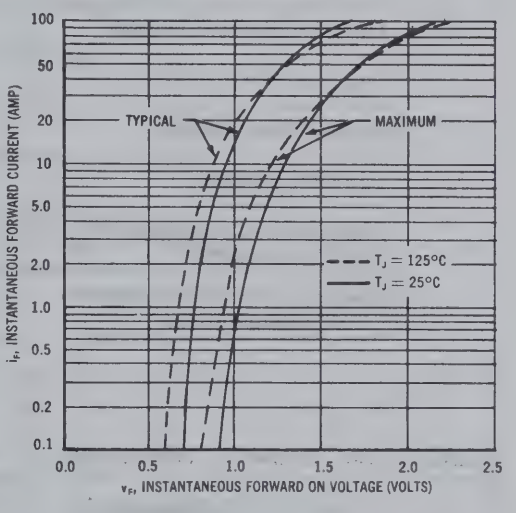
GATE TRIGGER CHARACTERISTICS



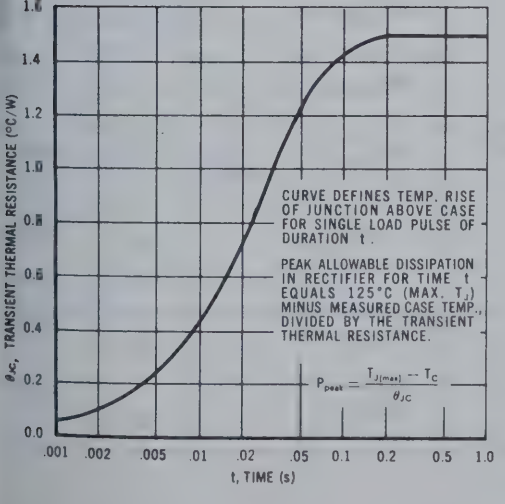
MAXIMUM ALLOWABLE CASE TEMPERATURE



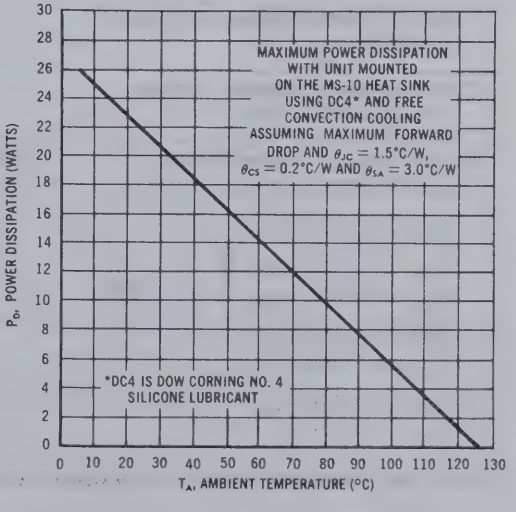
LOW CURRENT LEVEL



MAXIMUM TRANSIENT THERMAL RESISTANCE JUNCTION TO CASE



POWER DERATING CURVE



2N2604 (SILICON)
2N2605



CASE 26
(TO-46)

Collector electrically connected to case

PNP silicon annular transistors designed for low-level, low noise, high gain amplifiers from audio to high frequency range.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current	I_C	30	mAdc
Total Device Dissipation @T_A = 25°C Derate above 25°C	P_D	400 2.28	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	45	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CE} = 45 Vdc, V_{BE} = 0) (V_{CE} = 45 Vdc, V_{BE} = 0, T_A = 170°C)	I_{CES}	- -	10 10	nAdc μAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	I_{CBO}	-	10	nAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	-	2.0	nAdc

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2604		40	120	
	2N2605		100	300	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	2N2604		10	-	
	2N2605		20	-	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	2N2604		60	-	
	2N2605		150	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N2604		-	350	
	2N2605		-	600	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		V_{BE}	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)		f_T	30	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	6.0	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	35	Ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{rb}	-	10	X 10^{-4}
Small-Signal Current Gain (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2604	h_{fe}	60	350	-
	2N2605		150	600	
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	-	1.0	μmhos
Real Part of Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		$Re(h_{ie})$	-	200	Ohms
Noise Figure		NF			dB
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_G = 10 k ohms, BW = 10 Hz to 15.7 kHz)	2N2604		-	4.0	
	2N2605		-	3.0	

2N2635 (GERMANIUM)



CASE 22
(TO-18)

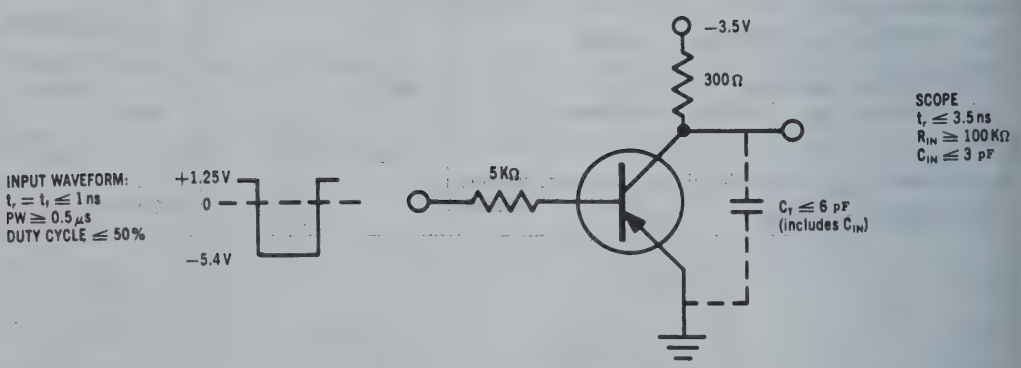
Collector connected to case

PNP germanium epitaxial mesa transistor for high-speed switching applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current (Continuous)	I_C	100	mAdc
Junction Temperature	T_J	+100	^oC
Storage Temperature	T_{stg}	-65 to +100	^oC
Device Dissipation @ 25°C Ambient Temperature (Derate 2mW/°C above 25°C)	P_D	150	mW

SWITCHING TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

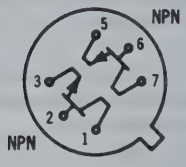
Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μ Adc, I_E = 0)	BV_{CBO}	30	50	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 2 mAdc, I_B = 0)	BV_{CEO}	15	30	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μ Adc, I_C = 0)	BV_{EBO}	2.5	4.5	---	Vdc
Collector-Base Cutoff Current (V_{CB} = 25V, I_E = 0) (V_{CB} = 25V, I_E = 0, T_A = +55°C)	I_{CBO}	--- ---	1 5	5 20	μ Adc
Emitter-Base Cutoff Current (V_{EB} = 1V, I_C = 0)	I_{EBO}	---	2	20	μ Adc
Static Forward Current Transfer Ratio (I_C = 10 mA, V_{CE} = 0.5V) (I_C = 50 mA, V_{CE} = 1V) (I_C = 50 mA, V_{CE} = 1V, T_A = -55°C) (I_C = 100 mA, V_{CE} = 1V)	h_{FE}	30 45 25 30	--- --- --- ---	--- 300 --- ---	---
Base-Emitter Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 50 mA, I_B = 2.5 mA) (I_C = 50 mA, I_B = 2.5 mA, T_A = -55°C) (I_C = 100 mA, I_B = 10 mA)	V_{BE}	--- --- --- ---	0.36 0.47 0.56 0.57	0.45 0.70 0.85 0.90	Vdc
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 50 mA, I_B = 2.5 mA) (I_C = 50 mA, I_B = 2.5 mA, T_A = +55°C) (I_C = 100 mA, I_B = 10 mA)	$V_{CE(sat)}$	--- --- --- ---	0.13 0.20 0.22 0.23	0.20 0.40 0.45 0.75	Vdc
Small-Signal Forward Current Transfer Ratio (I_C = 30 mA, V_{CE} = 2V, f = 100 MHz)	$\lvert h_{fe} \rvert$	1.5	---	---	---
Collector Output Capacitance (V_{CB} = 5 V, I_E = 0, f = 1 MHz)	C_{ob}	---	2.5	5	pF
Input Capacitance (V_{BE} = 1V, I_C = 0, f = 1 MHz)	C_{ib}	---	---	4	pF
Delay Time	t_d	---	15	20	ns
Rise Time	t_r	---	20	30	ns
Storage Time	t_s	---	100	185	ns
Fall Time	t_f	---	35	65	ns

2N2639 thru 2N2644 (SILICON)

Dual NPN silicon annular transistors designed for low-level, low-noise differential amplifier applications. Can be used in complementary circuits with 2N3806 series or 2N2802 series, for TO-89 flat packages see 2N3043-2N3048 series.



CASE 32C



PINS 4 AND 8 OMITTED

Pin Connections, Bottom View

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CB}	45		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	30		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	300	600	mW
Derate above 25°C		1.72	3.43	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	600	1200	mW
Derate above 25°C		3.43	6.87	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	45	—	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 5 Vdc, I_B = 0)		I_{CEO}	—	0.010	μAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	—	0.010	μAdc
(V_{CB} = 45 Vdc, I_E = 0, T_A = +150°C)			—	10	
Emitter-Base Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N2639, 2N2640, 2N2641	h_{FE}*	50	300	—
	2N2642, 2N2643, 2N2644		100	300	
(I_C = 10 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	2N2639, 2N2640, 2N2641		10	—	
	2N2642, 2N2643, 2N2644		20	—	
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N2639, 2N2640, 2N2641		55	—	
	2N2642, 2N2643, 2N2644		110	—	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N2639, 2N2640, 2N2641		65	—	
	2N2642, 2N2643, 2N2644		130	—	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$*	—	1.0	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{BE(sat)}$*	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)		f_T	35	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	—	8	pF
Input Impedance (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kHz)		h_{ib}	25k	32k	Ohms
Reverse Voltage Transfer Ratio (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kHz)		h_{rb}	—	600	X 10^{-6}
Small-Signal Current Gain (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kHz)	2N2639, 2N2640, 2N2641	h_{fe}	65	600	—
	2N2642, 2N2643, 2N2644		130	600	
Output Admittance (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kHz)		h_{ob}	—	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CB} = 5 Vdc, R_S = 10k ohms, Bandwidth = 10 Hz to 15 kHz)		NF	—	4	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio** (I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N2639, 2N2642	h_{FE1}/h_{FE2}**	0.9	1.0	—
	2N2640, 2N2643		0.8	1.0	
Base Voltage Differential (I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N2639, 2N2642	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5	mVdc
	2N2640, 2N2643		—	10	
Base Voltage Differential Temperature Gradient (I_C = 10 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +125°C)	2N2639, 2N2642	$\frac{\Delta\lvert V_{BE1} - V_{BE2} \rvert}{\Delta T_A}$	—	10	μV/°C
	2N2640, 2N2643		—	20	

*Pulse Test: Pulse Width = 300 μs; Duty Cycle ≤ 2%

**The lowest h_{FE} reading is taken as h_{FE1} for this test.

2N2646 (SILICON)
2N2647



Silicon annular PN unijunction transistors designed for use in pulse and timing circuits, sensing circuits and thyristor trigger circuits.

CASE 22A
(TO-18 Modified)
(Lead 3 connected to case)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D	300*	mW
RMS Emitter Current	I_e	50	mA
Peak Pulse Emitter Current**	i_e	2**	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage	V_{B2B1}	35	Volts
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

* Derate 3.0 mW/°C increase in ambient temperature. The total power dissipation (available power to Emitter and Base-Two) must be limited by the external circuitry.

** Capacitor discharge — 10 μF or less, 30 volts or less.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (V_{B2B1} = 10 V) (Note 1)	2N2646	η	0.56	—	0.75	—
	2N2647		0.68	—	0.82	
Interbase Resistance (V_{B2B1} = 3 V, I_E = 0)		R_{BB}	4.7	7.0	9.1	K ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3 V, I_E = 0, T_A = -55°C to +125°C)		αR_{BB}	0.1	—	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA) (Note 2)		$V_{EB1(sat)}$	—	3.5	—	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	—	15	—	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)	2N2646	I_{EO}	—	0.005	12	μA
	2N2647		—	0.005	0.2	
Peak Point Emitter Current (V_{B2B1} = 25 V)	2N2646	I_P	—	1.0	5.0	μA
	2N2647		—	1.0	2.0	
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms) (Note 2)	2N2646	I_V	4.0	6.0	—	mA
	2N2647		8.0	10	18	
Base-One Peak Pulse Voltage (Note 3, Figure 3)	2N2646	V_{OB1}	3.0	5.0	—	Volts
	2N2647		6.0	7.0	—	

NOTES

1. Intrinsic standoff ratio, η, is defined by equation:

$$\eta = \frac{V_P - V_{(EB1)}}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage
V_{B2B1} = Interbase Voltage
$V_{(EB1)}$ = Emitter to Base-One Junction Diode Drop (~0.5 V @ 10 μA)

2. Use pulse techniques: PW ~ 300 μs duty cycle ≤2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

3. Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

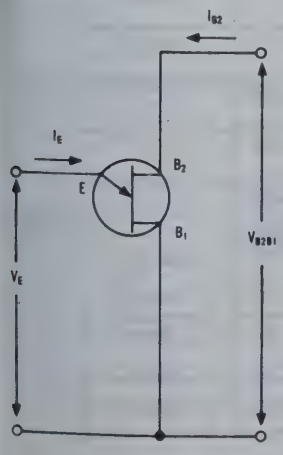


FIGURE 2 — STATIC EMITTER CHARACTERISTIC CURVES
(Exaggerated to Show Details)

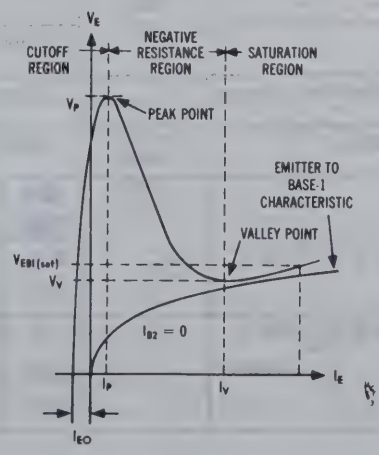
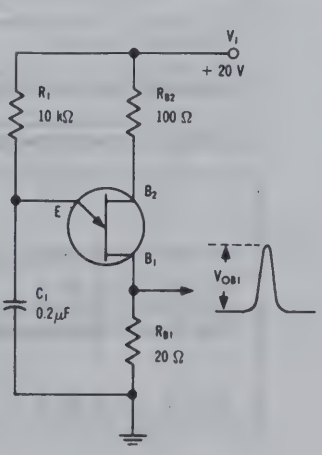


FIGURE 3 — V_{OB1} TEST CIRCUIT
(Typical Relaxation Oscillator)

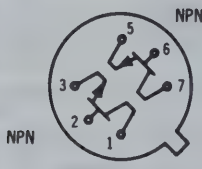


2N2652 (SILICON)
2N2652A

Dual NPN silicon transistors for use as a differential amplifier.



CASE 32 C



PINS 4 AND 8 OMITTED
Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	100		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current	I_C	500		mAdc
Operating Junction Temperature Range	T_J	-65 to +200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	0.3	0.6	Watt
Derate above 25°C		1.72	3.43	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.0	2.0	Watts
T_C = 100°C		0.57	1.14	Watt
Derate above 25°C		5.7	11.4	mW/°C

2N2652, 2N2652A (continued)

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 20 mAdc, I_B = 0)		BV_{CEO}*	60	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	100	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	2N2652	I_{CBO}	-	0.010	μAdc
	2N2652A		-	0.002	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	2N2652		-	15	
	2N2652A		-	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N2652	I_{EBO}	-	0.010	μAdc
	2N2652A		-	0.002	
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		h_{FE}	35	-	-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)			50	200	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)			15	-	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	-	1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	-	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	15	pF
Input Capacitance (V_{BE} = 0, 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	-	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{ie}	1.0	10.5	k ohms
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	20	35	ohms
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{fe}	50	300	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{oe}	4.0	50	μmhos
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 510 ohms, B. W. = 1.0 Hz, f = 1.0 kHz)		NF		8.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2652	h_{FE1}/h_{FE2}**	0.85	1.0	-
	2N2652A		0.9	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2652		0.85	1.0	
	2N2652A		0.9	1.0	
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$\lvert V_{BE1}-V_{BE2}\rvert$	-	3.0	mVdc
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)			-	3.0	
Base Voltage Differential Gradient (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +125°C)		$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	-	10	μV/°C

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

** The lowest of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

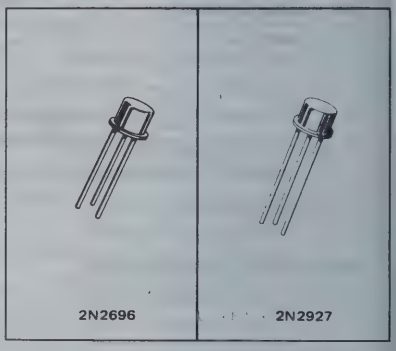
2N2696 (SILICON)
2N2927

PNP SILICON ANNULAR TRANSISTORS

. . . designed for use in medium-speed, non-saturated switching applications.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 25 Vdc @ I_C = 100 μAdc
- High Collector-Base Breakdown Voltage — BV_{CBO} = 25 Vdc @ I_C = 100 μAdc

PNP SILICON SWITCHING TRANSISTORS



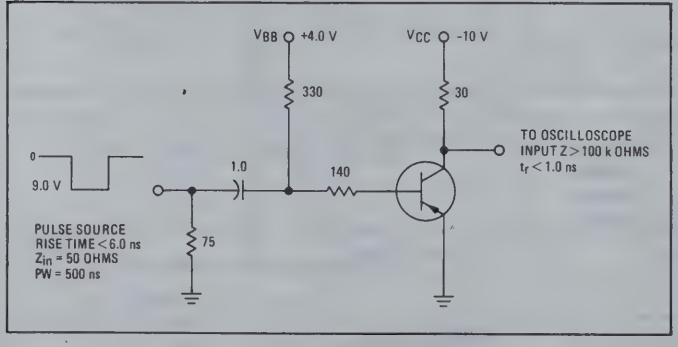
2N2696 2N2927

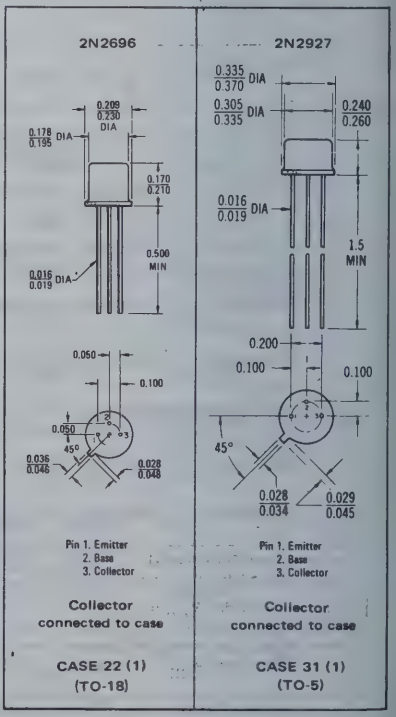
MAXIMUM RATINGS

Rating	Symbol	2N2696	2N2927	Unit
Collector-Emitter Voltage	V_{CEO}	25		Vdc
Collector-Base Voltage	V_{CB}	25		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	0.8 4.56	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	3.0 17.1	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT





*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage** (I_C = 100 μAdc, I_B = 0)	2N2927	BV_{CEO}	25	–	Vdc
(I_C = 10 mAdc, I_B = 0)	2N2696		25	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	25	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	2N2927	I_{CES}	–	25	nAdc
Collector Cutoff Current		I_{CBO}			
(V_{CB} = 10 Vdc, I_E = 0)			–	25	nAdc
(V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)			–	5.0	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 125°C)	2N2927		–	5.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	100	μAdc
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)	2N2927	I_B	–	25	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)			30	130	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)			12	–	
(I_C = 300 mAdc, V_{CE} = 2.0 Vdc)(1)			20	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)			–	0.25	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	1.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)			–	1.1	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	2.0	
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N2927	$V_{BE(on)}$	–	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	–	20	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	–	1500	ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	–	26	X 10^{-4}
Small-Signal Current Gain		h_{fe}			–
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			25	180	
(I_C = 50 mAdc, V_{CE} = 3.0 Vdc, f = 100 MHz)			1.0	–	
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	–	1200	μmhos
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = 10 Vdc, $I_C \approx$ 300 mAdc, $I_{B1} \approx$ 30 mAdc) (See Figure 1)	t_{on}	–	75	ns
Turn-Off Time	(V_{CC} = 10 Vdc, $I_C \approx$ 300 mAdc, $I_{B1} = I_{B2} \approx$ 30 mAdc) (See Figure 1)	t_{off}	–	170	ns

Indicates JEDEC Registered Data.
*Motorola Guarantees this data in addition to JEDEC Registered Data.
1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

JAN 2N2708 (SILICON)



CASE 20
(TO-72)

NPN silicon annular transistor designed for low power IF and RF use in VHF/UHF amplifier, mixer and oscillator applications.

Active Elements Isolated From Case

MAXIMUM RATINGS (T_A = 25° ± 3°C — unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	0.2	Watt
Derate above 25°C		1.14	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	0.3	Watt
Derate above 25°C		1.72	mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

TABLE I – GROUP A INSPECTION (T_A = 25°C ± 3°C – unless otherwise noted)

The fourth lead (case) shall be floating except for the following tests: G_{pe}, $r_b'C_c$, and NF.

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 1						
Visual and Mechanical Examination	2071	-	-	-	-	10
SUBGROUP 2						
Collector-Base Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	3036 Condition D	I_{CBO}	-	10	nAdc	5
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	3001 Condition D	BV_{CBO}	35	-	Vdc	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	3026 Condition D	BV_{EBO}	3.0	-	Vdc	
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0, Pulsed, Note 1)	3011 Condition D	BV_{CEO}	20	-	Vdc	
Forward-Current Transfer Ratio (V_{CE} = 2.0 Vdc, I_C = 2.0 mAdc)	3076	h_{FE}	30	200	-	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	3066	$V_{BE(sat)}$	-	1.0	Vdc	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	3071	$V_{CE(sat)}$	-	0.4	Vdc	
SUBGROUP 3						
Forward-Current Transfer Ratio (V_{CE} = 15 Vdc, I_C = 2.0 mAdc, f = 1.0 kHz)	3206	h_{fe}	30	180	-	10
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f ≥ 0.1 MHz and ≤ 1.0 MHz)	3236	C_{ob}	-	1.5	pF	
SUBGROUP 4						
Forward Current Transfer Ratio (V_{CE} = 15 Vdc, I_C = 2.0 mAdc, f = 100 MHz)	3306	h_{fe}	7.0	12	-	10
Amplifier Power Gain (Neutralized) (V_{CE} = 15 Vdc, I_C = 2.0 mAdc, f = 200 MHz)	(See Figure 1)	G_{pe}	15	22	dB	
Collector-Base Time Constant (V_{CB} = 15 Vdc, I_C = 2.0 mAdc, f = 31.9 MHz)		$r_b'C_c$	9.0	33	ps	
Noise Figure (V_{CE} = 15 Vdc, I_C = 2.0 mAdc, R_G = 50 ohms, f = 200 MHz)		NF	-	7.5	dB	
SUBGROUP 5						
High Temperature Operation: T_A = +150°C min Collector-Base Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	3036 (Notes 2 & 3)	I_{CBO}	-	1.0	μAdc	10
Low-Temperature Operation: T_A = -55° +0 -3°C Forward Current Transfer Ratio (V_{CE} = 2.0 Vdc, I_C = 2.0 mAdc)	3076 (Notes 2 & 3)	h_{FE}	10	-	-	

Note 1. Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2.0%

Note 2. Units shall be allowed to return to and be stabilized at 25°C prior to Low-Temperature Operational Test.

Note 3. Test measurement shall be made after thermal equilibrium has been reached at the temperature specified.

TABLE II – GROUP B INSPECTION (T_A = 25°C ± 3°C – unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 1						
Physical Dimensions	2066	-	-	-	-	20
SUBGROUP 2						
Soldering Heat, 1 cycle	2031	-	-	-	-	10
Temperature Cycling	1051 Condition C	-	-	-	-	
Thermal Shock (glass strain)	1056 Condition A	-	-	-	-	
Moisture Resistance, (No initial conditioning)	1021	-	-	-	-	
End Point Tests: (Note 4)						
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	3036 Condition D	I_{CBO}	-	20	nAdc	
Forward-Current Transfer Ratio (V_{CE} = 2.0 Vdc, I_C = 2.0 mAdc)	3076	h_{FE}	30	-	-	
SUBGROUP 3						
Shock (1500 G, 5 blows of approx. 0.5 ms each in orientations X1, Y1, Y2, Z1, total = 20 blows)	2016 non-operating	-	-	-	-	10
Vibration, variable frequency	2056	-	-	-	-	
Vibration Fatigue, 20 G	2046 non-operating	-	-	-	-	
Constant Acceleration (centrifuge) Orientations X1, Y1, Y2, Z1 20,000 G	2006	-	-	-	-	
End Point Tests: (Note 4)						
Same as for Subgroup 2						
SUBGROUP 4						
Lead Fatigue	2036 Condition E					15
End Point Tests: (Note 4)						
Seal		-	-	$5x10^{-7}$	atm cc/s	
Per Method 112, MIL-STD-202.	Condition C Procedure IIIa Test Cond. A for Gross Leaks					
SUBGROUP 5						
Salt atmosphere	1041	-	-	-	-	20
There shall be no evidence of flaking, pitting, or other visible signs of corrosion on sample units after test subjection.						
End Point Tests: (Note 4)						
Same as for Subgroup 2						
SUBGROUP 6						
High-Temperature Life T_{stg} = +200°C min	1031 non-operating	-	-	-	-	λ = 15
End Point Tests: (Note 4)						
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	3036 Condition D	I_{CBO}	-	50	nAdc	
Forward Current Transfer Ratio (V_{CE} = 2.0 Vdc, I_C = 2.0 mAdc)	3076	h_{FE}	22.5	-	-	
SUBGROUP 7						
Steady-State Operation Life (I_C = 20 mAdc, P_T = 200 mW)	1026	-	-	-	-	λ = 15
End Point Tests: (Note 4)						
Same as for Subgroup 6						

Note 4. End-point test measurements shall be made within 4 hours.

TABLE III – GROUP C INSPECTION (T_A = 25°C ± 3° – unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 1						
Barometric pressure, reduced (altitude operation) Normal mounting t = 60 s	1001 Condition D	-	-	-	-	15
Collector-Base Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)	3036 Condition D (Note 5)	I_{CBO}	-	1.0	μAdc	

Note 5. This test to be performed and measurement made during subjection of the sample units to the reduced barometric pressure specified.

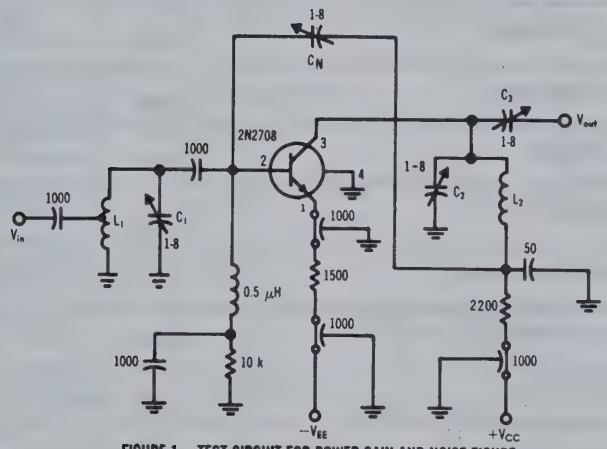


FIGURE 1 – TEST CIRCUIT FOR POWER GAIN AND NOISE FIGURE

Capacitance values in pF

L1 – 2½ turns #18 AWG wire, ⅜" ID by ½" lg.
L2 – 3 turns #22 AWG wire, ⅜" ID by ¾" lg.

Neutralization Procedure:

(A) Connect 200-MHz signal generator (with Z_{out} = 50 ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

(C) Apply V_{EE} and V_{CC}, and with signal generator adjusted for 1.0 mV output from amplifier, tune C_1, C_2, and C_3 for maximum output.

(D) Interchange connections to signal generator and output indicator.

(E) With sufficient signal applied to output terminals of amplifier, adjust C_N for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

2N2710 (SILICON)



CASE 22
(TO-18)

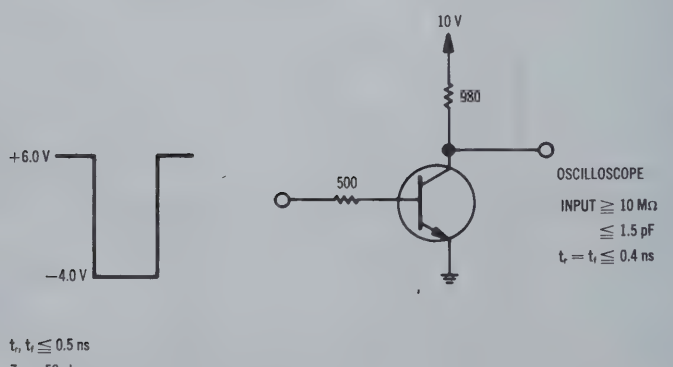
NPN silicon transistor primarily designed for high-speed, low-power saturated switching applications for industrial service.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current-Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.1	W mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.2	W
Operating Junction Temperature Range	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — STORAGE TIME TEST CIRCUIT

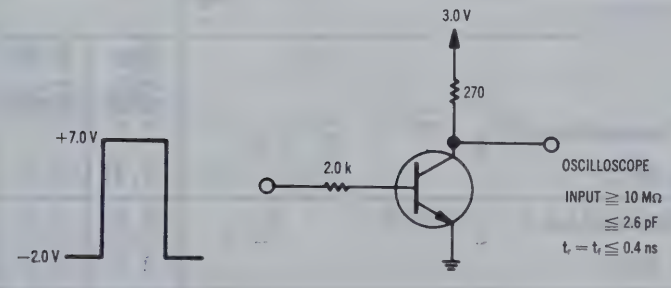


$t_r, t_f \leqq 0.5$ ns
$Z_{in} = 50$ ohms

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	30	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector-Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	30	nAdc
(V_{CB} = 20 VDC, I_E = 0, T_A = +150°C)		-	30	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40	-	-
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		40	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)		-	0.4	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)		-	1.3	
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	500	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 4.0 MHz)	C_{ob}	-	4.0	pF
Turn-On Time (Figure 2) (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	-	20	ns
Turn-Off Time (Figure 2) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{off}	-	35	ns
Charge-Storage Time (Figure 1) (V_{CC} = 10 Vdc, I_C = I_{B1} = I_{B2} = 10 mAdc)	t_s	-	15	ns

FIGURE 2 — TURN ON AND TURN OFF TIME TEST CIRCUIT



$t_r, t_f \leqq 0.5$ ns

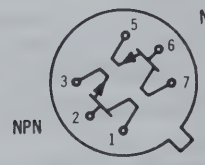
Z_{in} = 50 ohms

2N2720 (SILICON)
2N2721



CASE 32C

Dual NPN silicon transistors for small-signal, low-power differential amplifier applications.



PINS 4 AND 8 OMITTED
Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	80		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current	I_C	40		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	0.3	0.6	Watt
Derate above 25°C		1.71	3.4	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	0.6	1.2	Watts
Derate above 25°C		3.4	6.8	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	60	-	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)		I_{CEO}	-	10	nAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	-	0.01	μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)			-	10	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		h_{FE}	30	120	-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)			35	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)			42	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	80	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	6.0	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	32	ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{rb}	-	500	X 10^{-6}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{fe}	30	200	-
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	-	1.0	μmhos
MATCHING CHARACTERISTICS					
DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2720	h_{FE1}/h_{FE2}**	0.9	1.0	-
	2N2721		0.8	1.0	
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2720	$\lvert V_{BE1}-V_{BE2}\rvert$	-	5.0	mVdc
	2N2721		-	10	
Base Voltage Differential Gradient (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +25°C)	2N2720	$\Delta(V_{BE1}-V_{BE2})$	-	0.8	mV
	2N2721		-	1.6	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)	2N2720		-	1.0	
	2N2721		-	2.0	

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%

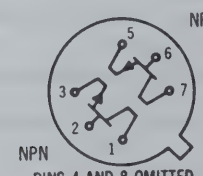
** The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2722 (SILICON)



Dual NPN silicon transistor for small-signal, low-power differential amplifier applications.

CASE 32C



PINS 4 AND 8 OMITTED
Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CB}	45		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	40		mAdc
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	0.3	0.6	Watt
Derate above 25°C		1.7	3.4	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	0.6	1.2	Watts
Derate above 25°C		3.4	6.8	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	45	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	45	-	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)	I_{CEO}	-	2.0	nAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	0.001 1.0	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	-	1.0	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50 100 125	250 - -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	6.0	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	25	32	ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb} *	-	600	X 10^{-6}
Small-Signal Current Gain (I_E = 0.1 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	100	700	-
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_G = 10 k ohms, f = 10 Hz to 15.7 kHz)	NF	-	4.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio** (I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)	h_{FE1}/h_{FE2}**	0.9	1.0	-
Base Voltage Differential (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	$\lvert V_{BE1} - V_{BE2} \rvert$	-	5.0	mVdc
Base Voltage Differential Gradient (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +25°C) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)	$\Delta(V_{BE1} - V_{BE2})$	- -	0.8 1.0	mVdc

* Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

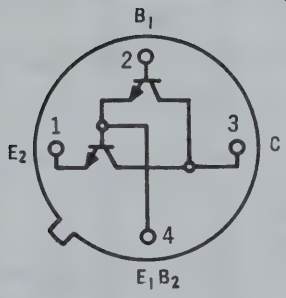
** The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2723 thru 2N2725 (SILICON)



CASE 20 (8)
(TO-72)

Two NPN silicon annular transistors connected as a darlington amplifier, and designed for applications requiring very high gain.



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

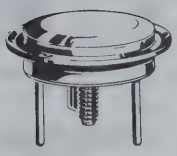
Rating	Symbol	2N2723 2N2724	2N2725	Unit
Collector Emitter Voltage	V_{CE2O}	60	45	Vdc
Collector-Base Voltage	V_{CB1}	80	45	Vdc
Emitter-Base Voltage	V_{E2B1}	12	10	Vdc
Collector Current	I_C	40	30	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	0.5		Watt
Derate above 25°C		2.9		mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.8		Watts
T_C = 100°C		1.0		Watt
Derate above 25°C		10.5		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_{B1} = 0)	2N2723, 2N2724	BV_{CE2O}*	60	-	Vdc
	2N2725		45	-	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_{E2} = 0)	2N2723, 2N2724	BV_{CB1O}	80	-	Vdc
	2N2725		45	-	
Emitter-Base Breakdown Voltage (I_{E2} = 10 μAdc, I_C = 0)	2N2723, 2N2724	BV_{E2B1O}	12	-	Vdc
	2N2725		10	-	
Collector Cutoff Current (V_{CB1} = 60 Vdc, I_E = 0)	2N2723, 2N2724	I_{CB1O}	-	0.01	μAdc
(V_{CB1} = 60 Vdc, I_E = 0, T_A = 150°C)	2N2723, 2N2724		-	10	
(V_{CB1} = 30 Vdc, I_E = 0)	2N2725		-	0.002	
(V_{CB1} = 30 Vdc, I_E = 0, T_A = 150°C)	2N2725		-	2.0	
Emitter Cutoff Current (V_{B1E2} = 10 Vdc, I_C = 0)	2N2723, 2N2724	I_{E2B1O}	-	10	nAdc
(V_{B1E2} = 6.0 Vdc, I_C = 0)	2N2725		-	1.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE2} = 5.0 Vdc, I_{B2} = 0)	2N2723	h_{FE}	2000	10,000	-
	2N2724		7000	50,000	
(I_C = 100 μAdc, V_{CE2} = 5.0 Vdc, I_{B2} = 0)	2N2725		2000	10,000	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		$V_{CE2(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		$V_{BE2(sat)}$	-	1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (Each Unit) (I_C = 10 mAdc, V_{CE1} or V_{CE2} = 10 Vdc, f = 20 MHz)		f_T	100	-	MHz
Output Capacitance (V_{CB1} = 10 Vdc, I_{E2} = 0, f = 140 kHz)	2N2723, 2N2724	C_{ob1}	-	10	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE2} = 5.0 Vdc, f = 1.0 kHz)	2N2723	h_{fe}	1500	15,000	-
	2N2724		5000	60,000	
(I_C = 10 μAdc, V_{CE2} = 5.0 Vdc, f = 1.0 kHz)	2N2725		1500	15,000	
Noise Figure (Input Stage Only) (I_C = 50 μAdc, V_{CE} = 5.0 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz, BW = 100 kHz)	2N2723	NF	-	10	dB
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz, BW = 100 kHz)	2N2724		-	6.0	
(I_C = 3.0 μAdc, V_{CE} = 5.0 Vdc, R_S = 30 k ohms, f = 1.0 kHz, BW = 100 kHz)	2N2725		-	6.0	

* Pulse Test: Pulse Width ≤ 12 ms, Duty Cycle ≤ 2.0 %.

2N2728 (GERMANIUM)



CASE 7

PNP germanium high-current power transistors especially designed for switching and power converter circuit operating from low-voltage power sources such as solar cells, thermo-electric generators, sea cells, fuel cells, and 1.5-volt batteries.

MAXIMUM RATINGS

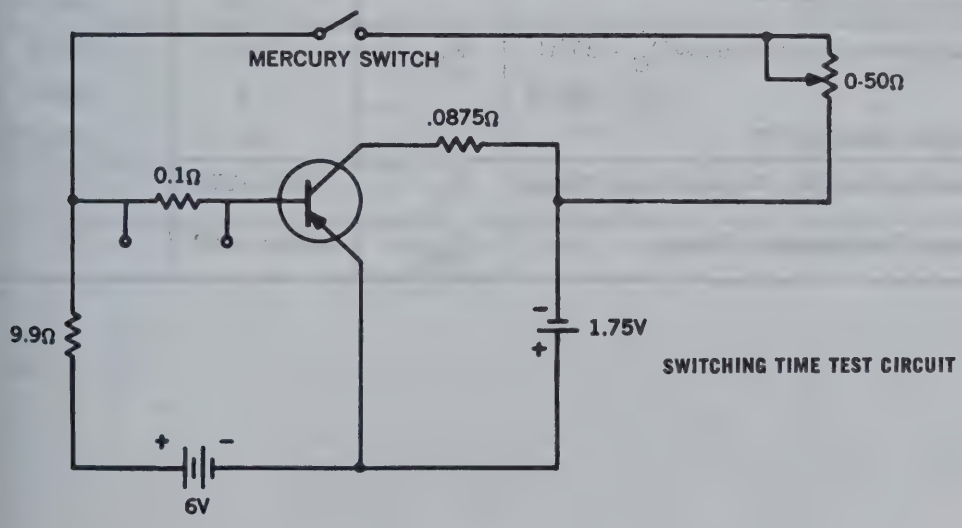
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current (continuous)	I_C	50	Adc
Base Current (continuous)	I_B	10	Adc
Total Device Dissipation @ 25°C Case Temperature	P_D	170	Watts
Operating Temperature	T_J	+110	°C
Storage Temperature	T_{stg}	-65 to +110	°C
Thermal Resistance (Junction to Case)	θ_{JC}	0.5	°C/W

2N2728 (continued)

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current V_{CE} = 15 V, V_{BE} = 1 V V_{CE} = 10 V, V_{BE} = 1 V, T_C = 100°C	I_{CEX}	- -	- -	10 35	mAdc
Emitter-Base Cutoff Current V_{EB} = 15 V	I_{EBO}	-	-	10	mAdc
Emitter Floating Potential V_{CB} = 15 V, I_E = 0	V_{EBF}	-	-	0.5	Vdc
Collector-Emitter Breakdown Voltage* I_C = 500 mA, I_B = 0	BV_{CEO}	5.0	10	-	V
DC Current Transfer Ratio I_C = 20 A, V_{CE} = 2 V	h_{FE}	40	-	130	-
Collector-Emitter Saturation Voltage I_C = 50 A, I_B = 5 A	$V_{CE(sat)}$	-	0.075	0.1	Vdc
Base-Emitter Voltage I_C = 50 A, I_B = 5 A	$V_{BE(sat)}$	-	0.85	1.0	Vdc
Common Emitter Cutoff Frequency I_C = 20 A, V_{CE} = 2 V	$f_{\alpha e}$	3.0	4.5	-	kHz
Rise Time I_C = 20 A, V_{CC} = 1.75 V, $I_{B(on)}$ = 2 A	t_r	-	18	25	μs
Storage Time V_{BE} = 6 V, R_{be} = 10 Ω	t_s	-	15	20	μs
Fall Time V_{BE} = 6 V, R_{be} = 10 Ω	t_f	-	10	15	μs

* To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.



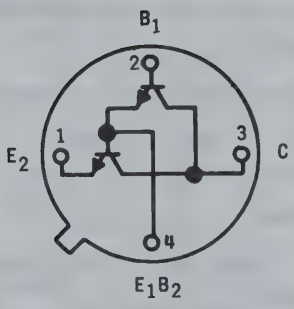
SWITCHING TIME TEST CIRCUIT

2N2785 (SILICON)



CASE 20(8)
(TO-72)

Two NPN silicon annular transistors connected as a darlington amplifier, and designed for applications requiring very high gain.



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE2O}	40	Vdc
Collector-Base Voltage	V_{CB1}	60	Vdc
Emitter-Base Voltage	V_{E2B1}	15	Vdc
(Pin 4 to Pin 2)		7.5	Vdc
Total Device Dissipation @ T_A = 25°C	P_D	0.5	Watt
Derate above 25°C		3.33	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.8	Watts
T_C = 100°C		1.0	Watt
Derate above 25°C		10	mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 20 mAdc, I_{B1} = 0)	BV_{CE2O}*	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_{E2} = 0)	BV_{CB1O}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_{E2} = 100 μAdc, I_C = 0)	BV_{E2B1O}	15	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	-	500	nAdc
Collector Cutoff Current (V_{CB1} = 30 Vdc, I_E = 0) (V_{CB1} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CB1O}	- -	0.05 10	μAdc
Emitter Cutoff Current (V_{E2B1} = 5.0 Vdc, I_C = 0)	I_{E2B1O}	-	20	nAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 1.0 mAdc, V_{CE2} = 4.0 Vdc) (I_C = 10 mAdc, V_{CE2} = 5.0 Vdc) (I_C = 100 mAdc, V_{CE2} = 5.0 Vdc)	h_{FE}*	600 1200 2000	- - 20,000	-
Collector-Emitter Saturation Voltage (I_C = 15 mAdc, I_{B1} = 3.0 mAdc)	$V_{CE2(sat)}$	-	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE2} = 5.0 Vdc, f = 10 MHz)	f_T	10	-	MHz
Output Capacitance (V_{CB1} = 10 Vdc, I_{E2} = 0, f = 1.0 MHz)	C_{ob1}	-	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB1} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	30	80	Ohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE2} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	10	x 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE2} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	600	-	-
Output Admittance (I_C = 1.0 mAdc, V_{CB1} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	0.5	μmhos

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N2800 (SILICON)
2N2801
2N2837
2N2838



CASE 22 (TO-18) — **CASE 31** (TO-5)

2N2837, 2N2838 — 2N2800, 2N2801

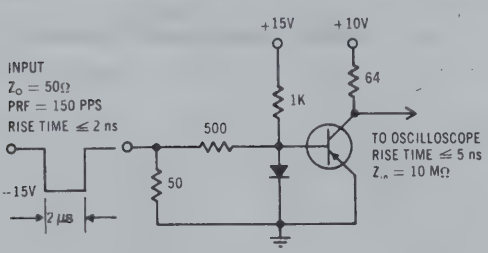
Collector connected to case

PNP silicon annular transistors for medium-speed switching applications.

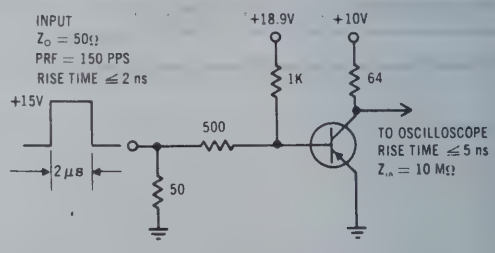
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	800	mA
Total Device Dissipation @ 25°C Ambient Temperature	P_D		
2N2800, 2N2801 — TO-5		0.8	Watt
Derating Factor Above 25°C		4.57	mW/°C
2N2837, 2N2838 — TO-18		0.5	Watt
Derating Factor Above 25°C		2.86	mW/°C
Total Device Dissipation @ 25°C Case Temperature	P_D		
2N2800, 2N2801 — TO-5		3	Watts
Derating Factor Above 25°C		17.3	mW/°C
2N2837, 2N2838 — TO-18		1.8	Watts
Derating Factor Above 25°C		10.3	mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

DELAY AND RISE TIME TEST CIRCUIT



STORAGE AND FALL TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	35	-	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 0.5 Vdc)	I_{CEX}	-	100	nAdc
Base Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 0.5 Vdc)	I_{BL}	-	100	nAdc
DC Forward Current Transfer Ratio	h_{FE}			-
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)				
2N2800, 2N2837		20	-	
2N2801, 2N2838		30	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*				
2N2800, 2N2837		30	90	
2N2801, 2N2838		75	225	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)*				
2N2800, 2N2837		15	-	
2N2801, 2N2838		30	-	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)*				
2N2800, 2N2837		25	-	
2N2801, 2N2838		40	-	
Collector Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		-	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)		-	1.2	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		-	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		-	1.8	
Output Capacitance (V_{CB} = 10 Vdc, f = 100 kHz)	C_{ob}	-	25	pF
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	120	-	MHz

SWITCHING CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Typical	Maximum	Unit
Delay Time	t_d	9	25	ns
Rise Time	t_r	25	45	ns
Storage Time	t_s	100	225	ns
Fall Time	t_f	30	45	ns

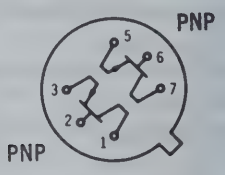
*Pulse Test: Pulse Width ≤ 300 μs, duty cycle ≤ 2%

2N2802 thru 2N2807 (SILICON)

Dual PNP silicon annular transistors designed for low-level, low-noise differential amplifier applications. Can be used in complementary circuits with 2N2639 thru 2N2644 series, for TO-89 flat packages see 2N3049, 2N3050 series.



CASE 32 C



PINS 4 AND 8 OMITTED
Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CB}	25		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	30		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	250	500	mW
Derate above 25°C		1.43	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	500	1000	mW
Derate above 25°C		2.86	5.72	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

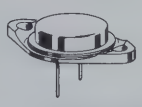
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	20	—	Vdc
Collector-Base Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)		I_{CBO}	—	0.010	μAdc
(V_{CB} = 25 Vdc, I_E = 0, T_A = +150°C)			—	10	
Emitter-Base Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N2802, 2N2803, 2N2804	h_{FE}*	15	—	—
	2N2805, 2N2806, 2N2807		30	—	
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N2802, 2N2803, 2N2804		20	120	
	2N2805, 2N2806, 2N2807		40	120	
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	2N2802, 2N2803, 2N2804		10	—	
	2N2805, 2N2806, 2N2807		20	—	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N2802, 2N2803, 2N2804		20	—	
	2N2805, 2N2806, 2N2807		40	—	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$*	—	0.5	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$*	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)		f_T	60	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	—	8	pF
Input Impedance (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kHz)		h_{ib}	25k	32k	Ohms
Reverse Voltage Transfer Ratio (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kHz)		h_{rb}	—	1200	X 10^{-6}
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	2N2802, 2N2803, 2N2804	h_{fe}	20	200	—
	2N2805, 2N2806, 2N2807		40	200	
Noise Figure (I_C = 10 μAdc, V_{CB} = 5 Vdc, R_S = 10k ohms, Bandwidth = 10 Hz to 15.7 kHz)		NF	—	4	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N2802, 2N2805	h_{FE1}/h_{FE2}**	0.9	1.0	—
	2N2803, 2N2806		0.8	1.0	
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N2802, 2N2805	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5	mVdc
	2N2803, 2N2806		—	10	
Base Voltage Differential Temperature Gradient (I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +125°C)	2N2802, 2N2805	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C
	2N2803, 2N2806		—	20	

*Pulse Test: Pulse Width ≤ 300 μs: Duty Cycle ≤ 2%

**The lowest h_{FE} reading is taken as h_{FE1} for this test.

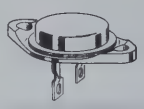
2N2832 (GERMANIUM)
2N2833
2N2834

PNP germanium transistors for switching and amplifier applications.



CASE 11A
(TO-3 modified)

Collector connected to case



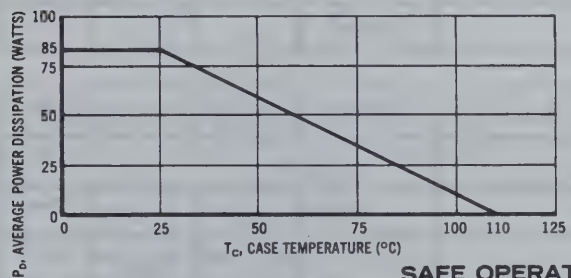
CASE 4-04
(TO-41)

For units with solder lugs attached, specify device MP2832 etc. (TO-41 package)

MAXIMUM RATINGS

Rating	Symbol	2N2832	2N2833	2N2834	Unit
Collector-Emitter Voltage	V_{CEO}	50	75	100	Vdc
Collector-Base Voltage	V_{CB}	80	120	140	Vdc
Emitter-Base Voltage	V_{EB}	2.0			Vdc
Collector Current - Continuous	I_C	20			Adc
Base Current	I_B	5.0			Adc
Total Device Dissipation @ $T_C = 25°C$	P_D	85			Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			

FIGURE 1 — POWER DERATING CURVE



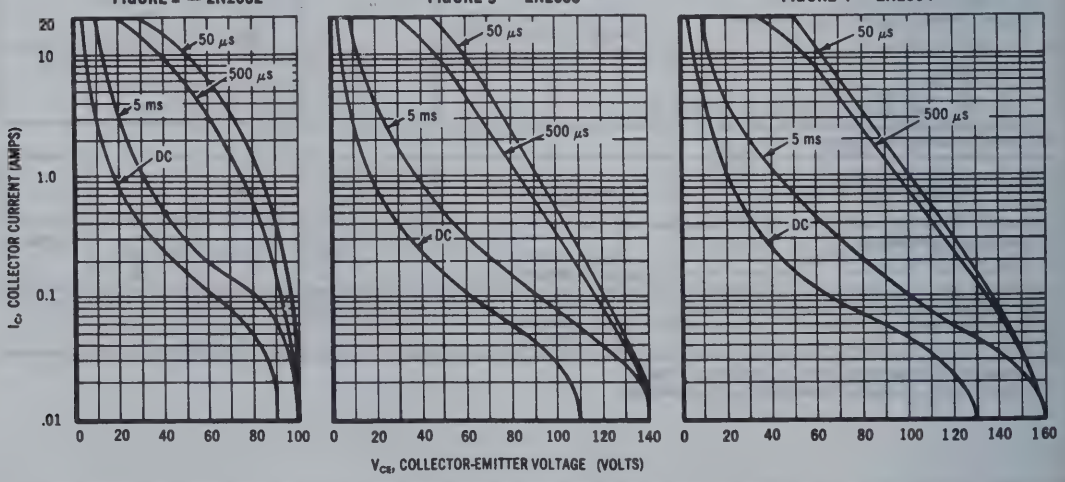
THESE TRANSISTORS ARE ALSO SUBJECT TO SAFE AREA CURVES AS INDICATED BY FIGURES 2, 3, 4. BOTH LIMITS ARE APPLICABLE AND MUST BE OBSERVED

SAFE OPERATING AREAS

FIGURE 2 — 2N2832

FIGURE 3 — 2N2833

FIGURE 4 — 2N2834



The Safe Operating Area Curves indicate the I_C - V_{CE} limits below which the devices will not go into secondary breakdown. As secondary breakdown is independent of temperature and duty cycle, these curves can be used as long as the average power derating curve (Figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

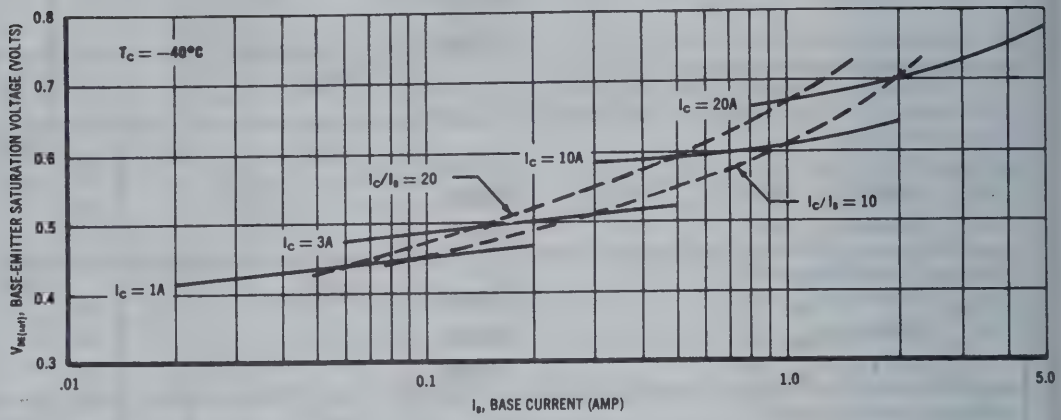
2N2832 thru 2N2834 (Continued)

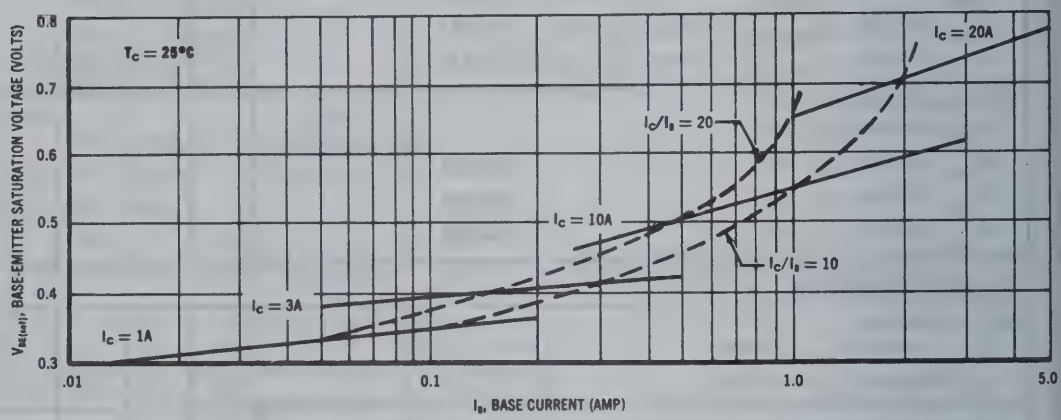
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage** (I_C = 100 mAdc, I_B = 0)	2N2832	$BV_{CEO(sus)}$**	50	-	-	Volts
	2N2833		75	-	-	
	2N2834		100	-	-	
Emitter-Base Breakdown Voltage (I_E = 50 mAdc, I_C = 0)		BV_{EBO}	2.0	-	-	Vdc
Floating Potential*		V_{EBF}*				Volts
(V_{CB} = 80 Vdc, I_E = 0)	2N2832		-	-	0.5	
(V_{CB} = 120 Vdc, I_E = 0)	2N2833		-	-	0.5	
(V_{CB} = 140 Vdc, I_E = 0)	2N2834		-	-	0.5	
Collector Cutoff Current*		I_{CES}*				mAdc
(V_{CE} = 100 Vdc, V_{BE} = 0)	2N2832		-	-	20	
(V_{CE} = 140 Vdc, V_{BE} = 0)	2N2833		-	-	20	
(V_{CE} = 160 Vdc, V_{BE} = 0)	2N2834		-	-	20	
Collector Cutoff Current**		I_{CEX}**				mAdc
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N2832		-	-	40	
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N2833		-	-	40	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N2834		-	-	40	
Collector Cutoff Current*		I_{CBO}*				mAdc
(V_{CB} = 2.0 Vdc, I_E = 0)			-	-	0.3	
(V_{CB} = 80 Vdc, I_E = 0)	2N2832		-	-	10	
(V_{CB} = 120 Vdc, I_E = 0)	2N2833		-	-	10	
(V_{CB} = 140 Vdc, I_E = 0)	2N2834		-	-	10	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)			50	75	-	
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)			25	-	100	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc)			-	-	0.15	
(I_C = 10 Adc, I_B = 1.0 Adc)			-	-	0.30	
(I_C = 20 Adc, I_B = 2.0 Adc)			-	-	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc)			-	-	0.6	
(I_C = 10 Adc, I_B = 1.0 Adc)			-	-	0.75	
(I_C = 20 Adc, I_B = 2.0 Adc)			-	-	1.0	
DYNAMIC CHARACTERISTICS						
Small Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 5.0 MHz)		h_{fe}	2.0	3.5	-	-
Rise Time		t_r	-	2.0	4.0	μs
Storage Time		t_s	-	3.0	6.0	μs
Fall Time		t_f	-	1.0	2.5	μs

*SWEEP TEST: 1/2 Sine Wave, 60 Hz min.
**PULSE TEST: Pulse Width = 1.0 ms, 2.0% Duty Cycle.

FIG 5 – BASE-EMITTER SATURATION VOLTAGE VARIATIONS





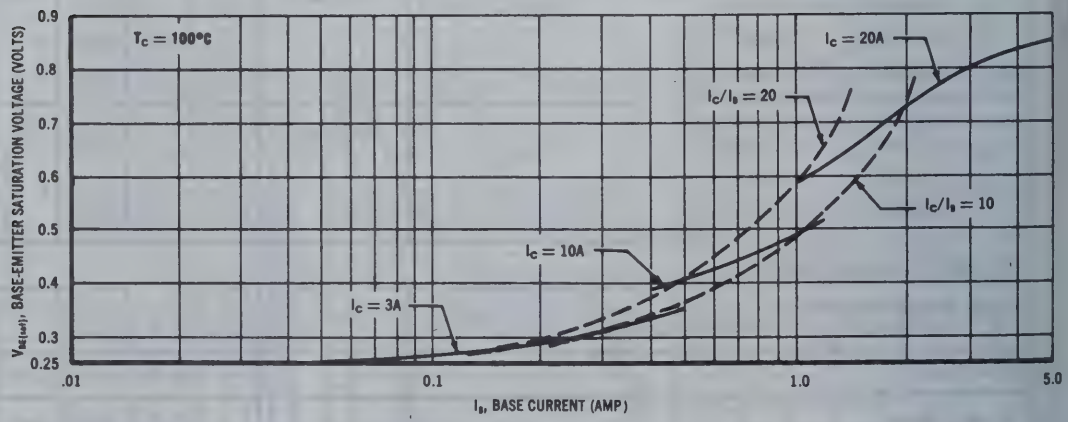
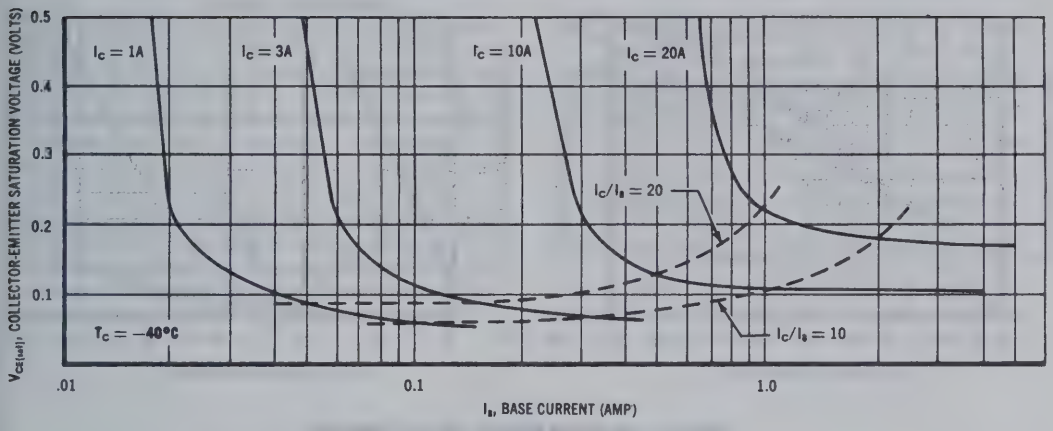
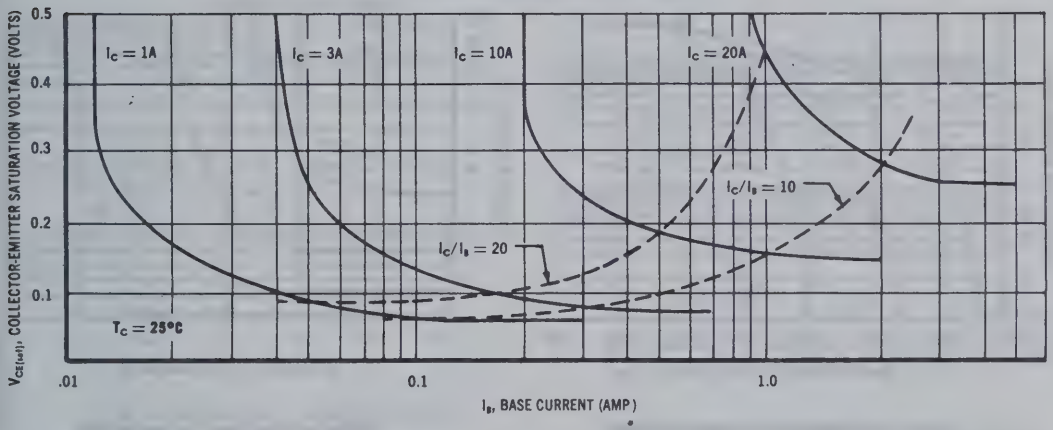


FIG 6 — COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS





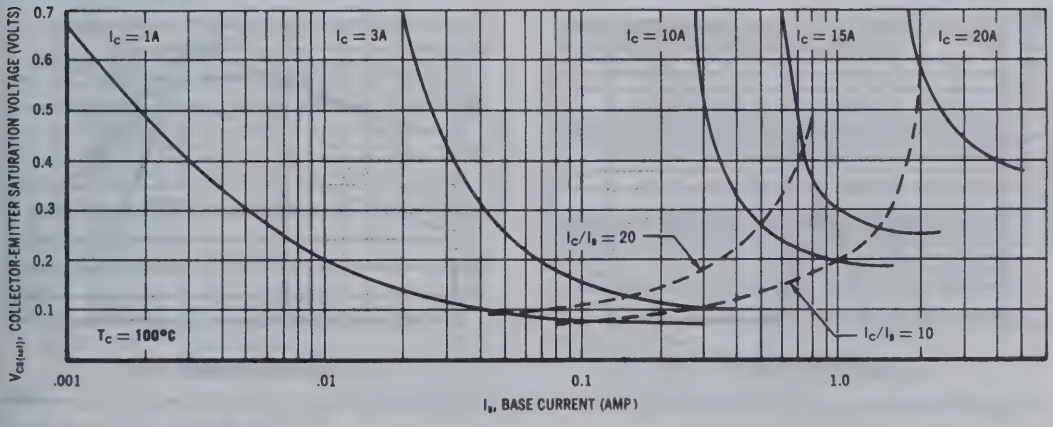


FIGURE 7 — CURRENT VARIATIONS

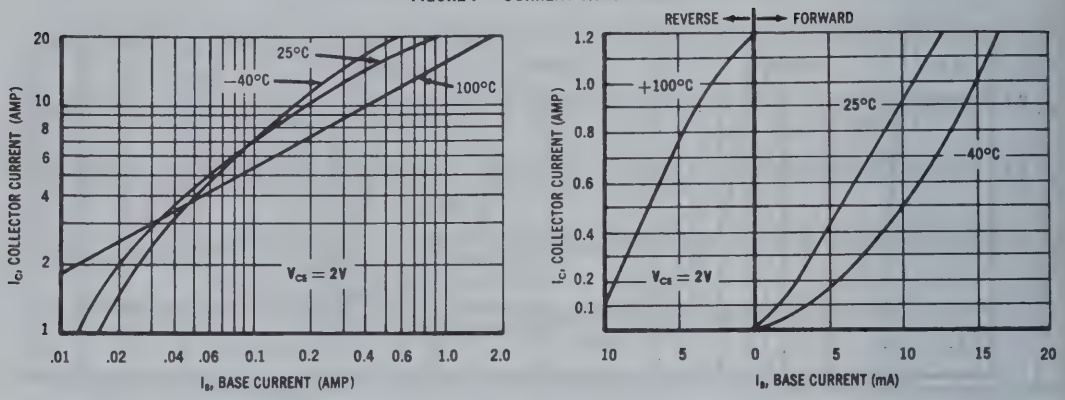


FIGURE 8 — COLLECTOR CURRENT-VOLTAGE VARIATION

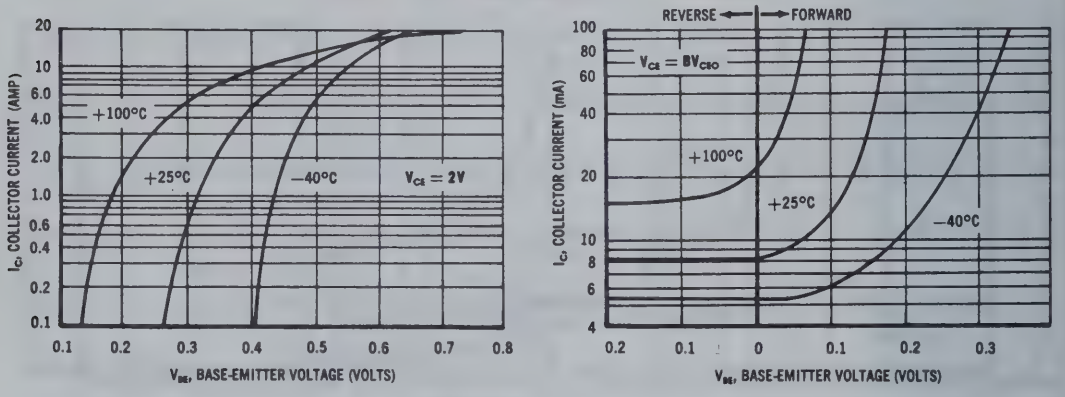


FIG 9 — BASE CURRENT-VOLTAGE VARIATIONS

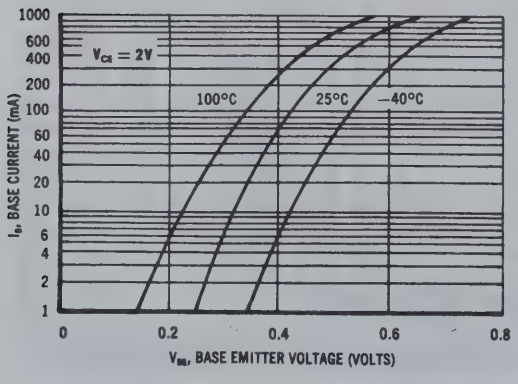


FIGURE 10 CURRENT-GAIN VARIATIONS

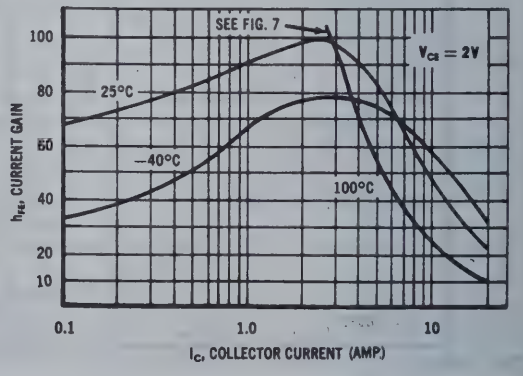


FIG 11 — RISE and FALL TIME vs COLLECTOR CURRENT

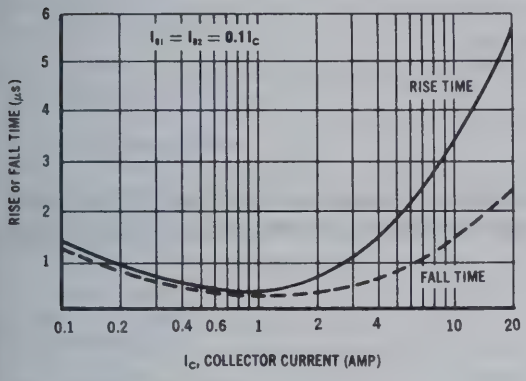


FIG 12 — STORAGE TIME vs COLLECTOR CURRENT

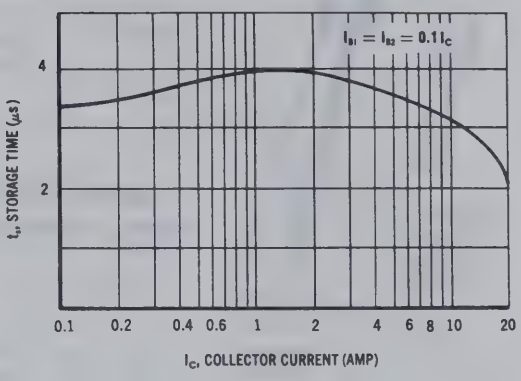
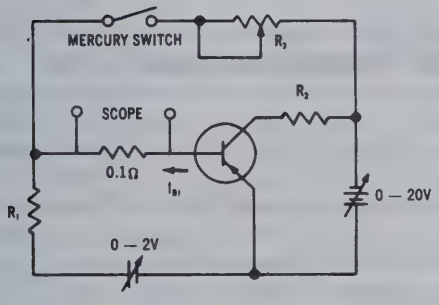


FIG 13 — SWITCHING TIME TEST CIRCUIT



Characteristic	Sym	Max	Unit
Rise Time	t_r	4	μs
Storage Time	t_s	6	μs
Fall Time	t_f	2.5	μs

ADJUST R_1, R_2, R_3, for $I_{B1} = I_{B2} = 0.1 I_C$

PULSE CONDITIONS; $I_C = 5$ AMP, $I_{B1} = 0.5$ AMP

Switching times shown are for constant current drive conditions. Faster times can be realized by the use of a lower source impedance or a speed-up capacitor. See Chapter 5 of the Motorola Switching Handbook for a more detailed explanation.

FIG 14 — CURRENT GAIN — BANDWIDTH PRODUCT vs COLLECTOR CURRENT

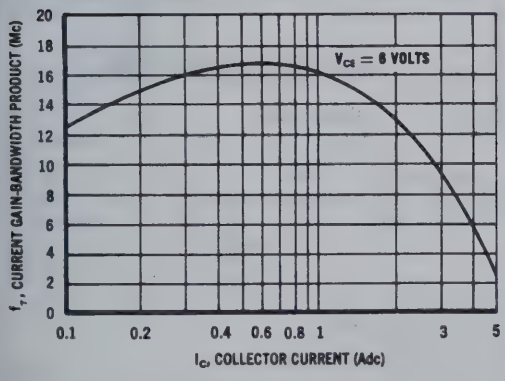
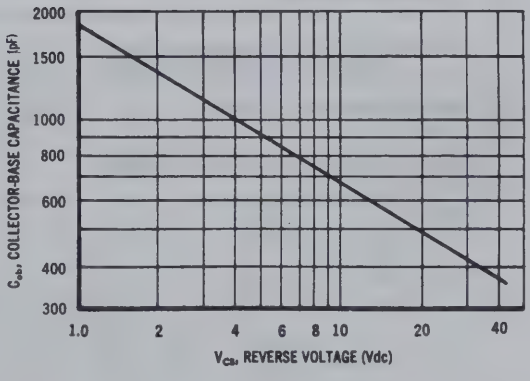


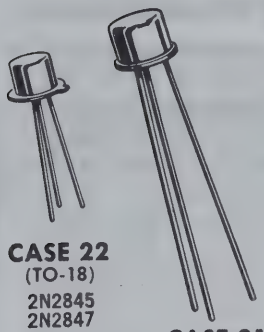
FIG 15 — OUTPUT CAPACITANCE vs REVERSE VOLTAGE



2N2837, 2N2838

For Specifications, See 2N2800 Data.

2N2845 thru 2N2848 (SILICON)



CASE 22
(TO-18)
2N2845
2N2847

CASE 31
(TO-5)
2N2846
2N2848

NPN silicon annular transistors designed for high-speed, medium-power saturated switching applications.

MAXIMUM RATINGS

Rating	Symbol	2N2845	2N2846	2N2847	2N2848	Unit
Collector-Emitter Voltage*	V_{CEO}*	30	30	20	20	Vdc
Collector-Base Voltage	V_{CB}	60	60	60	60	Vdc
Emitter-Base Voltage	V_{EB}	5	5	5	5	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.1	800 4.6	360 2.1	800 4.6	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	3.0 17.2	1.2 6.9	3.0 17.2	Watts mW/°C
Operating Junction Temperature Range	T_J	-65 to 200				°C
Storage Temperature Range	T_{stg}	-65 to + 200				°C

*Applicable from 1 mA to 30 mA (Pulsed)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, I_B = 0)	2N2845, 2N2846	$BV_{CEO(sus)}$*	30	—	Vdc
(I_C = 30 mAdc, I_B = 0)	2N2847, 2N2848		20	—	
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	5.0	—	Vdc
Collector-Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)		I_{CES}	—	0.2	μAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	—	200	μAdc
Base Leakage Current (V_{CE} = 30 Vdc, V_{BE} = 0)		I_{BL}	—	0.2	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N2845, 2N2846	h_{FE}*	30	120	—
	2N2847, 2N2848		40	140	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N2845, 2N2846		20	—	
	2N2847, 2N2848		30	—	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)	All Types		10	—	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	All Types	$V_{CE(sat)}$*	—	0.4	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	2N2845, 2N2846		—	1.0	
	2N2847, 2N2848		—	0.75	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$*	—	1.2	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.6	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	—	8.0	pF
Turn-On Time (Figure 1) (V_{CC} = 10 Vdc, I_C ≈ 150 mAdc, I_{B1} ≈ 15 mAdc)	2N2845, 2N2846	t_{on}	—	40	ns
(V_{CC} = 6 Vdc, I_C ≈ 150 mAdc, I_{B1} ≈ 15 mAdc)	2N2847, 2N2848		—	25	
Turn-Off Time (Figure 2) (V_{CC} = 10 Vdc, I_C ≈ 150 mAdc, I_{B1} ≈ I_{B2} ≈ 15 mAdc)	2N2845, 2N2846	t_{off}	—	40	ns
(V_{CC} = 6 Vdc, I_C ≈ 150 mAdc, I_{B1} ≈ I_{B2} ≈ 15 mAdc)	2N2847, 2N2848		—	40	

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = ≤ 2%

FIGURE 1 — TURN-ON TIME TEST CIRCUIT

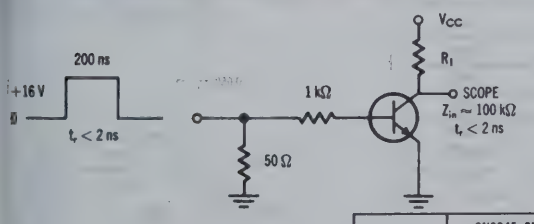
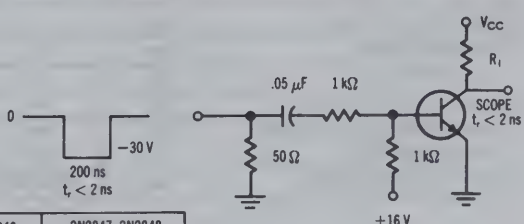


FIGURE 2 — TURN-OFF TIME TEST CIRCUIT



	2N2845, 2N2846	2N2847, 2N2848
V_{CC}	10 V	6 V
R_1	62 Ω	39 Ω

2N2857 (SILICON)

NPN SILICON RF SMALL-SIGNAL TRANSISTOR

. . . designed primarily for use in high-gain, low-noise amplifier, oscillator, and mixer applications. Can also be used in UHF converter applications.

- High Current-Gain—Bandwidth Product —
  f_T = 1.6 GHz (Typ) @ I_C = 8.0 mAdc
- Low Noise Figure —
  NF = 4.5 dB (Max) @ f = 450 MHz
- Low Collector-Base Time Constant —
  $r_b'C_C$ = 15 ps (Max) @ I_E = 2.0 mAdc
- Characterized with Scattering Parameters
- Ideal for Micro-Power Applications

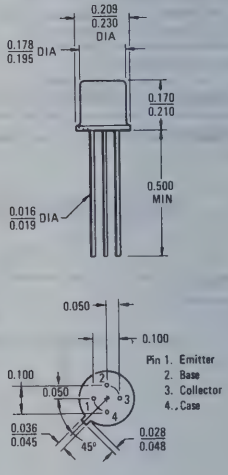
NPN SILICON RF SMALL-SIGNAL TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current — Continuous	I_C	40	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



CASE 20 (10)
TO-72 PACKAGE

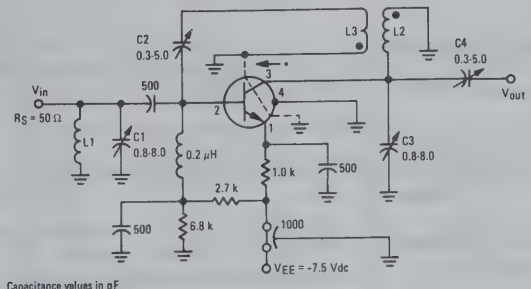
Active Elements Isolated from Case

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage** (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	2.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	–	150	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product ① (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	1000	–	1900	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	–	0.7	1.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	h_{fe}	50	–	220	–
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.9 MHz)	$r_b'C_c$	4.0	–	15	ps
Noise Figure (Figure 1)	NF				dB
(I_E = 0.1 mAdc, V_{CE} = 1.0 Vdc, R_S = 50 ohms, f = 450 MHz) ②		–	5.8	–	
(I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 450 MHz)		–	3.7	4.5	
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1)	G_{pe}				dB
(I_E = 0.1 mAdc, V_{CE} = 1.0 Vdc, f = 450 MHz) ②		–	11	–	
(I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)		12.5	–	19	
Power Output (Figure 2) (I_E = 12 mAdc, V_{CB} = 10 Vdc, f = 500 MHz)	P_{out}	30	–	–	mW

*Indicates JEDEC Registered Data.
**Motorola guarantees this data in addition to JEDEC Registered Data.
① f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
② Micro-Power Specifications.

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.

L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.

* – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

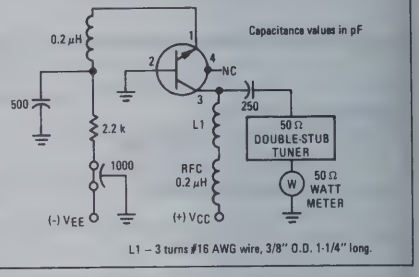
(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.

(D) Interchange connections to signal generator and RF voltmeter.

(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

FIGURE 2 – TEST CIRCUIT FOR OSCILLATOR POWER OUTPUT



L1 – 3 turns #16 AWG wire, 3/8" O.D. 1-1/4" long.

FIGURE 3 – NOISE FIGURE versus FREQUENCY

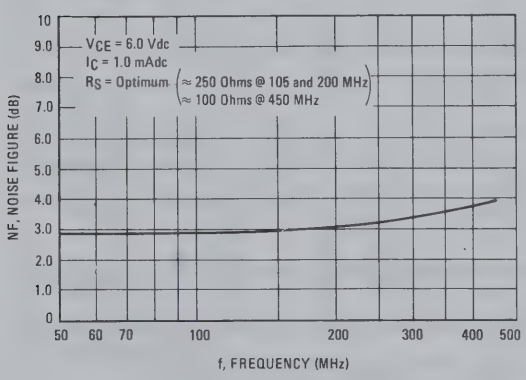


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

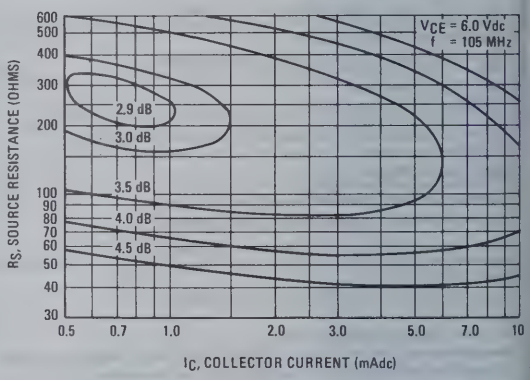


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

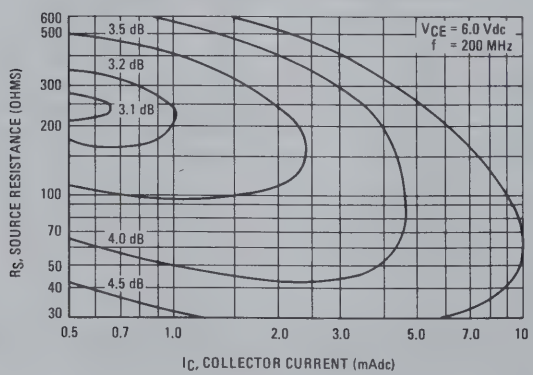


FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT



FIGURE 7 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

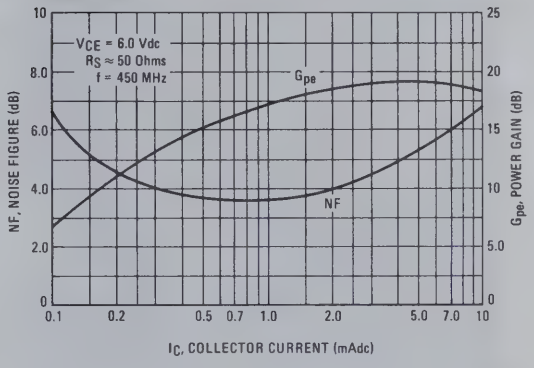


FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

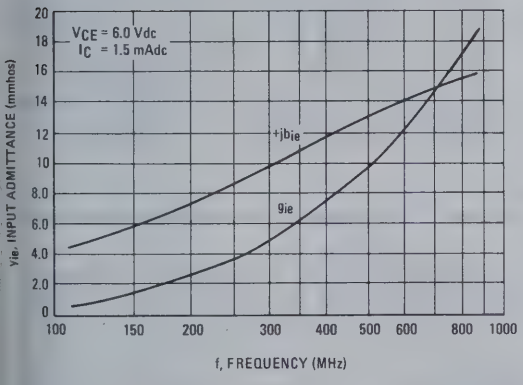


FIGURE 9 – OUTPUT ADMITTANCE versus FREQUENCY

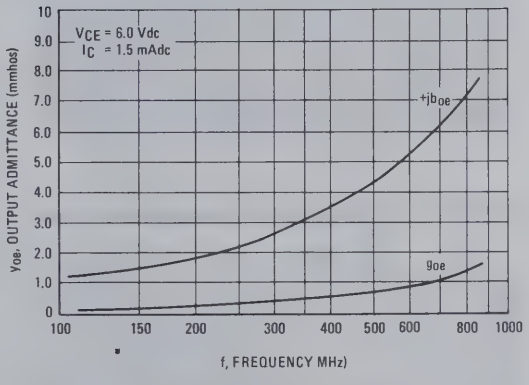


FIGURE 10 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

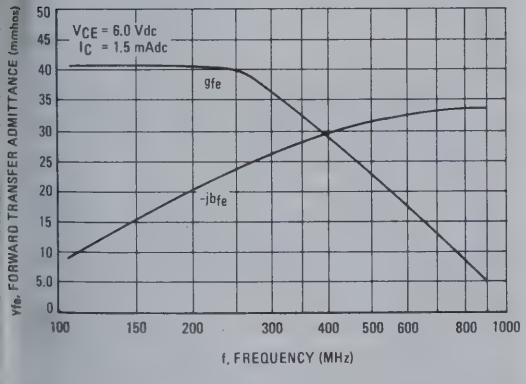


FIGURE 11 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

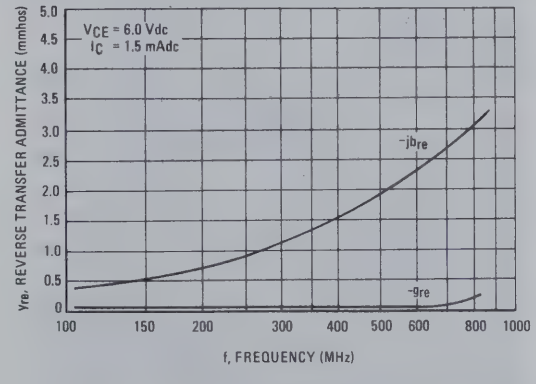


FIGURE 12 – S_{11}, INPUT REFLECTION COEFFICIENT

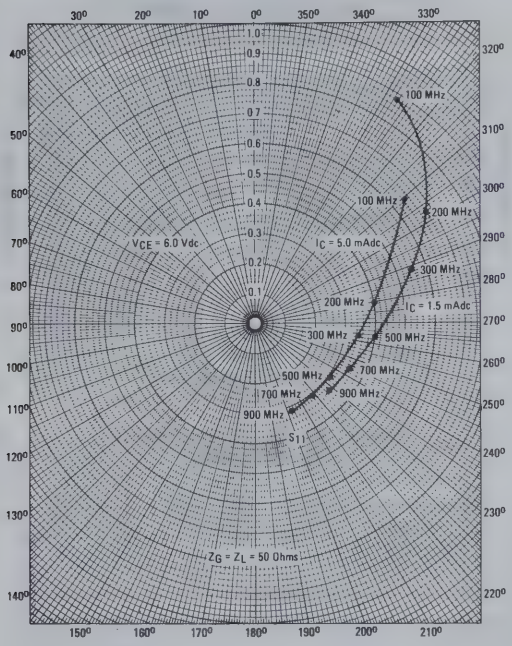


FIGURE 13 – S_{22}, OUTPUT REFLECTION COEFFICIENT

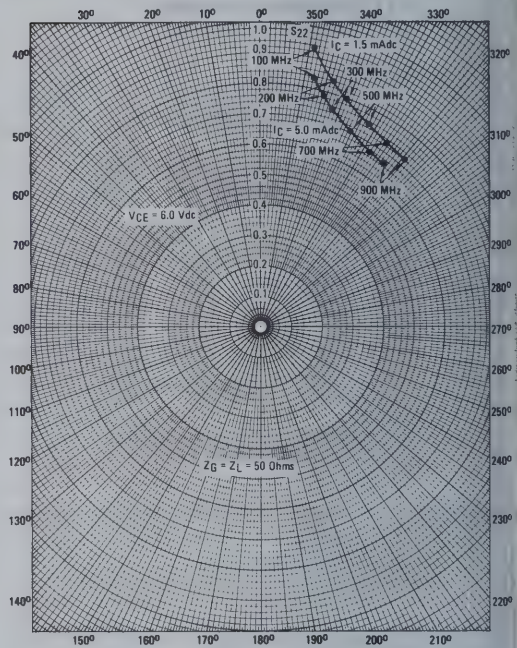


FIGURE 14 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

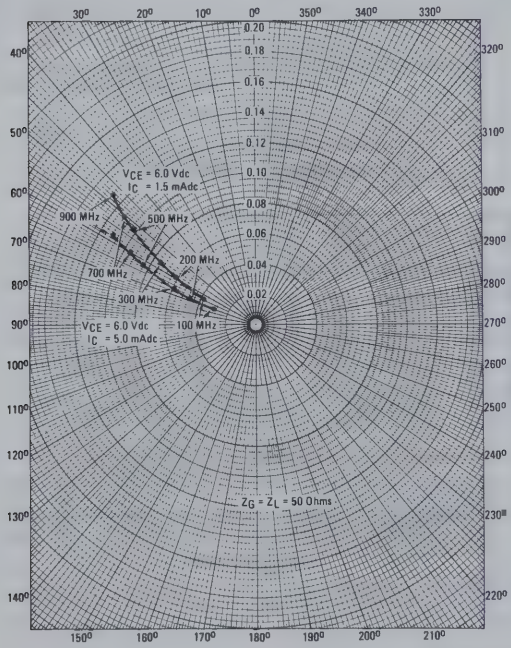


FIGURE 15 – S_{21}, FORWARD TRANSMISSION COEFFICIENT

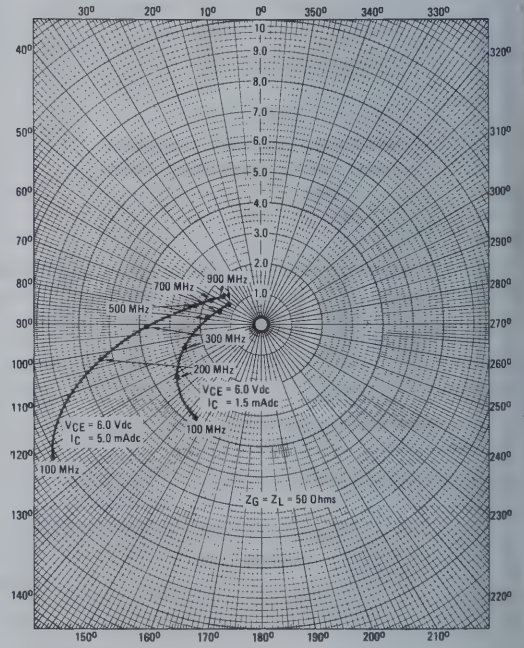
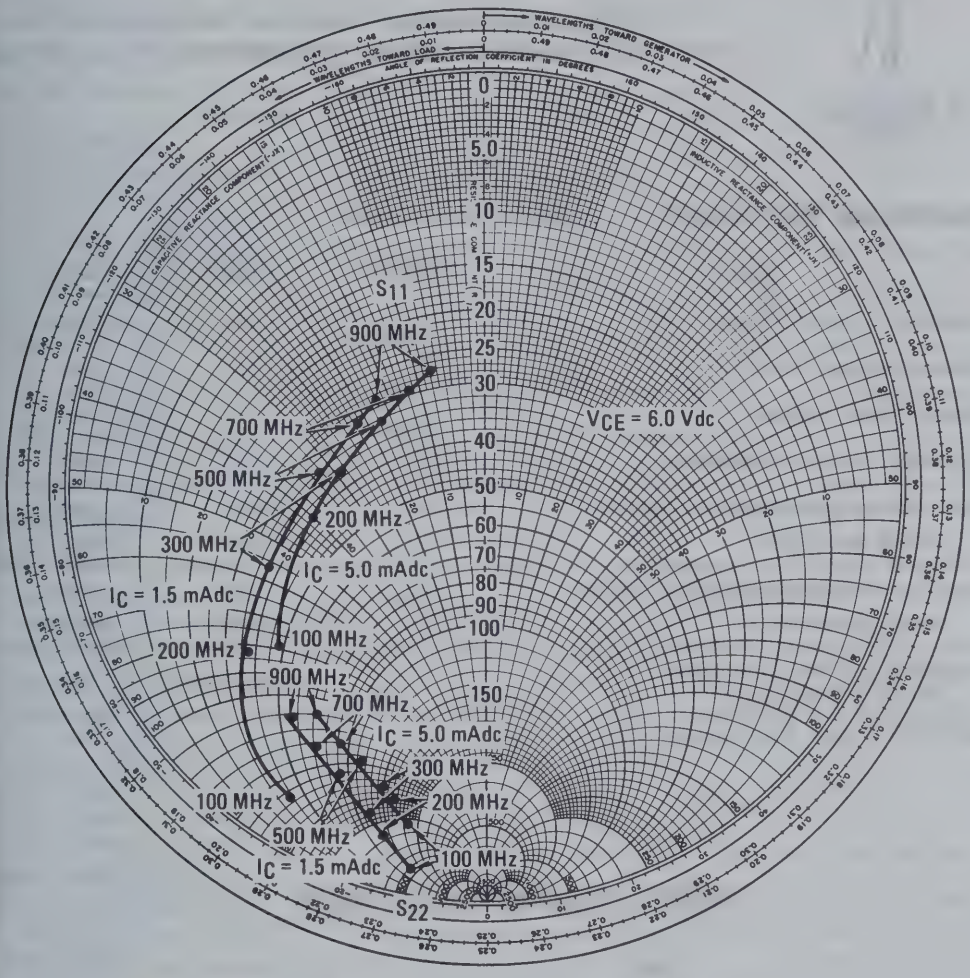


FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



2N2894 (SILICON)



CASE 22
(TO-18)

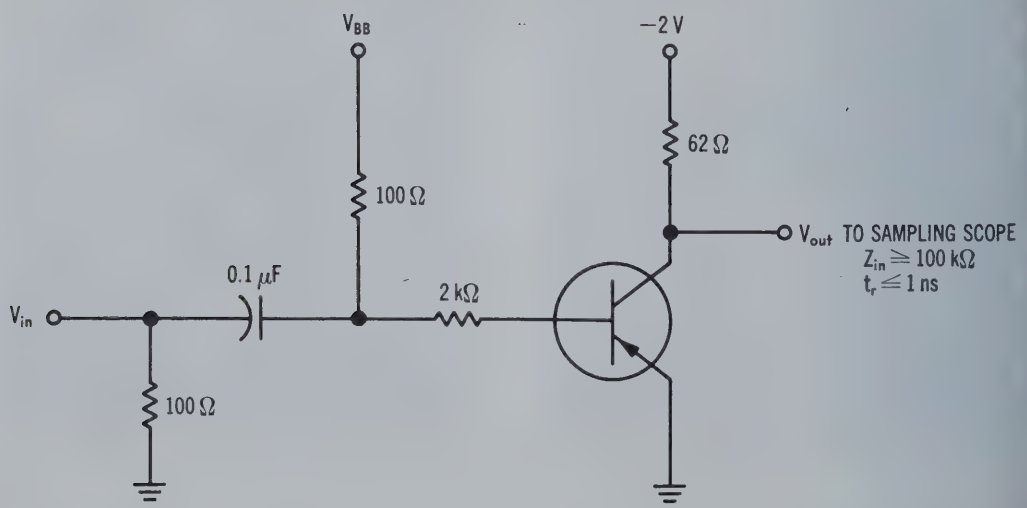
PNP silicon annular transistor designed for low-level, high-speed switching applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage *	V_{CEO}*	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current-Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1200 6.85	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Applicable from 0.01 to 10 mAdc.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	12	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4	—	Vdc
Collector-Cutoff Current (V_{CE} = 6 Vdc, V_{BE} = 0)	I_{CES}	—	80	nAdc
Collector-Cutoff Current (V_{CB} = 6 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	—	10	μAdc
Base Current (V_{CE} = 6 Vdc, V_{BE} = 0)	I_B	—	80	nAdc
ON CHARACTERISTICS				
DC Current Gain*	h_{FE}*			—
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)		30	—	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc)		40	150	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C)		17	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		25	—	
Collector-Emitter Saturation Voltage*	$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		—	0.15	
(I_C = 30 mAdc, I_B = 3 mAdc)		—	0.2	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.5	
Base-Emitter Saturation Voltage*	$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		0.78	0.98	
(I_C = 30 mAdc, I_B = 3 mAdc)		0.85	1.2	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	1.7	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	6.0	pF
Input Capacitance (V_{BE} = -0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	—	6.0	pF
Turn-On Time, Figure 1 (V_{CC} = 2 Vdc, $V_{BE(off)}$ = 3 Vdc, I_C = 30 mAdc, I_{B1} = 1.5 mAdc)	t_{on}	—	60	ns
Turn-Off Time, Figure 1 (V_{CC} = 2 Vdc, I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc)	t_{off}	—	90	ns

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 1%

2N2895 (SILICON)
2N2896
2N2897



CASE 22
(TO-18)

NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.

MAXIMUM RATINGS

Rating	Symbol	2N2895	2N2896	2N2897	Unit
Collector-Emitter Voltage	V_{CEO}	65	90	45	Vdc
Collector-Emitter Voltage	V_{CER}	80	140	60	Vdc
Collector-Base Voltage	V_{CB}	120	140	60	Vdc
Emitter-Base Voltage	V_{EB}	← 7.0 →			Vdc
Collector Current	I_C	← 1.0 →			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 0.5 → ← 2.86 →			Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 1.8 → ← 10.3 →			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	2N2895	$BV_{CEO(sus)}$*	65	-	Vdc
	2N2896		90	-	
	2N2897		45	-	
Collector-Emitter Breakdown Voltage* (I_C = 100 mAdc, R_{BE} = 10 ohms)	2N2895	BV_{CER}*	80	-	Vdc
	2N2896		140	-	
	2N2897		60	-	
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	2N2895	BV_{CBO}	120	-	Vdc
	2N2896		140	-	
	2N2897		60	-	
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	2N2895	I_{CBO}	-	0.002	μAdc
	2N2896		-	0.01	
	2N2897		-	0.05	
(V_{CB} = 60 Vdc, I_E = 0, T_A = +150°C)	2N2895		-	2.0	
	2N2897		-	50	
(V_{CB} = 90 Vdc, I_E = 0)	2N2896		-	0.01	
(V_{CB} = 90 Vdc, I_E = 0, T_A = +150°C)	2N2896		-	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N2895	I_{EBO}	-	0.002	μAdc
	2N2896		-	0.01	
	2N2897		-	0.05	
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 10 Vdc)	2N2895	h_{FE}	10	-	-
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	2N2895		20	-	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2896, 2N2897		35	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2895		35	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N2895, 2N2896		20	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*	2N2895		40 *	120 *	
	2N2896		60 *	200 *	
	2N2897		50 *	200 *	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)*	2N2895		25 *	-	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	2N2895, 2N2896	$V_{CE(sat)}$*	-	0.6	Vdc
	2N2897		-	1.0	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	2N2895, 2N2896	$V_{BE(sat)}$*	-	1.2	Vdc
	2N2897		-	1.3	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N2895, 2N2896	f_T	120	-	MHz
	2N2897		100	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	80	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2895	h_{fe}	50	200	-
	2N2896, 2N2897		50	275	
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 500 ohms, f = 1.0 kHz, BW = 15 kHz)	2N2895	NF	-	8.0	dB

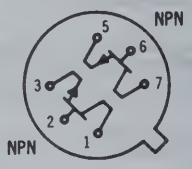
* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.8%.

2N2903 (SILICON)
2N2903A

Dual NPN silicon transistors designed for differential amplifier applications.



CASE 32C



PINS 4 AND 8 OMITTED

Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Power Dissipation @ T_A = 25°C	P_D	200	300	mW
Derate above 25°C		1.14	1.71	mW/°C
Power Dissipation @ T_C = 25°C	P_D	600	1200	mW
T_C = 100°C		350	700	mW
Derate above 25°C		3.43	6.86	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25 C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	30	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 μAdc, I_C = 0)	BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	-	0.01	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150 C)		-	15	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	-	0.01	μAdc

* Pulse Test: Pulse Width < 300 μs, Duty Cycle < 2.0%.

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25 C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)		60	-	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)		25	-	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		125	625	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)		60	-	
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)	f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	1.0	-	k ohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	-	6.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	150	600	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	5.0	30	μmhos
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	20	30	ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	5.0	X 10^{-4}
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	0.2	μmho
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)	NF	-	7.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio** (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) 2N2903	h_{FE1}/h_{FE2}**	0.8	1.0	-
2N2903A		0.9	1.0	
Base Voltage Differential (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) 2N2903	$\lvert V_{BE1}-V_{BE2}\rvert$	-	10	mVdc
2N2903A		-	5.0	
Base Voltage Differential Gradient (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +125°C) 2N2903	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	-	20	μV/°C
2N2903A		-	10	

** Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

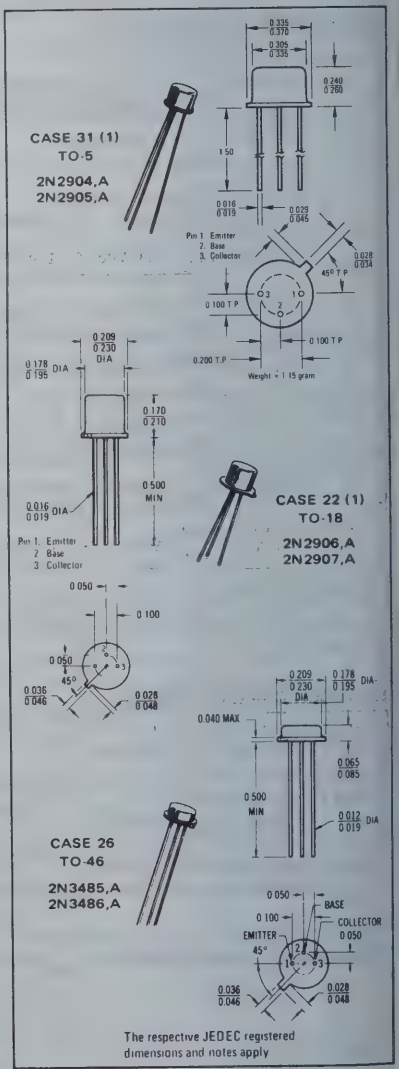
2N2904, A thru 2N2907, A (SILICON)
2N3485, A, 2N3486, A

PNP SILICON ANNULAR HERMETIC TRANSISTORS

. . . designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.

- High DC Current Gain Specified – 0.1 to 500 mAdc
- High Current-Gain–Bandwidth Product – f_T = 200 MHz (Min) @ I_C = 50 mAdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- 2N2904,A thru 2N2907,A Complement to NPN 2N2218,A, 2N2219,A, 2N2221,A, 2N2222,A
- JAN/JANTX Available for 2N2904,A thru 2N2907,A

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTORS



SELECTOR GUIDE

Device Type	BV_{CEO} I_C = 10 mAdc Volts	h_{FE} I_C = 1.0 mAdc Min	h_{FE} I_C = 150 mAdc Min	h_{FE} I_C = 500 mAdc Min	Package
2N2904	40	25	40	20	TO-5
2N2905		50	100	30	
2N2906		25	40	20	TO-18
2N2907		50	100	30	
2N3485		25	40	20	TO-46
2N3486		50	100	30	
2N2904A	60	40	40	40	TO-5
2N2905A		100	100	50	
2N2906A		40	40	40	TO-18
2N2907A		100	100	50	
2N3485A		40	40	40	TO-46
2N3486A		100	100	50	

*MAXIMUM RATINGS

Rating	Symbol	Non-A Suffix	A-Suffix		Unit
Collector-Emitter Voltage	V_{CEO}	40	60		Vdc
Collector-Base Voltage	V_{CB}	60			Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current – Continuous	I_C	600			mAdc
		2N2904,A 2N2905,A	2N2906,A 2N2907,A	2N3485,A 2N3486,A	
Total Device Dissipation @ T_A = 25°C	P_D	600	400	400	mW
Derate above 25°C		3.43	2.28	2.28	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	3.0	1.8	2.0	Watts
Derate above 25°C		17.2	10.3	11.43	mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	–65 to +200			°C

***ELECTRICAL CHARACTERISTICS** (T_A = 25° unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	Non-A Suffix	BV_{CEO}	40	–	–	Vdc
	A-Suffix		60	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)		I_{CEX}	–	–	50	nAdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 50 Vdc, I_E = 0)	Non-A Suffix		–	–	0.020	
	A-Suffix		–	–	0.010	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	Non-A Suffix		–	–	20	
	A-Suffix		–	–	10	
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)		I_B	–	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2904,2N2906,2N3485		20	–	–	
	2N2905,2N2907,2N3486		35	–	–	
	2N2904A,2N2906A,2N3485A		40	–	–	
	2N2905A,2N2907A,2N3486A		75	–	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2904,2N2906,2N3485		25	–	–	
	2N2905,2N2907,2N3486		50	–	–	
	2N2904A,2N2906A,2N3485A		40	–	–	
	2N2905A,2N2907A,2N3486A		100	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2904,2N2906,2N3485		35	–	–	
	2N2905,2N2907,2N3486		75	–	–	
	2N2904A,2N2906A,2N3485A		40	–	–	
	2N2905A,2N2907A,2N3486A		100	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2904,A,2N2906,A,2N3485,A		40	–	120	
	2N2905,A,2N2907,A,2N3486,A		100	–	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2904,2N2906,2N3485		20	–	–	
	2N2905,2N2907,2N3486		30	–	–	
	2N2904A,2N2906A,2N3485A		40	–	–	
	2N2905A,2N2907A,2N3486A		50	–	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	–	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	–	1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)(1)			–	–	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	–	2.6	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	–	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 15a)	t_{on}	–	26	45	ns
Delay Time		t_d	–	6.0	10	ns
Rise Time		t_r	–	20	40	ns
Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 15b)	t_{off}	–	70	100	ns
Storage Time		t_s	–	50	80	ns
Fall Time		t_f	–	20	30	ns

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

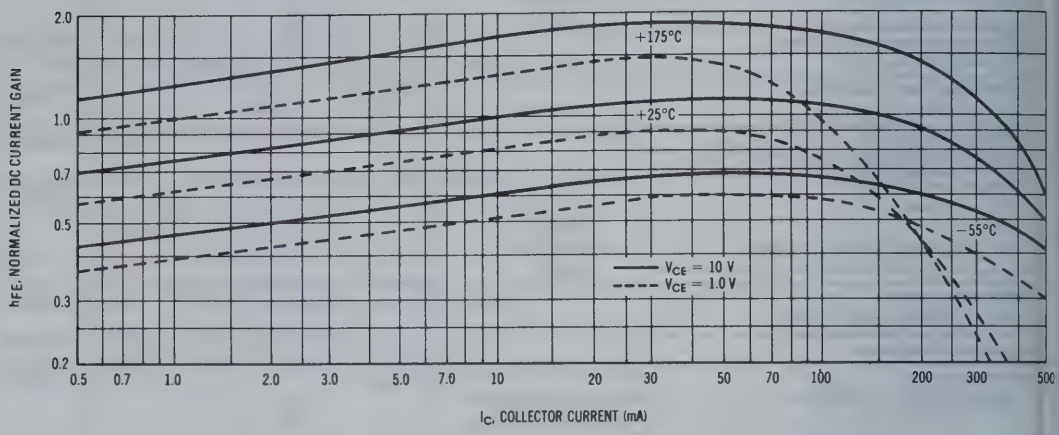
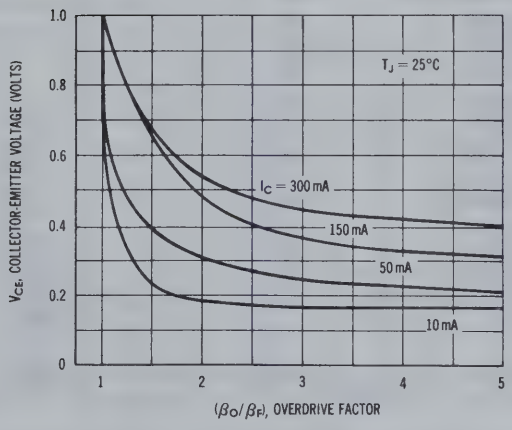


FIGURE 2 – NORMALIZED COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O (current gain at edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit.

EXAMPLE: For type 2N2905, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at $I_C = 150$ mA an overdrive factor of at least 3 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.60 of h_{FE} @ 10 volts. Using the guaranteed minimum of 100 @ 150 mA and 10 V, $\beta_O = 60$ and substituting values in the overdrive equation, we find:

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\ V}{I_C/I_{BF}} \qquad 3 = \frac{60}{150/I_{BF}} \qquad I_{BF} \approx 7.5\ mA$$

FIGURE 3 – "ON" VOLTAGES

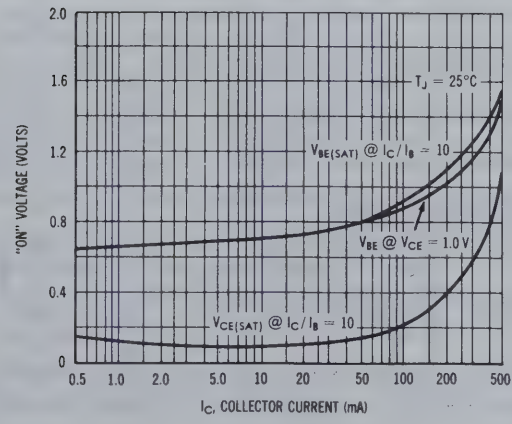
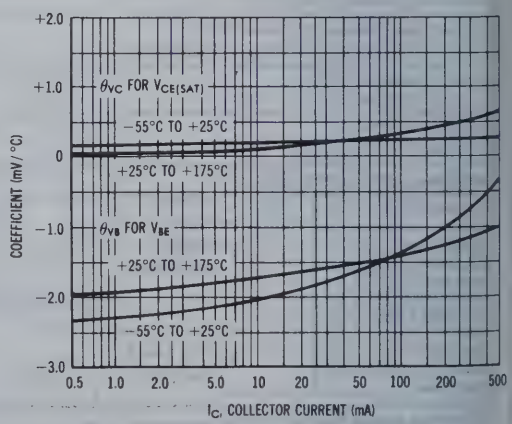


FIGURE 4 – TEMPERATURE COEFFICIENTS



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 V, T_A = 25°C

FIGURE 5 – FREQUENCY EFFECTS

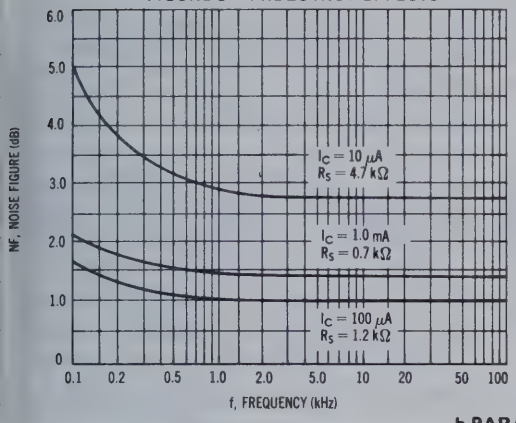
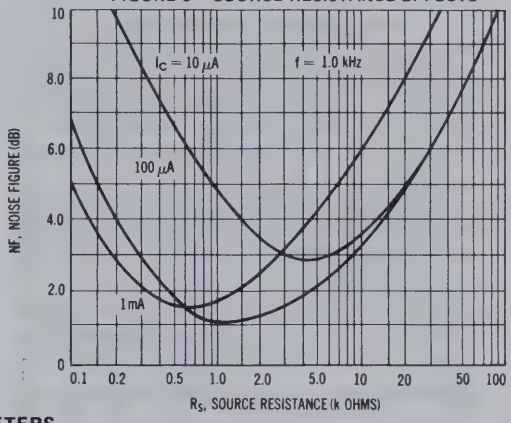


FIGURE 6 – SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 7 – INPUT IMPEDANCE

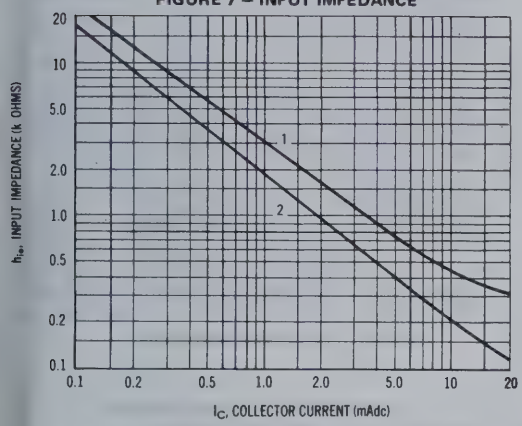


FIGURE 8 – VOLTAGE FEEDBACK RATIO

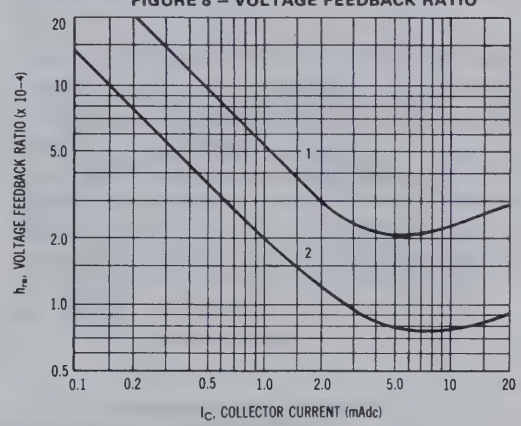


FIGURE 9 – CURRENT GAIN

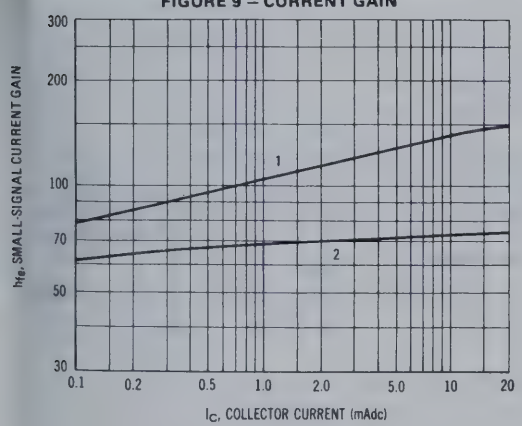


FIGURE 10 – OUTPUT ADMITTANCE

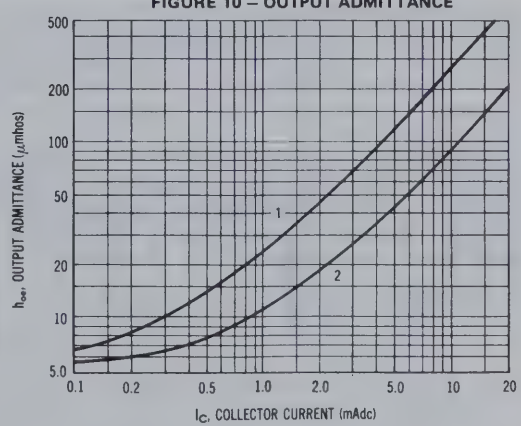


FIGURE 11 – TURN ON TIME

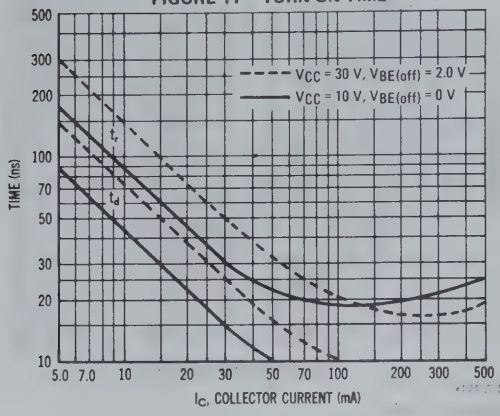


FIGURE 12 – CHARGE DATA

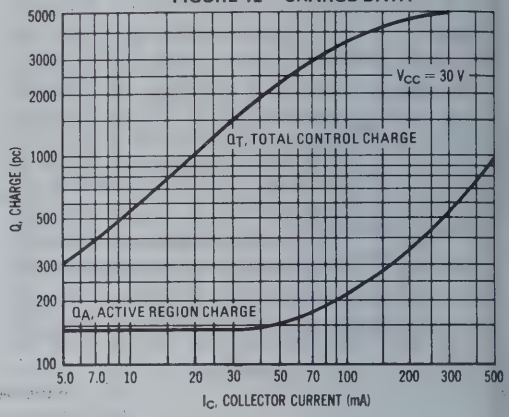


FIGURE 13 – STORAGE TIME

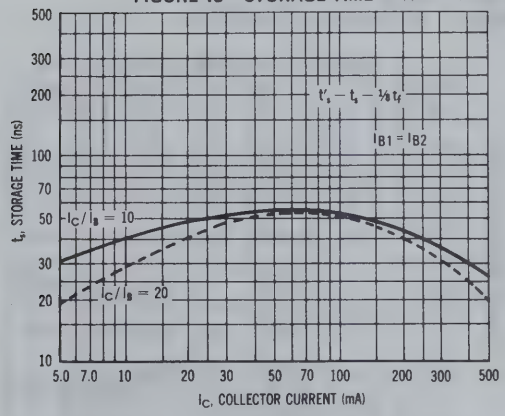


FIGURE 14 – FALL TIME

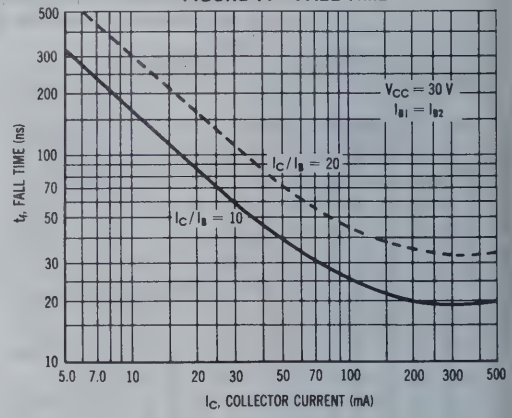


FIGURE 15a – DELAY AND RISE TIME TEST CIRCUIT

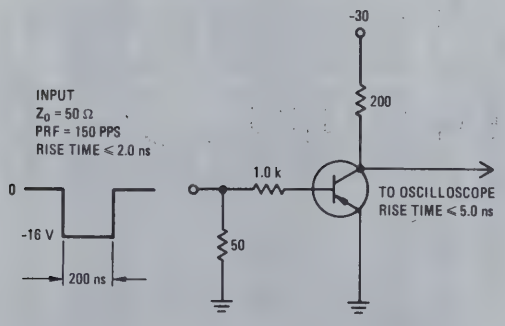


FIGURE 15b – STORAGE AND FALL TIME TEST CIRCUIT

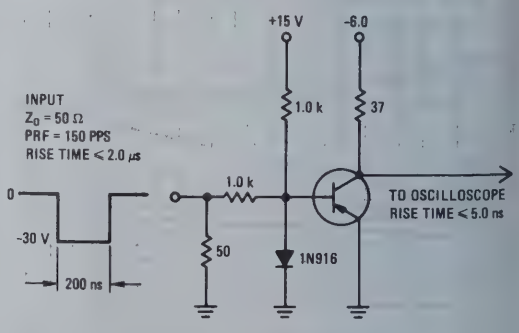


FIGURE 16 – CURRENT-GAIN–BANDWIDTH PRODUCT

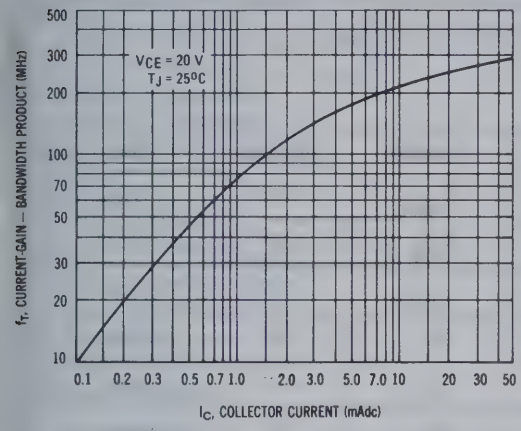


FIGURE 17 – CAPACITANCES

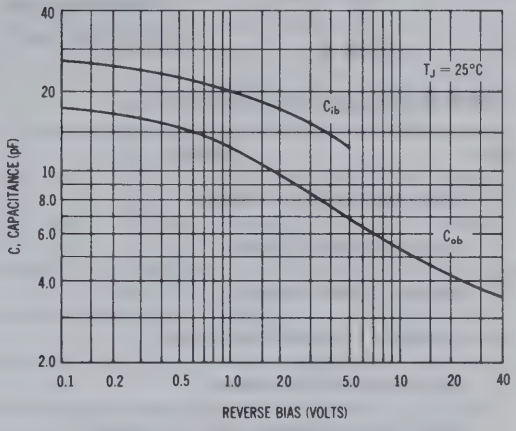
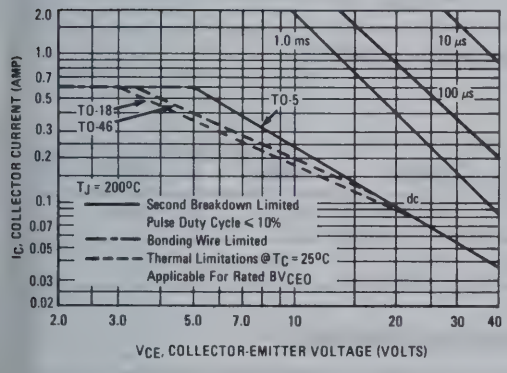


FIGURE 18 – ACTIVE REGION SAFE OPERATING AREAS

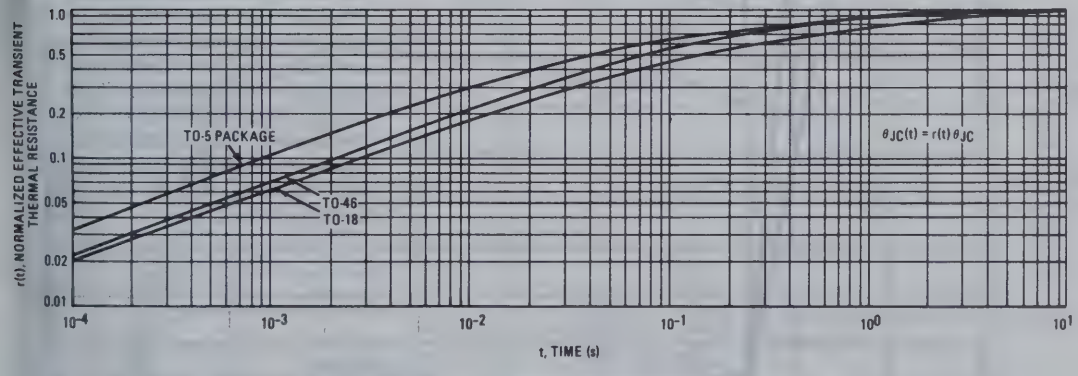


This graph shows the maximum I_C-V_{CE} limits of the device both from the standpoint of thermal dissipation (at 25°C case temperature), and secondary breakdown. For case temperatures other than 25°C, the thermal dissipation curve must be modified in accordance with the derating factor in the Maximum Ratings table.

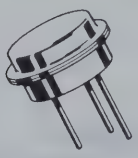
To avoid possible device failure, the collector load line must fall below the limits indicated by the applicable curve. Thus, for certain operating conditions the device is thermally limited, and for others it is limited by secondary breakdown.

For pulse applications, the maximum I_C-V_{CE} product indicated by the dc thermal limits can be exceeded. Pulse thermal limits may be calculated by using the transient thermal resistance curve of Figure 19.

FIGURE 19 – THERMAL RESISTANCE



2N2912 (GERMANIUM)



CASE 8

PNP high-speed, high-frequency power transistor especially designed for switching and power converter circuits operating from low-voltage power sources such as solar cells, thermo-electric generators, sea cells, fuel cells and 1.5 volt batteries.

MAXIMUM RATINGS

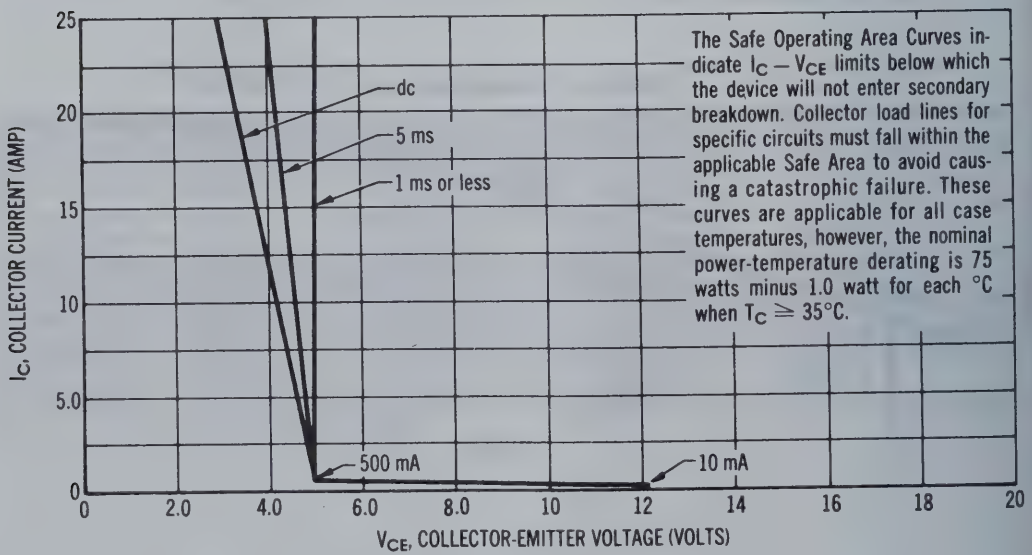
Rating	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	1.5	Vdc
Collector Current-Continuous	I_C	25	Adc
Base Current-Continuous	I_B	3.0	Adc
Total Device Dissipation @ T_C = 35°C Derate above 35°C	P_D	75 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

Lead temperature 1/16" from case for 10 seconds = 240°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	30	°C/W

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



2N2912 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 500 mAdc, I_B = 0)		BV_{CEO}*	5.0	—	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 500 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	—	10	mAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, R_{BE} = 5.0 ohms)		I_{CER}	—	10	mAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, $V_{BE(off)}$ = 0.2 Vdc) (V_{CE} = 5.0 Vdc, $V_{EB(off)}$ = 0.2 Vdc, T_C = 85°C)		I_{CEX}	— —	10 15	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	10	mAdc
Emitter Cutoff Current (V_{BE} = 1.5 Vdc, I_C = 0)		I_{EBO}	—	50	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 Adc, V_{CE} = 2.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2	h_{FE}	150 200	— 800	—
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc) (I_C = 25 Adc, I_B = 2.5 Adc)	2	$V_{CE(sat)}$	— —	0.12 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc) (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{BE(sat)}$	— —	0.5 1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc, f = 1.0 MHz)		f_T	10	—	MHz
Rise Time (V_{CC} = 10 Vdc, I_C = 5.0 Adc)	3	t_r	—	2.0	μs
Storage Time (V_{CC} = 10 Vdc, I_C = 5.0 Adc)	3	t_s	—	10	μs
Fall Time (V_{CC} = 10 Vdc, I_C = 5.0 Adc)	3	t_f	—	2.0	μs

*Sweep Test: 1/2 Cycle sine wave, 60 Hz

FIGURE 2 — TYPICAL COLLECTOR CHARACTERISTICS

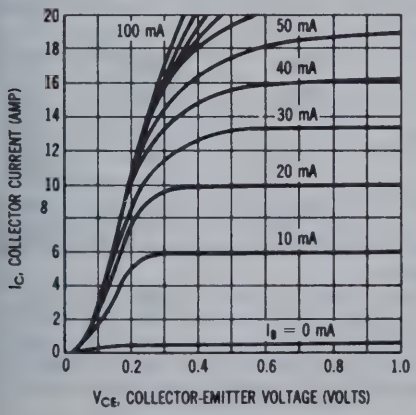
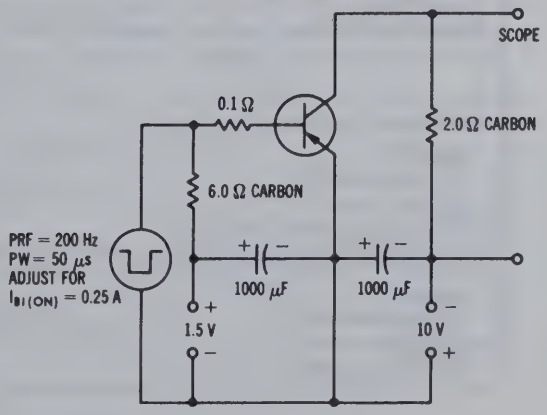


FIGURE 3 — SWITCHING-TIME TEST CIRCUIT



2N2913 thru 2N2920
2N2972 thru 2N2979

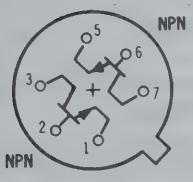
Dual NPN silicon annular transistors, especially designed for low-level, low-noise differential-amplifier applications, feature very high Beta guaranteed from 10 μAdc to 1.0 mAdc and excellent noise characteristics.





CASE 35
(TO-71)

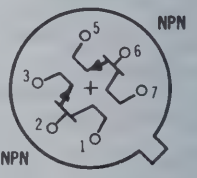
2N2972
thru
2N2979



Pins 4 and 8 omitted

CASE 32C

2N2913
thru
2N2920



Pin Connections, Bottom View
All Leads Electrically Isolated From Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	2N2913–18 2N2972–77	2N2919–20 2N2978–79	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CB}	45	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0		
Collector Current	I_C	30		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Case 32C		300	600	mW
Derate above 25°C		1.7	3.4	mW/°C
Case 35		250	300	mW
Derate above 25°C		1.43	1.72	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
Case 32C		750	1500	mW
Derate above 25°C		4.3	8.6	mW/°C
Case 35		500	750	mW
Derate above 25°C		2.85	4.3	mW/°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	2N2913 thru 18, 2N2972 thru 77	$BV_{CEO(sus)}$	45		-	Vdc
	2N2919, 2N2920, 2N2978, 2N2979		60		-	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N2913 thru 18, 2N2972 thru 77	BV_{CBO}	45		-	Vdc
	2N2919, 2N2920, 2N2978, 2N2979		60		-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0		-	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)		I_{CEO}	-	-	0.002	μAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	2N2913 thru 18, 2N2972 thru 77	I_{CBO}	-	-	0.010	μAdc
	2N2919, 2N2920, 2N2978, 2N2979		-	-	0.002	
(V_{CB} = 45 Vdc, I_E = 0, T_A = 150°C)	All Types		-	-	10	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	-	0.002	μAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2913, 15, 17, 19, 2N2972, 74, 76, 78	h_{FE}*	60	-	240	-
	2N2914, 16, 18, 20, 2N2973, 75, 77, 79		150	-	600	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	2N2913, 15, 17, 19, 2N2972, 74, 76, 78		15	-	-	
	2N2914, 16, 18, 20, 2N2973, 75, 77, 79		30	-	-	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2913, 15, 17, 19, 2N2972, 74, 76, 78		100	-	-	
	2N2914, 16, 18, 20, 2N2973, 75, 77, 79		225	-	-	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2913, 15, 17, 19, 2N2972, 74, 76, 78		150	-	-	
	2N2914, 16, 18, 20, 2N2973, 75, 77, 79		300	-	-	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	-	-	0.35	Vdc
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	-	-	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	60	-	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	-	4.0	6.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	28	32	ohms
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	-	-	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms,		NF				dB
f = 1.0 kHz, BW = 200 Hz)	2N2914, 16, 18, 20, 2N2973, 75, 77, 79		-	2.0	3.0	
	2N2913, 15, 17, 19, 2N2972, 74, 76, 78		-	3.0	4.0	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms,			-			
f = 10 Hz to 15.7 kHz, BW = 10 kHz)	2N2914, 16, 18, 20, 2N2973, 75, 77, 79		-	2.0	3.0	
	2N2913, 15, 17, 19, 2N2972, 74, 76, 78			3.0	4.0	
DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2917, 18, 2N2976, 77	h_{FE1}/h_{FE2}**	0.8	-	1.0	-
	2N2915, 16, 19, 20, 2N2974, 75, 78, 79		0.9	-	1.0	
Base Voltage Differential (I_C = 10 μAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2917, 18, 2N2976, 77	$\lvert V_{BE1}-V_{BE2}\rvert$	-	-	10	mVdc
	2N2915, 16, 19, 20, 2N2974, 75, 78, 79		-	-	5.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2917, 18, 2N2976, 77		-	-	5.0	
	2N2915, 16, 19, 20, 2N2974, 75, 78, 79		-	-	3.0	
Base Voltage Differential Gradient (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +25°C)		$\Delta(V_{BE1}-V_{BE2})$				mVdc
	2N2917, 18, 2N2976, 77		-	-	1.6	
	2N2915, 16, 19, 20, 2N2974, 75, 78, 79		-	-	0.8	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25°C to +125°C)						
	2N2917, 18, 2N2976, 77		-	-	2.0	
	2N2915, 16, 19, 20, 2N2974, 75, 78, 79		-	-	1.0	

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

** The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2929 (GERMANIUM)



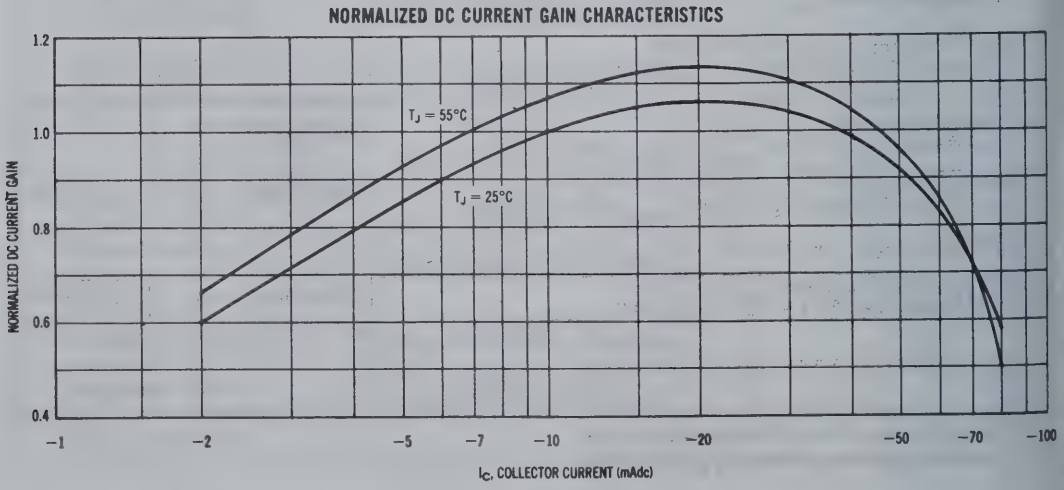
CASE 31
(TO-5)

PNP germanium epitaxial mesa transistor for low noise, broadband, power and driver amplifier applications.

Collector connected to case

MAXIMUM RATINGS

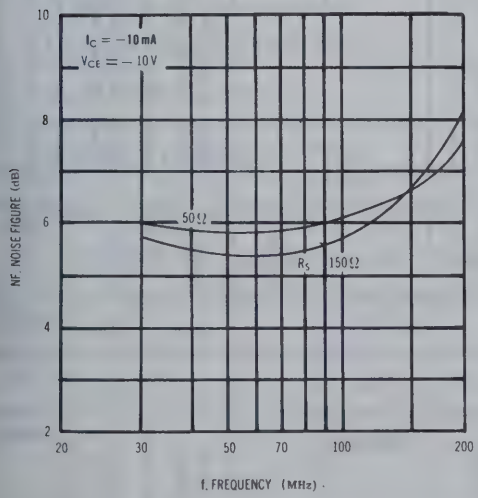
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Volts
Collector-Emitter Voltage	V_{CES}	25	Volts
Collector-Emitter Voltage	V_{CEO}	10	Volts
Emitter-Base Voltage	V_{EB}	0.75	Volts
Collector Current	I_C	100	mA
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	300 4	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	750 10	mW $mW/^oC$
Junction Temperature	T_J	100	^oC
Storage Temperature Range	T_{stg}	-65 to +100	^oC



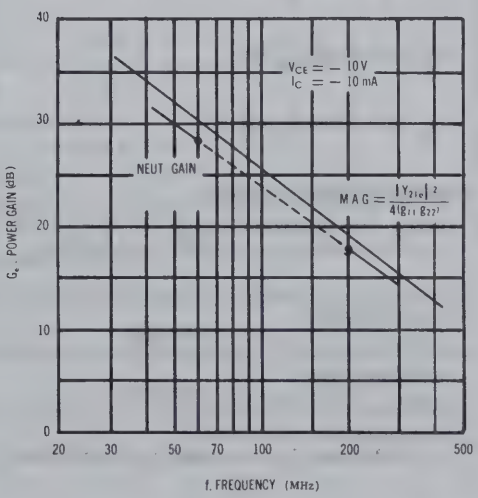
ELECTRICAL CHARACTERISTICS

Characteristic	Sym	Test Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 100 μAdc, I_E = 0	25	45	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 100 μAdc, V_{EB} = 0	25	45	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	I_C = 10 mAdc, I_B = 0	10	20	—	Vdc
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E = 1 mAdc, I_C = 0	0.75	1.5	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 Vdc, I_E = 0	—	0.15	5	μAdc
		V_{CB} = 10 Vdc, I_E = 0, T_A = +55°C	—	—	50	
Emitter Cutoff Current	I_{EBO}	V_{EB} = 0.5 Vdc, I_C = 0	—	1	100	μAdc
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} = 10 Vdc, I_C = 10 mAdc	10	30	100	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 50 mAdc, I_B = 10 mAdc	—	0.15	0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 50 mAdc, I_B = 10 mAdc	—	0.55	1.0	Vdc
Small-Signal Forward Current Transfer Ratio	h_{fe}	I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz	10	35	120	—
Current Gain - Bandwidth Product	f_T	I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz	800	1100	1400	MHz
		I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz	1000	1250	1600	
		I_C = 40 mAdc, V_{CE} = 10 Vdc, f = 100 MHz	700	1200	—	
Collector-Base Time Constant	$r_b' C_c$	V_{CB} = 10 Vdc, I_E = 20 mAdc, f = 31.8 MHz	10	25	40	ps
Real Part of Small-Signal Short Circuit Input Impedance	$Re(h_{ie})$	I_C = 10 mA, V_{CE} = 10 V, f = 1000 MHz	—	45	75	ohms
Collector-Base Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz	—	1.75	2.5	pF
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 60 MHz	26	28	—	dB
		V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 200 MHz	—	16	—	
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 2 Adc, f = 200 MHz R_G = 50 Ω	—	5.5	—	dB

NOISE FIGURE versus FREQUENCY



MAXIMUM AVAILABLE GAIN versus FREQUENCY



2N2944 (SILICON)
2N2945
2N2946

PNP silicon annular transistors designed for low-level, high-speed chopper applications.



CASE 26
(TO-46)

Collector electrically connected to case

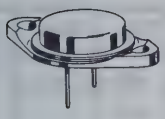
MAXIMUM RATINGS

Rating	Symbol	2N2944	2N2945	2N2946	Unit
Emitter-Collector Voltage	V_{ECO}	10	20	35	Vdc
Collector-Base Voltage	V_{CB}	15	25	40	Vdc
Emitter-Base Voltage	V_{EB}	15	25	40	Vdc
Collector Current	I_C	← 100 →			mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D	← 500 →			mW
Derate above 25°C		← 2.8 →			mW/°C
Total Device Dissipation @ $T_C = 25°C$	P_D	← 2.0 →			Watts
Derate above 25°C		← 11.4 →			mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Cutoff Current		I_{CBO}				nAdc
(V_{CB} = 15 Vdc, I_E = 0)	2N2944		-	-	0.1	
(V_{CB} = 25 Vdc, I_E = 0)	2N2945		-	-	0.2	
(V_{CB} = 40 Vdc, I_E = 0)	2N2946		-	-	0.5	
Emitter Cutoff Current		I_{EBO}				nAdc
(V_{EB} = 15 Vdc, I_C = 0)	2N2944		-	-	0.1	
(V_{EB} = 25 Vdc, I_C = 0)	2N2945		-	-	0.2	
(V_{EB} = 40 Vdc, I_C = 0)	2N2946		-	-	0.5	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)	2N2944		80	180	-	
	2N2945		40	160	-	
	2N2946		30	130	-	
Forward Current Transfer Ratio (inverted connection)		$h_{FE(inv)}$				-
(I_C = 200 μAdc, V_{CE} = 0.5 Vdc)	2N2944		6.0	20	-	
	2N2945		4.0	17	-	
	2N2946		3.0	15	-	
Offset Voltage		$V_{EC(off)}$				mVdc
(I_B = 200 μAdc, I_E = 0)	2N2944		-	0.18	0.3	
	2N2945		-	0.23	0.5	
	2N2946		-	0.27	0.8	
(I_B = 1.0 mAdc, I_E = 0)	2N2944		-	0.4	0.6	
	2N2945		-	0.5	1.0	
	2N2946		-	0.6	2.0	
(I_B = 2.0 mAdc, I_E = 0)	2N2944		-	0.8	1.0	
	2N2945		-	0.9	1.6	
	2N2946		-	1.0	2.5	
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 MHz)	2N2944		10	15	-	
	2N2945		5.0	13	-	
	2N2946		3.0	12	-	
Output Capacitance		C_{ob}				pF
(V_{CB} = 6.0 Vdc, I_E = 0, f = 500 kHz)			-	3.2	10	
Input Capacitance		C_{ib}				pF
(V_{EB} = 6.0 Vdc, I_C = 0, f = 500 kHz)			-	1.9	6.0	
Dynamic On Series Resistance		$r_{ec(on)}$				Ohms
(I_C = 100 μAdc, I_B = 1.0 mAdc, I_E = 0, f = 1.0 kHz)	2N2944		-	4.0	20	
	2N2945		-	4.5	35	
	2N2946		-	5.0	45	

2N2947 (SILICON)
2N2948



NPN silicon annular transistors for power amplifier applications to 100 MHz.

CASE 1
(TO-3)

Collector connected to case

MAXIMUM RATINGS*

Rating	Symbol	2N2947	2N2948	Unit
Collector-Base Voltage	V_{CB}	60	40	Vdc
Collector-Emitter Voltage	V_{CES}	60	40	Vdc
Emitter - Base Voltage	V_{EB}	3	2	Vdc
Collector-Current (continuous)	I_C	1.5		Adc
Base-Current (continuous)	I_B	500		mAdc
Power Input (Nominal)	P_{in}	5.0		Watts
Power Output (Nominal)	P_{out}	20.0		Watts
Total Device Dissipation @ 25°C Case Temperature	P_D	25.0		Watts
Derating Factor above 25°C		167		mW/°C
Junction Temperature	T_J	175		°C
Storage Temperature Range	T_{stg}	-65 to + 175		°C

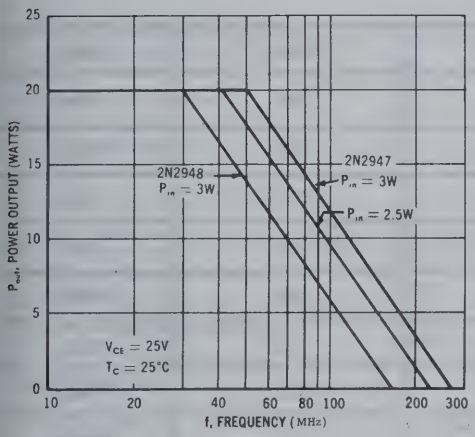
*The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See electrical characteristics.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

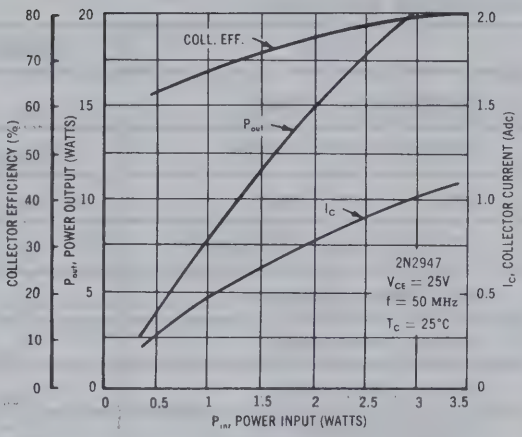
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage*	$V_{CES(sus)}$	2N2947: I_C = 0.250 A, R_{BE} = 0	90	120	--	Volts
		2N2948: I_C = 0.250A, R_{BE} = 0	80	100	--	
Collector-Emitter-Open Base Sustain Voltage*	$V_{CEO(sus)}$	2N2947: I_C = 0.250A, I_B = 0	40	--	--	Volts
		2N2948: I_C = 0.250A, I_B = 0	20	--	--	
Collector-Emitter Current	I_{CES}	2N2947: V_{CE} = 60 Vdc, V_{BE} = 0	--	--	0.5	mAdc
		V_{CE} = 50 Vdc, V_{BE} = 0, T_C = 175°C	--	--	1.0	
		2N2948: V_{CE} = 40 Vdc, V_{BE} = 0	--	--	0.5	
		V_{CE} = 30 Vdc, V_{BE} = 0, T_C = 175°C	--	--	1.0	
Collector Cutoff Current	I_{CBO}	2N2947: V_{CB} = 50 Vdc, I_E = 0	--	--	1	μAdc
		2N2948: V_{CB} = 30 Vdc, I_E = 0	--	--	1	
Emitter Cutoff Current	I_{EBO}	2N2947: V_{EB} = 3 Vdc, I_C = 0	--	--	100	μAdc
		2N2948: V_{EB} = 2 Vdc, I_C = 0	--	--	100	
DC Current Gain	h_{FE}	2N2947: I_C = 400 mAdc, V_{CE} = 2Vdc	2.5	--	35	
		2N2948: I_C = 400 mAdc, V_{CE} = 2 Vdc	2.5	--	100	
		Both Types: I_C = 1 Adc, V_{CE} = 2 Vdc	2.5	--	--	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 1.0 Adc, I_B = 500 mAdc	--	--	0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 1.0 Adc, I_B = 500 mAdc	--	--	2.0	Vdc
AC Current Gain	$\lvert h_{fe} \rvert$	V_{CE} = 2.0 Vdc, I_C = 400 mAdc, f = 50 MHz	2.0	--	--	
Collector Output Capacitance	C_{ob}	V_{CB} = 25 Vdc, I_E=0, f = 100 kHz	--	--	60	pF
Power Input	P_{in}	P_{out} = 15 W, f = 50 MHz, V_{CE} = 25 Vdc	--	2.0	3.0	Watts
Efficiency	η	$I_{C(max)}$ = 1A 2N2947	60	80	--	%
Power Input	P_{in}	P_{out} = 15 W, f = 30 MHz, V_{CE} = 25 Vdc	--	2.0	3.0	Watts
Efficiency	η	$I_{C(max)}$ = 1.0 A 2N2948	60	70	--	%

* Pulse Measurement: Pulse Width ≤ 100 μs, Duty Cycle = 2.0%.

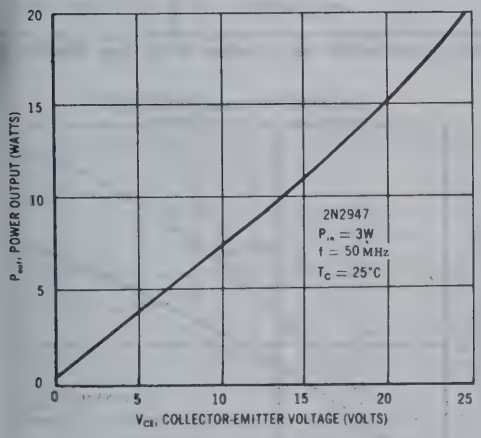
POWER OUTPUT versus FREQUENCY



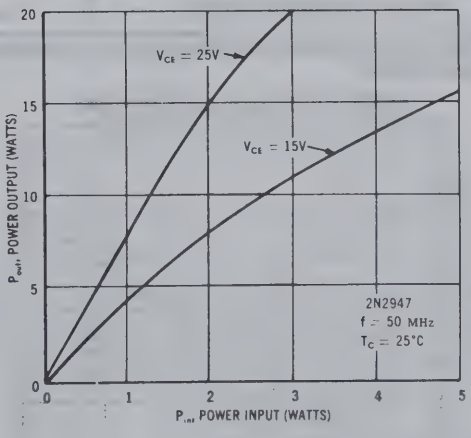
OUTPUT CHARACTERISTICS versus POWER INPUT



POWER OUTPUT versus COLLECTOR VOLTAGE



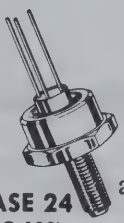
POWER OUTPUT versus POWER INPUT



2N2949 (SILICON)
2N2950



CASE 23
(TO-107)
2N2949



CASE 24
(TO-102)
2N2950

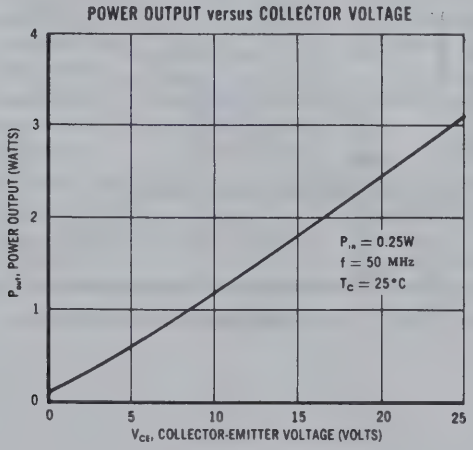
NPN silicon annular transistors for power amplifier and driver applications to 100 MHz.

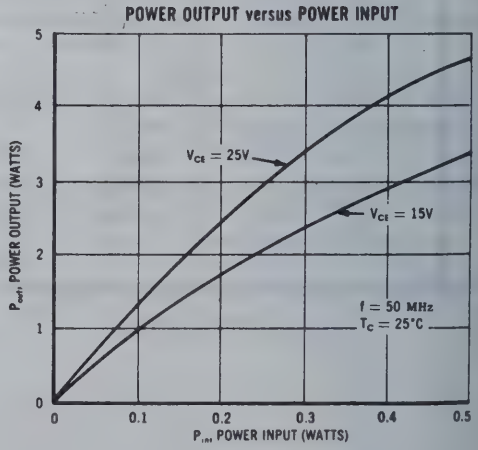
Collector connected to case; stud isolated from case

MAXIMUM RATINGS*

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Emitter Voltage	V_{CES}	60		Vdc
Emitter - Base Voltage	V_{EB}	3.0		Vdc
Collector Current (Continuous)	I_C	0.7		Adc
Base Current (Continuous)	I_B	100		mAdc
RF Input Power (Nom)	P_{in}	1.0		Watt
RF Output Power (Nom)	P_{out}	5.0		Watts
Total Device Dissipation (25°C Case temperature) (Derating Factor above 25°C)	P_D	6.0 40		Watts mW/°C
Total Device Dissipation at 25° Ambient (Derating Factor above 25°C)	P_D	2N2949 0.5 3.33	2N2950 0.7 4.67	Watt mW/°C
Junction Temperature	T_J	175		°C
Storage Temperature Range	T_{stg}	-65 to + 175		°C

* The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See Electrical Characteristics.

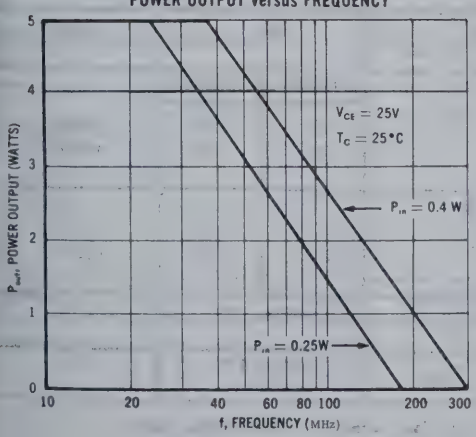


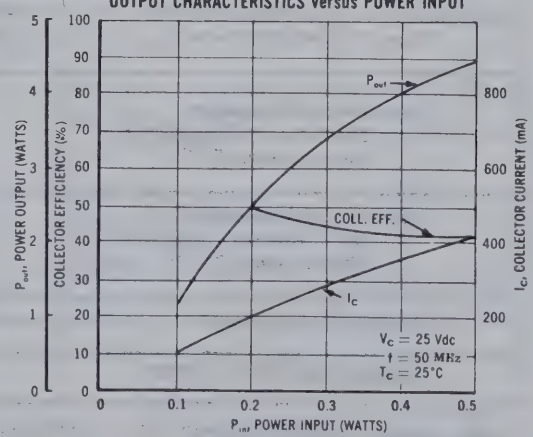


ELECTRICAL CHARACTERISTICS $T_A = 25°C$ unless otherwise noted

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}^*$	I_C=0.250 A, R_{BE}= 0	85	120	--	Volts
Collector Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}^*$	I_C=0.250A, I_B=0	40	--	--	Volts
Collector-Emitter Current	I_{CES}	V_{CE}= 60 Vdc, V_{BE}=0 V_{CE}=50 Vdc, V_{BE}= 0 T_C= +175°C	-- --	-- --	100 500	μAdc
Collector - Cutoff Current	I_{CBO}	V_{CB}=50 Vdc, I_E=0	--	--	0.1	μAdc
Emitter-Cutoff Current	I_{EBO}	V_{EB}= 3 Vdc, I_C=0	--	--	100	μAdc
DC Current Gain	h_{FE}	V_{CE}= 2.0 Vdc I_C= 40 mAdc V_{CE}=2.0 Vdc I_C= 400 mAdc	5.0 5.0	-- --	100 --	-- --
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C= 400 mAdc, I_B= 80 mAdc	--	--	0.5	Vdc
Emitter-Base Saturation Voltage	$V_{BE(sat)}$	I_C=400 mAdc, I_B=80mAdc	--	--	2.0	Vdc
AC Current Gain	$\lvert h_{fe} \rvert$	V_{CE}=2.0 Vdc I_C=40 mAdc, f=50 MHz	2.0	--	--	--
Collector Output Capacitance	C_{ob}	V_{CB}= 25 Vdc, I_E=0 f=100 kHz	--	--	20	pF
Power Input	P_{in}	P_{out}=3.5 watts, f=50 MHz V_{CE}=25 Vdc, $I_{C(max)}$=325 mA	--	--	0.35	Watt
Efficiency	η		43	--	--	%

*Pulse Width ≤ 100 μs, Duty Cycle ≈ 2%





2N2951 (SILICON)
2N2952



CASE 31
(TO-5)
2N2951



CASE 22
(TO-18)
2N2952

NPN silicon annular Star transistors for power amplifier applications to 100 MHz.

Collector connected to case

MAXIMUM RATINGS*

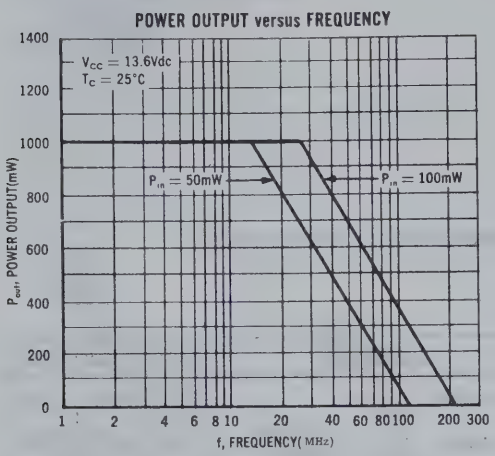
Rating	Symbol	Value		Units
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Emitter Voltage	V_{CES}	60		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current (continuous)	I_C	250		mAdc
Base Current (continuous)	I_B	50		mAdc
Total Device Dissipation (25°C Case Temperature) (Derate above 25°C)	P_D	2N2951 3 20	2N2952 1.8 12	Watts mW/°C
Total Device Dissipation (25°C Ambient Temperature) (Derate above 25°C)	P_D	0.8 5.33	0.5 3.33	mW/°C
Junction Temperature	T_J	-65 to 175		°C
Storage Temperature Range	T_{stg}	-65 to 175		°C

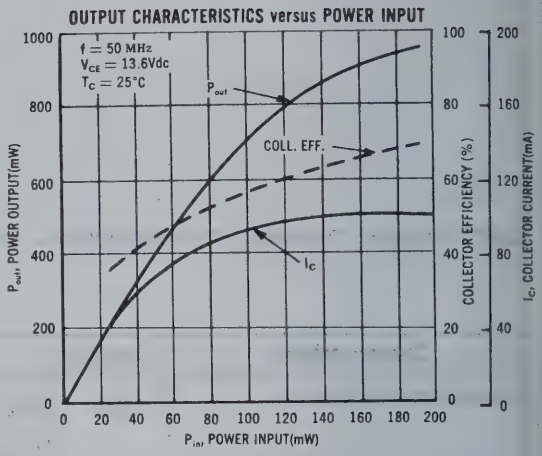
* The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See Electrical Characteristics.

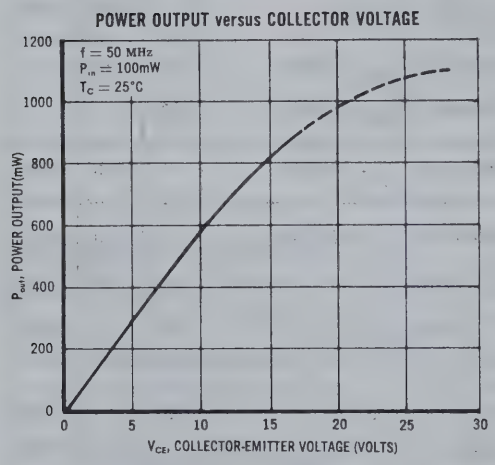
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Max	Unit
Collector-Emitter Current	I_{CES}	V_{CE} = 60Vdc, V_{BE} = 0	--	100	μAdc
		V_{CE} = 50Vdc, V_{BE} = 0, T_C = 175°C	--	500	μAdc
Collector Cutoff Current	I_{CBO}	V_{GB} = 50 Vdc, I_E = 0	--	0.1	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 5 Vdc, I_C = 0	--	100	μAdc
DC Current Gain	h_{FE}	I_C = 10 mAdc, V_{CE} = 10Vdc	20	150	--
		I_C = 150mAdc, V_{CE} = 10 Vdc*	20	--	--
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 150 mAdc, I_B = 15 mAdc	--	0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE}(sat)$	I_C = 150 mAdc, I_B = 15 mAdc	--	2.0	Vdc
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	I_C = 100 mA, R_{BE} = 0	30	--	Volts
Collector-Emitter Open Base Sustain Voltage	$V_{CEO(sus)}$*	I_C = 100 mA, I_B = 0	20	--	Volts
AC Current Gain	$\lvert h_{fe} \rvert$	V_{CE} = 10 Vdc, I_C = 10 mAdc f = 50 MHz	4.0	--	--
Collector Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E=0, f = 100kHz	--	8	pF
Power Input	P_{in}	Test Circuit Fig. 1 P_{out} = 600 mW f = 50 MHz V_{CE} = 13.6 Vdc $I_{C(max)}$ = 125 mA	--	100	mW
Efficiency	η		35	--	%

*Pulse Width = 100 μs, Duty Cycle = 2%







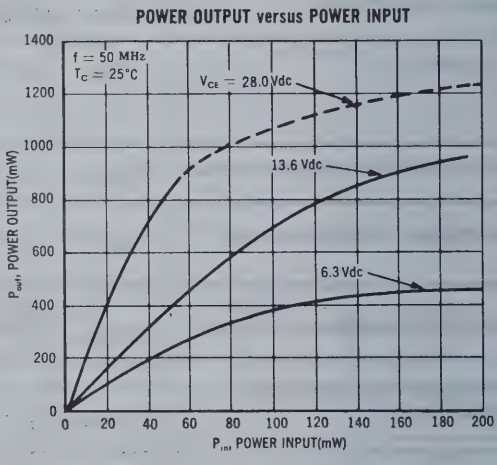
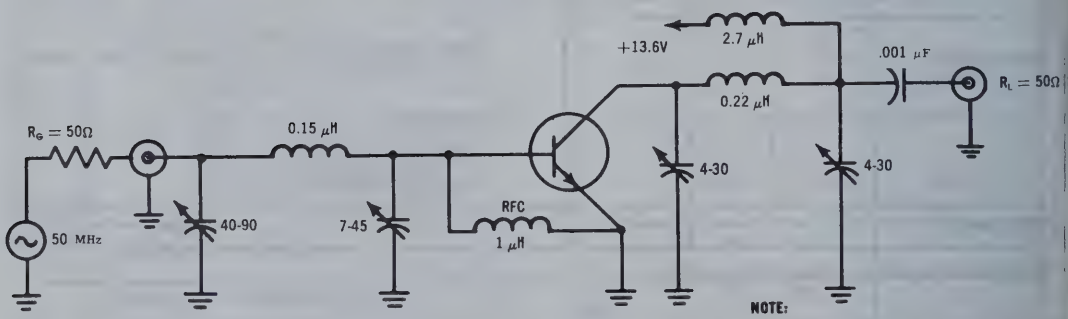
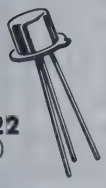


FIGURE 1 — POWER OUTPUT AND POWER GAIN CIRCUIT



NOTE:
GROUND POINT must be kept as close as possible to the transistor emitter lead. Transistor must be mounted with heat sink.

2N2955 (GERMANIUM)
2N2956
2N2957



CASE 22
(TO-18)

PNP germanium epitaxial mesa transistors for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector-Emitter Voltage 2N2955 2N2956 2N2957	V_{CEO}	25 20 18	Vdc
Collector Current	I_C	100	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Total Device Dissipation at 25°C Case Temperature (Derate 4 mW/°C above 25°C)	P_D	300	mW
Total Device Dissipation at 25°C Ambient Temperature (Derate 2 mW/°C above 25°C)	P_D	150	mW

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	40	60	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	3.5	5	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, Emitter-Base Termination - Open) 2N2955 2N2956 2N2957	8	BV_{CEO}	25 20 18	35 28 25	--- --- ---	Vdc
Collector-Emitter Reverse Current (V_{CE} = 25 Vdc, V_{EB} = 0.5 Vdc)		I_{CEX}	---	---	10	μAdc
Base Leakage Current (V_{CE} = 25 Vdc, V_{EB} = 0.5 Vdc)	9	I_{BL}	---	---	10	μAdc

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
On Characteristics							
Forward Current Transfer Ratio			h_{FE}				---
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N2955	1		20	43	---	
	2N2956	2		30	64	---	
	2N2957	3		60	105	---	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N2955			20	43	60	
	2N2956			40	76	120	
	2N2957			100	130	---	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N2956			30	69	---	
	2N2957			60	115	---	
Collector-Emitter Saturation Voltage			$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	2N2955	5		---	0.12	0.20	
	2N2956	6		---	0.12	0.18	
	2N2957	7		---	0.09	0.15	
(I_C = 50 mAdc, I_B = 5 mAdc)	2N2955			---	0.20	0.30	
	2N2956			---	0.16	0.25	
	2N2957			---	0.13	0.20	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2956			---	0.23	0.34	
	2N2957			---	0.18	0.26	
Base-Emitter Voltage		4	V_{BE}				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	2N2955			---	0.38	0.50	
	2N2956			---	0.37	0.47	
	2N2957			---	0.36	0.44	
(I_C = 50 mAdc, I_B = 5 mAdc)	2N2955			---	0.51	0.65	
	2N2956			---	0.48	0.60	
	2N2957			---	0.45	0.55	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2956			---	0.56	0.70	
	2N2957			---	0.52	0.65	
Transient Characteristics							
Output Capacitance		10	C_{ob}				pF
(V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)				---	2.5	4	
Input Capacitance		10	C_{ib}				pF
(V_{BE} = 1 Vdc, I_C = 0, f = 1 MHz)				---	3.3	---	
Small Signal Forward Current			$\lvert h_{fe} \rvert$				---
Transfer Ratio (V_{CE} = 5 Vdc,	2N2955			2	3.5	---	
I_C = 10 mAdc, f = 100 MHz)	2N2956			2.5	3.75	---	
	2N2957			3	4.0	---	
Delay Time		12	t_d				ns
(V_{CC} = 12 Vdc, I_{CS} = 50 mAdc,				---	7	15	
I_{B1} = 5 mAdc, V_{BE} (Off) = 2.2 Vdc)							
Rise Time		12, 13	t_r				ns
(same conditions as t_d)	2N2955			---	25	40	
	2N2956			---	18	30	
	2N2957			---	15	25	
Storage Time		12,16	t_s				ns
(V_{CC} = 12 Vdc, I_{CS} = 50 mAdc,	2N2955			---	28	40	
I_{B1} = 5 mAdc, I_{B2} = 5 mAdc)	2N2956			---	37	55	
	2N2957			---	42	60	
Fall Time		12, 15	t_f				ns
(same conditions as t_s)	2N2955			---	25	40	
	2N2956			---	18	35	
	2N2957			---	18	35	
Total Control Charge		17	Q_T				pc
(I_C = 10 mAdc, I_B = 1 mAdc)	2N2955			---	84	---	
	2N2956			---	88	---	
	2N2957			---	88	---	
Active Region Time Constant		14	τ_A				ns
(I_C = 10 mAdc)				---	2.9	---	

FIGURE 1 — CURRENT GAIN CHARACTERISTICS

2N2955

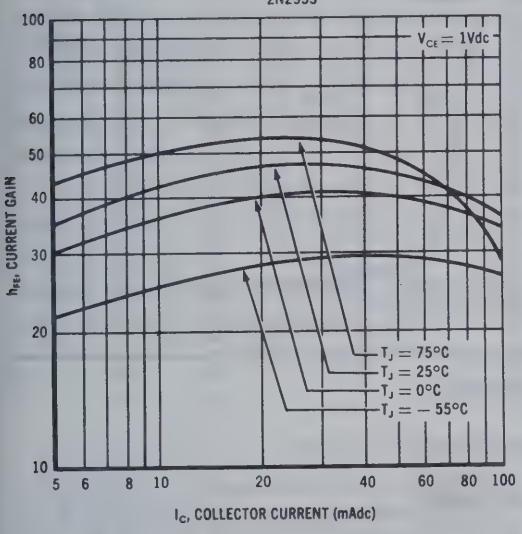


FIGURE 2 — CURRENT GAIN CHARACTERISTICS

2N2956

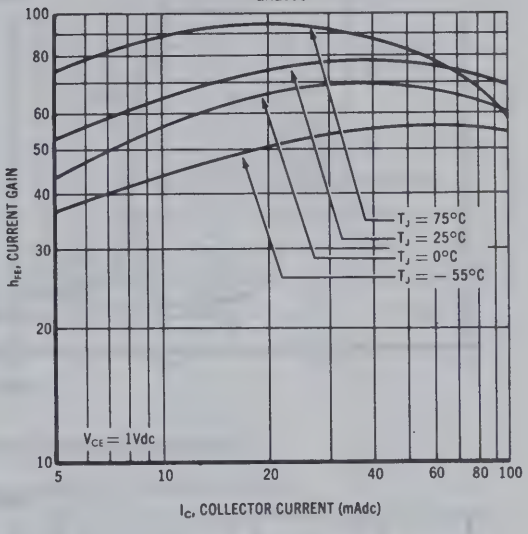


FIGURE 3 — CURRENT GAIN CHARACTERISTICS

2N2957

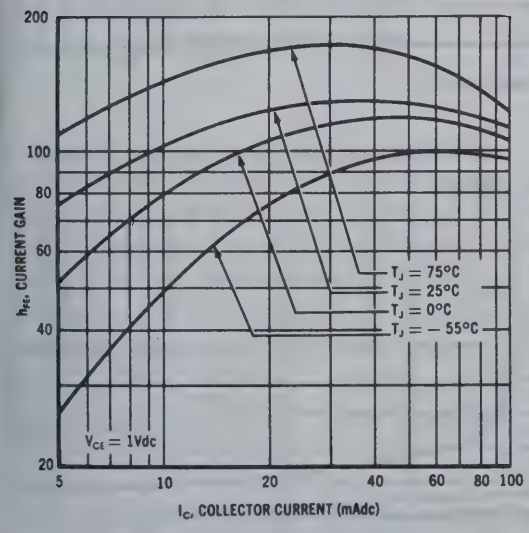
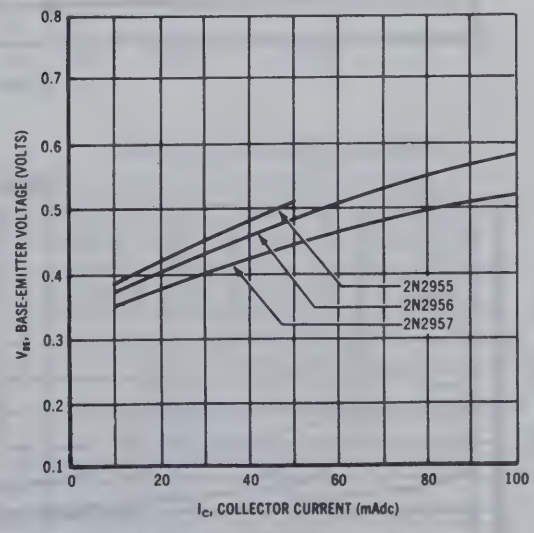


FIGURE 4 — BASE EMITTER VOLTAGE versus COLLECTOR CURRENT



COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT

FIGURE 5 —2N2955

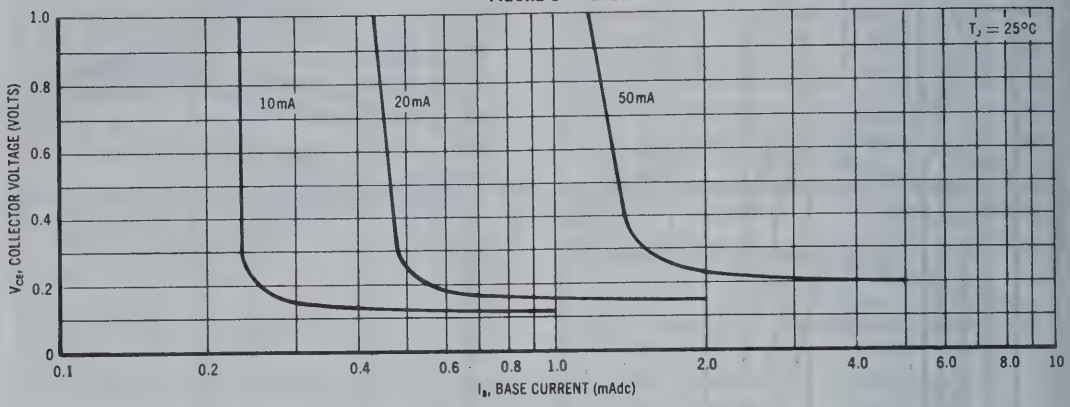


FIGURE 6 —2N2956

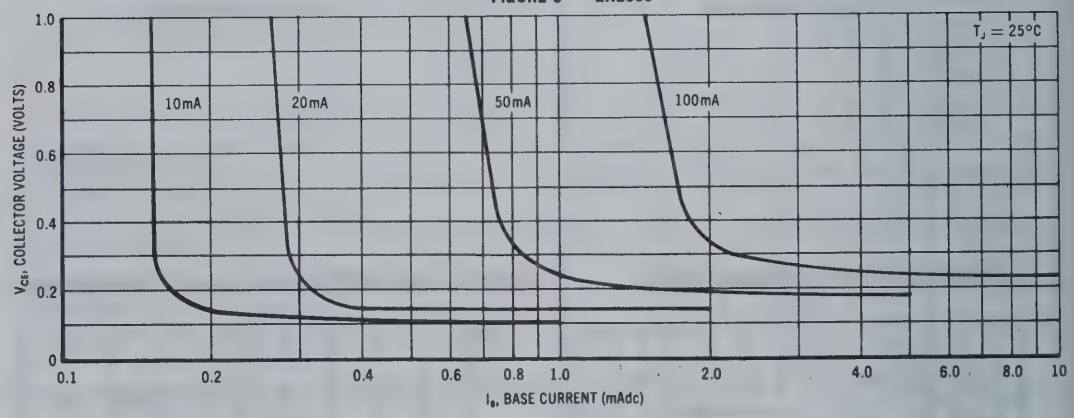


FIGURE 7 —2N2957

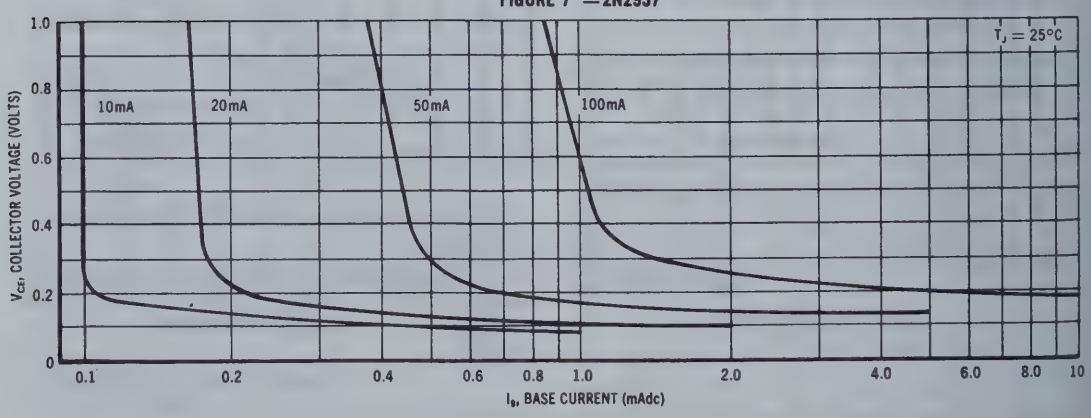
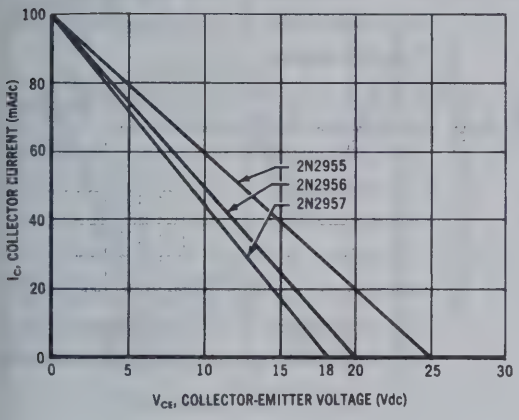
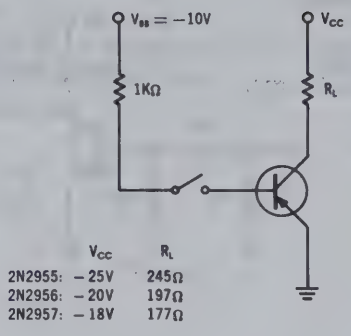


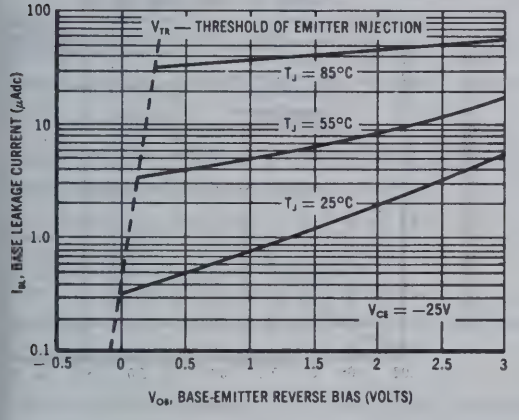
FIGURE 8 — OPEN BASE LOAD LINE RATING & TEST CIRCUIT



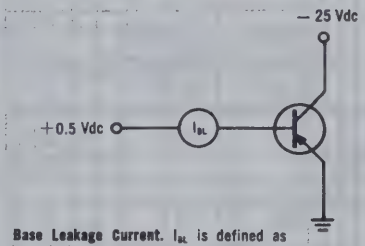


	V_{CC}	R_L
2N2955:	−25V	245Ω
2N2956:	−20V	197Ω
2N2957:	−18V	177Ω

FIGURE 9 — COMMON EMITTER DC LEAKAGE CHARACTERISTICS



BASE LEAKAGE CURRENT TEST CIRCUIT



Base Leakage Current. I_{BL} is defined as base leakage current with both junctions reverse biased. I_C is always less than I_{BL} for $V_{OB} > V_T$. (V_{OB} is off condition base bias, V_T is base voltage at threshold of condition.)

FIGURE 10 — JUNCTION CAPACITANCE versus REVERSE BIAS

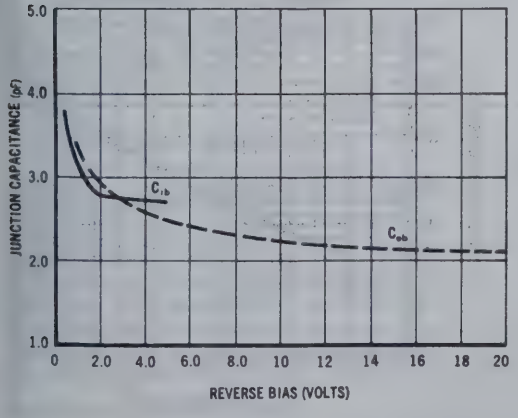


FIGURE 11 — TEMPERATURE COEFFICIENTS

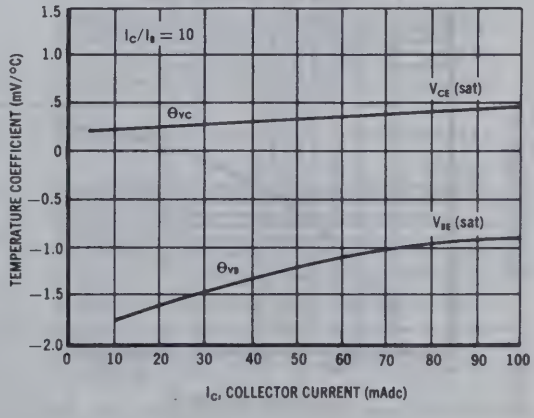


FIGURE 12 — SWITCHING TIME TEST CIRCUIT

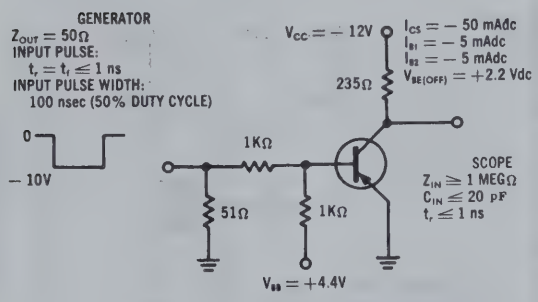


FIGURE 13 — RISE TIME FACTOR

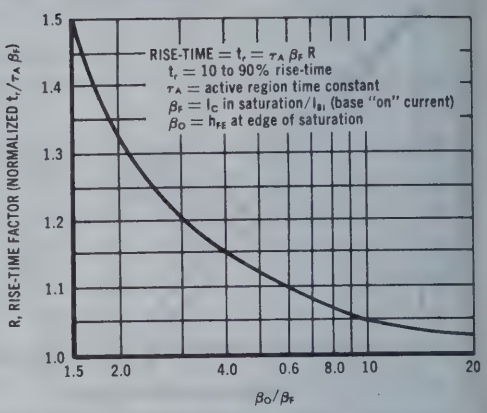


FIGURE 14 — ACTIVE REGION TIME CONSTANT

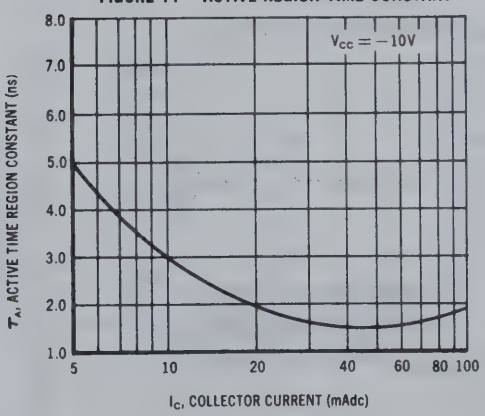


FIGURE 15 — FALL TIME FACTOR

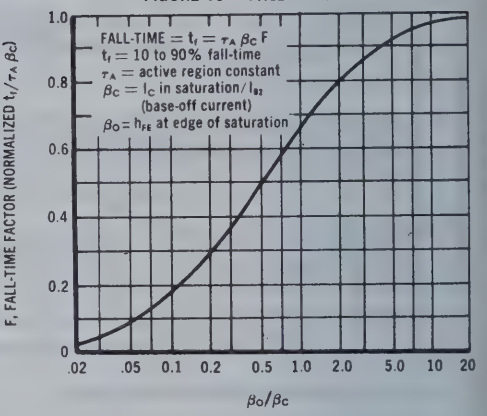


FIGURE 16 — STORAGE TIME

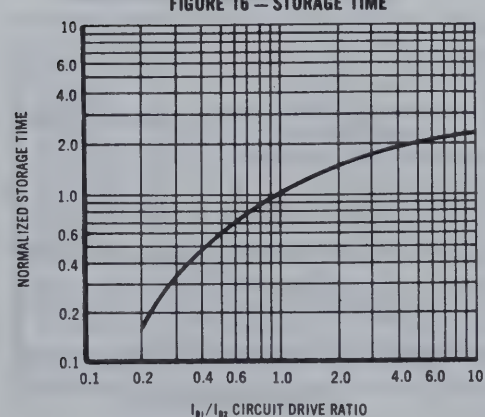
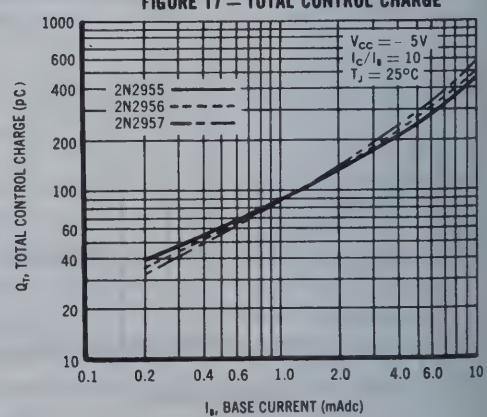
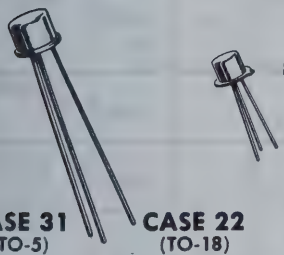


FIGURE 17 — TOTAL CONTROL CHARGE



2N2958 (SILICON)
2N2959
2N3115
2N3116



NPN silicon annular Star transistors for high-speed switching and amplifier applications.

CASE 31 (TO-5) — 2N2958, 2N2959

CASE 22 (TO-18) — 2N3115, 2N3116

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N2958 2N2959 (TO-5)	2N3115 2N3116 (TO-18)	Unit
Collector-Base Voltage	V_{CB}	60	60	Vdc
Collector-Emitter Voltage	V_{CEO}	20	20	Vdc
Emitter-Base Voltage	V_{EB}	5	5	Vdc
Collector-Current	I_C	600	600	mAdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	 3 20	 1.8 12	 Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	 0.6 4.00	 0.4 2.67	 Watts mW/°C
Junction Temperature Range	T_J	-65 to +175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS $T_A = 25°C$ unless otherwise noted

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	--- ---	0.025 15	μ Adc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)	I_{CEX}	---	.050	μ Adc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)	I_{BL}	---	.050	μ Adc
Collector-Base Breakdown Voltage (I_C = 10 μ Adc, I_E = 0)	BV_{CBO}	60	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, pulsed, I_B = 0)	BV_{CEO}*	20	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μ Adc, I_C = 0)	BV_{EBO}	5	---	Vdc
Collector Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE\ (sat)}$*	---	0.5	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE\ (sat)}$*	---	1.3	Vdc
DC Forward Current Transfer Ratio (I_C = 150 mAdc, 2N2958, 2N3115 V_{CE} = 10 Vdc) 2N2959, 2N3116	h_{FE}	40 100	120 300	---
Common-Base Open Circuit Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 100 kHz)	C_{ob}	---	8	pF
Delay Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_d	---	20	ns
Rise Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_r	---	75	ns
Storage Time (V_{CC} = 6 V, I_{CS} = 150 mA, I_{B1} = 15 mA, I_{B2} = 15 mA)	t_s	---	300	ns
Fall Time (V_{CC} = 6 V, I_{CS} = 150 mA, I_{B1} = 15 mA, I_{B2} = 15 mA)	t_f	---	200	ns
Current Gain-Bandwidth Product (I_C = 20 mA, V_{CE} = 20 V, f = 100 MHz)	f_T	250	---	MHz

*PULSE TEST: Pulse width ≤ 300 μs, duty cycle ≤ 2%

2N2972 thru 2N2979

For Specifications, See 2N2913 Data.

2N3009 (SILICON)
2N3013
2N3014

NPN silicon epitaxial switching transistors designed for high-speed, medium-power saturated switching applications



Collector connected to case

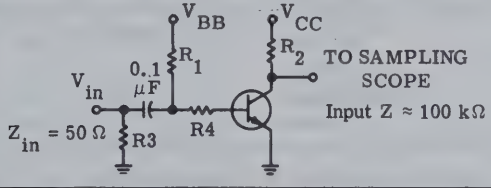
CASE 27
(TO-52)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage* 2N3009, 2N3013 2N3014	V_{CEO}*	15 20	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage 2N3009 2N3013, 2N3014	V_{EB}	4.0 5.0	Vdc
Collector Current — Continuous (10 μs pulse) Peak	I_C	200 500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C @ T_C = 100°C Derate above 25°C	P_D	1.20 0.68 6.85	Watts Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

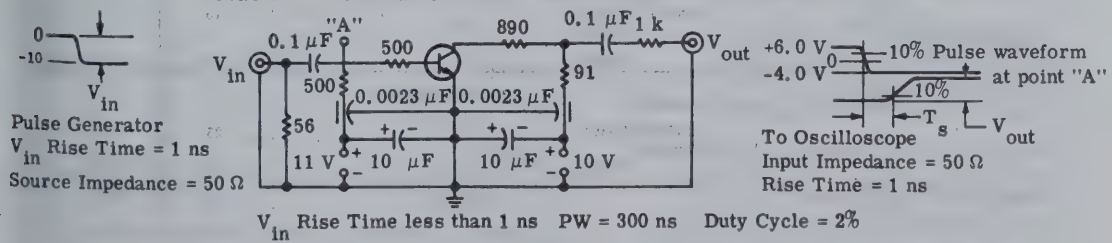
* Applicable from 0.01 mA to 10 mA (Pulsed)

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT



Type	Test	SWITCHING TEST CIRCUIT VALUES							INPUT PULSE		
		V_{in}	V_{BB}	V_{CC}	R_1	R_2	R_3	R_4	t_r	t_f	Pulse Width
		(volts)			(ohms)				(nanoseconds)		
2N3009 2N3013	t_{on} & t_{off}	11	-5.0	15	300	50	75	170	<1.0	<1.0	>100
2N3014	t_{on}	7.0	GND	2.0	100	62	100	2.0 k	<1.0	-	>200
	t_{off}	-13	7.0	2.0							

FIGURE 2 — CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



V_{in} Rise Time less than 1 ns PW = 300 ns Duty Cycle = 2%

2N3009, 2N3013, 2N3014 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	2N3009, 2N3013 2N3014	$BV_{CEO(sus)}$*	15 20	- -	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		BV_{CES}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N3009 2N3013, 2N3014	BV_{EBO}	4.0 5.0	- -	Vdc
Collector-Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	2N3009	I_{CES}	-	0.5	μAdc
(V_{CE} = 20 Vdc, V_{BE} = 0, T_A = +85°C)	2N3009		-	15	
(V_{CE} = 20 Vdc, V_{BE} = 0)	2N3013, 2N3014		-	0.3	
(V_{CE} = 20 Vdc, V_{BE} = 0, T_A = +125°C)	2N3013, 2N3014		-	40	
Base Current (V_{CE} = 20 Vdc, V_{BE} = 0)	2N3009 2N3013, 2N3014	I_B	- -	0.5 0.3	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 30 mAdc, V_{CE} = 0.4 Vdc)	All Types	h_{FE}*	30	120	
(I_C = 10 mAdc, V_{CE} = 0.4 Vdc)	2N3014		25	-	
(I_C = 100 mAdc, V_{CE} = 0.5 Vdc)	2N3009, 2N3013		25	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3014		25	-	
(I_C = 300 mAdc, V_{CE} = 1.0 Vdc)	2N3009, 2N3013		15	-	
(I_C = 30 mAdc, V_{CE} = 0.4 Vdc, T_A = -55°C)	2N3013, 2N3014		12	-	
Collector-Emitter Saturation Voltage* (I_C = 30 mAdc, I_B = 3.0 mAdc)	All Types	$V_{CE(sat)}$*	-	0.18	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3009, 2N3013		-	0.28	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3014		-	0.35	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3009, 2N3013		-	0.50	
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N3014		-	0.18	
(I_C = 30 mAdc, I_B = 3.0 mAdc, T_A = +85°C)	2N3009		-	0.30	
(I_C = 30 mAdc, I_B = 3.0 mAdc, T_A = +125°C)	2N3013, 2N3014		-	0.25	
Base-Emitter Saturation Voltage* (I_C = 30 mAdc, I_B = 3.0 mAdc)	All Types	$V_{BE(sat)}$*	0.75	0.95	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)	All Types		-	1.20	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3009, 2N3013		-	1.70	
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N3014		0.70	0.80	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	350	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	-	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	-	8.0	pF
Turn-On Time (Figure 1) ($V_{EB(off)}$ = 5.0 V, V_{CC} = 15 V, I_C = 300 mAdc, I_{B1} ≈ 30 mAdc)	2N3009, 2N3013	t_{on}	-	15	ns
($V_{EB(off)}$ = 0, V_{CC} = 2.0 V, I_C = 30 mAdc, I_{B1} ≈ 3.0 mAdc)	2N3014		-	16	
Turn-Off Time (Figure 1) (V_{CC} = 15 V, I_C = 300 mAdc, I_{B1} ≈ I_{B2} ≈ 30 mAdc)	2N3009, 2N3013	t_{off}	-	25	ns
(V_{CC} = 2.0 V, I_C = 30 mAdc, I_{B1} ≈ I_{B2} ≈ 3.0 mAdc)	2N3014		-	25	
Charge-Storage Time (Figure 2) (I_C ≈ I_{B1} ≈ I_{B2} ≈ 10 mAdc)		t_s	-	18	ns

* Pulse Test: Pulse Width = 300 μs; Duty Cycle ≤ 2%.

2N3010 (SILICON)



CASE 22
(TO-18)

NPN silicon low-power transistor primarily designed for high-speed, saturated switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage*	V_{CEO}*	6.0	Vdc
Collector-Emitter Voltage	V_{CES}	11	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.30 1.71	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

* Applicable from 0.01 mAdc to 10 mAdc (Pulsed).

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

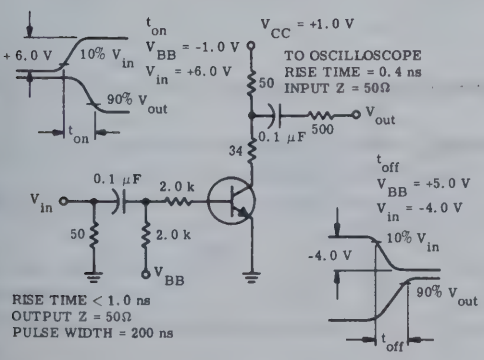
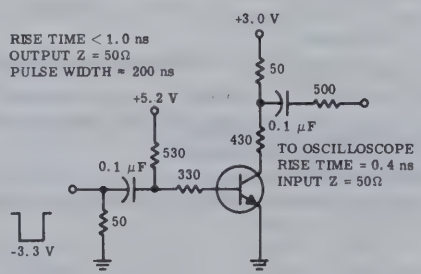


FIGURE 2 — CHARGE-STORAGE TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	6.0	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	11	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CE} = 11 Vdc, V_{BE} = 0)	I_{CES}	-	10	μAdc
(V_{CE} = 5.0 Vdc, V_{BE} = 0)		-	0.1	
(V_{CE} = 5.0 Vdc, V_{BE} = 0, T_A = +85°C)		-	5.0	
Base Cutoff Current (V_{CE} = 11 Vdc, $V_{EB(off)}$ = 0)	I_{BL}	-	10	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 1.0 mAdc, V_{CE} = 0.4 Vdc)	h_{FE}*	15	-	-
(I_C = 10 mAdc, V_{CE} = 0.4 Vdc)		25	125	
(I_C = 30 mAdc, V_{CE} = 0.4 Vdc)		15	-	
Collector-Emitter Saturation Voltage* (I_C = 1.0 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$*	-	0.25	Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		-	0.25	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		-	0.38	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 85°C)		-	0.4	
Base-Emitter Saturation Voltage* (I_C = 1.0 mAdc, I_B = 0.1 mAdc)	$V_{BE(sat)}$*	0.68	0.85	Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.75	0.95	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		-	1.3	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)	f_T	600	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	2.0	pF
Turn-On Time (Figure 1) (V_{CC} = 1.0 Vdc, $V_{BE(off)}$ = 1.0 Vdc, I_C = 10 mAdc, I_{B1} ≈ 2.0 mAdc)	t_{on}	-	12	ns
Turn-Off Time (Figure 1) (V_{CC} = 1.0 Vdc, I_C ≈ 10 mAdc, I_{B1} ≈ I_{B2} ≈ 1.0 mAdc)	t_{off}	-	12	ns
Charge Storage Time (Figure 2) (I_C = I_{B1} ≈ I_{B2} = 5.0 mAdc)	t_s	-	6.0	ns

* Pulse Test: Pulse Length = 300 μs; Duty Cycle ≤ 2.0%.

2N3011 (SILICON)



NPN silicon low-power transistor primarily designed for high-speed, saturated switching applications.

Collector connected to case

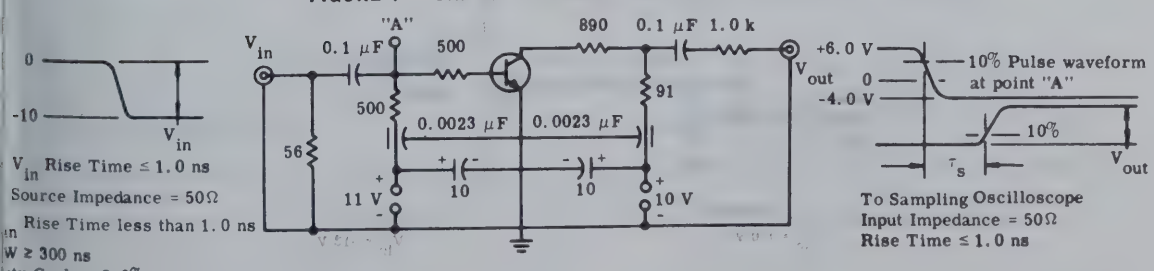
CASE 22
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage*	V_{CEO}*	12	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector-Current-Continuous Peak (10 μs Pulse)	I_C	200 500	mAdc
Total Device Dissipation @ T_A=25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C=25°C T_C=100°C Derate above 25°C	P_D	1.20 0.68 6.85	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

* Applicable from 0.01 mA to 10 mA (Pulsed)

FIGURE 1 — CHARGE-STORAGE TIME TEST CIRCUIT



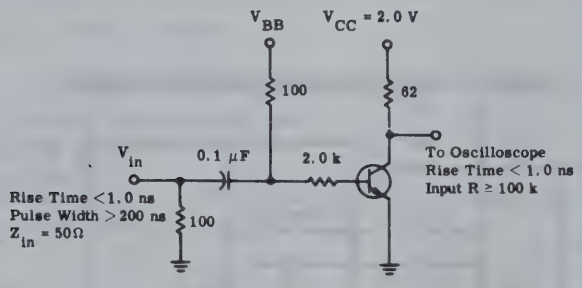
2N3011 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	12	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	30	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0) (V_{CE} = 20 Vdc, V_{BE} = 0, T_A = +85°C)	I_{CES}	- -	0.4 10	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	I_{BL}	-	0.4	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 0.35 Vdc) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}*	30 25 12	120 - -	-
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +85°C)	$V_{CE(sat)}$*	- - - -	0.20 0.25 0.50 0.30	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$*	0.72 - -	0.87 1.15 1.60	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	4.0	pF
Turn-On Time (Figure 2) (V_{CC} = 2.0 Vdc, $V_{EB(off)}$ = 0, I_C ≈ 30 mAdc, I_{B1} ≈ 3.0 mAdc)	t_{on}	-	15	ns
Turn-Off Time (Figure 2) (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} ≈ $-I_{B2}$ ≈ 3.0 mAdc)	t_{off}	-	20	ns
Charge Storage Time (Figure 1) (I_C = I_{B1} ≈ $-I_{B2}$ ≈ 10 mAdc)	t_s	-	13	ns

* Pulse Test: Pulse Length = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



T_{on}: V_{BB} Grounded
V_{in} = 7.0 V

T_{off}: V_{BB} = 7.0 V
V_{in} = -13 V

2N3012 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for use in medium-speed saturated switching applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 12 Vdc @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.15 Vdc @ I_C = 10 mAdc

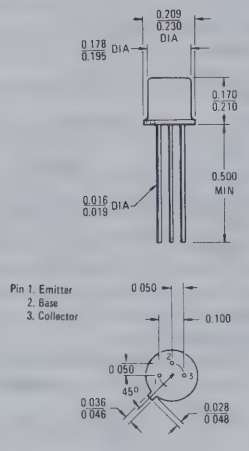
PNP SILICON SWITCHING TRANSISTOR



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



Collector Connected to Case
CASE 22 (1)
TO-18

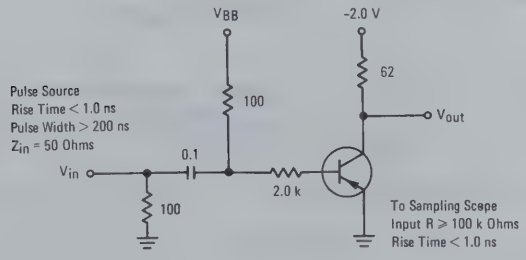
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min*	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0) (Emitter-Base Termination — Open Base)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0)	I_{CES}	—	80	nAdc
(V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = +85°C)		—	5.0	μAdc
Base Current (V_{CE} = 6.0 Vdc, V_{BE} = 0)	I_B	—	30	nAdc
		—		
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	h_{FE}	25	—	—
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc)		30	120	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		20	—	
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.15	Vdc
(I_C = 30 mAdc, I_B = 3.0 mAdc)		—	0.2	
(I_C = 30 mAdc, I_B = 3.0 mAdc, T_A = +85°C)		—	0.4	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.5	
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.78	0.98	Vdc
(I_C = 30 mAdc, I_B = 3.0 mAdc)		0.85	1.2	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	1.7	
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	6.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	—	6.0	pF
Small-Signal Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	4.0	—	—
SWITCHING CHARACTERISTICS (See Figure 1)				
Turn-On Time (V_{CC} = 2.0 Vdc, $I_C \approx$ 30 mAdc, $I_{B1} \approx$ 1.5 mAdc)	t_{on}	—	60	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, $I_C \approx$ 30 mAdc, $I_{B1} = I_{B2} \approx$ 1.5 mAdc)	t_{off}	—	75	ns

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

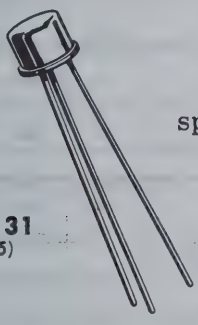


Notes:
(1) Collector Current ≈ 30 mA
(2) Turn On and Turn Off Base Currents ≈ 1.5 mA
(3) t_{on} V_{BB} = +3.0 V V_{in} = -7.0 V
t_{off} V_{BB} = -4.0 V V_{in} = +6.0 V

2N3013
2N3014

For Specifications, See 2N3009 Data.

2N3015 (SILICON)



CASE 31
(TO-5)

Collector connected to case

NPN silicon annular transistor designed for high-speed, medium-power saturated switching applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage*	V_{CEO}*	30	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 4.6	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

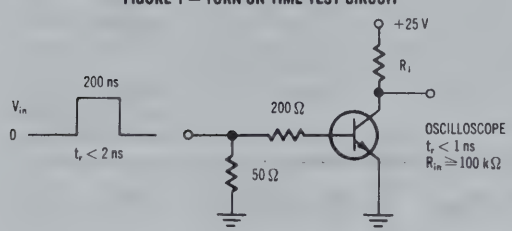
*Applicable from 1.0 mA to 30 mA (Pulsed)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	30	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector-Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	—	0.2	μAdc
Collector-Cutoff Current (V_{CB} = 30 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	—	200	μAdc
Base Leakage Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{BL}	—	0.2	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 300 mAdc, V_{CE} = 0.7 Vdc)	h_{FE}*	30 10	120 —	—
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$*	— —	0.4 1.0	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$*	— —	1.2 1.6	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	8.0	pF
Turn-On Time (Figure 1) (V_{CC} = 25 Vdc, I_C ≈ 300 mAdc, I_{B1} ≈ 30 mAdc) (V_{CC} = 25 Vdc, I_C ≈ 500 mAdc, I_{B1} ≈ 50 mAdc)	t_{on}	— —	40 40	ns
Turn-Off Time (Figure 2) (V_{CC} = 25 Vdc, I_C ≈ 300 mAdc, I_{B1} ≈ I_{B2} = 30 mAdc) (V_{CC} = 25 Vdc, I_C ≈ 500 mAdc, I_{B1} ≈ I_{B2} = 50 mAdc)	t_{off}	— —	60 60	ns

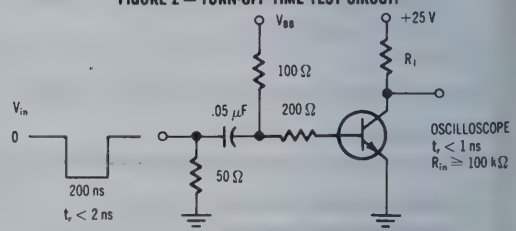
*Pulse Test: Pulse Width = 300 μs; Duty Cycle ≤ 2%

FIGURE 1 — TURN-ON TIME TEST CIRCUIT



I_C mA	V_{in} Volts	R_i ohms
300	7	80
500	11	48

FIGURE 2 — TURN-OFF TIME TEST CIRCUIT



I_C mA	V_{in} Volts	V_{BB} Volts	R_i ohms
300	−13	10	80
500	−21	16	48

2N3019 (SILICON)
2N3020



CASE 31
(TO-5)

Collector connected to case

NPN silicon annular transistors designed for high-current, high-frequency amplifier applications.

MAXIMUM RATINGS

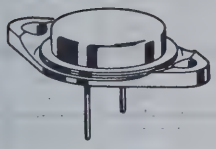
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CB}	140	Vdc
Emitter-Base Voltage	V_{EB}	7	Vdc
Collector Current	I_C	1	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.6	W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5 28.6	W mW/°C
Operating Junction Temperature Range	T_J	-65 to +200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_B = 0)		BV_{CEO}*	80	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	140	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7	–	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0)		I_{CBO}	–	0.010	μAdc
(V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)			–	10	
Emitter Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)		I_{EBO}	–	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N3019	h_{FE}*	50	–	–
	2N3020		30	100	
(I_C = 10 mAc, V_{CE} = 10 Vdc)	2N3019		90	–	
	2N3020		40	120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N3019		100	300	
	2N3020		40	120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc, T_C = -55°C)	2N3019		40	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N3019		50	–	
	2N3020		30	100	
(I_C = 1 Adc, V_{CE} = 10 Vdc)	Both Types		15	–	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$*	–	0.2	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.5	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$*	–	1.1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N3019	f_T	100	–	MHz
	2N3020		80		
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	–	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1 MHz)		C_{ib}	–	60	pF
Small-Signal Current Gain (I_C = 1mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	2N3019	h_{fe}	80	400	–
	2N3020		30	200	
Collector-Base Time Constant (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 4 MHz)		$r'_b C_c$	–	400	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, f = 1 kHz, R_S = 1 kohm)	2N3019	NF	–	4	dB

*Pulse Test: Pulse Width ≤ 300 μs, duty cycle ≤ 1%

2N3021 thru 2N3026 (SILICON)



CASE 1
(TO-3)

PNP silicon power transistors for Class C power amplifiers, high-current core switching and high-speed switching and amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	2N3021 2N3024	2N3022 2N3025	2N3023 2N3026	Unit
Collector-Base Voltage	V_{CB}	30	45	60	Volts
Collector-Emitter Voltage	V_{CEO}	30	45	60	Volts
Emitter-Base Voltage	V_{EB}	4.0			Volts
Collector Current	I_C	3.0			Amp
Base Current	I_B	0.5			Amp
Power Dissipation	P_D	25			Watts
Junction Operating Temperature Range	T_J	-65 to +175			°C

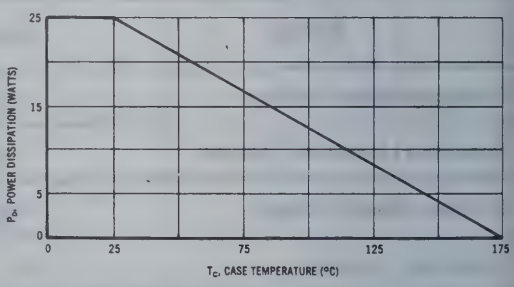
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise specified)

Characteristics		Symbol	Min	Max	Unit
Emitter-Base Cutoff Current (V_{BE} = 4 Vdc)		I_{EBO}	—	1.0	mAdc
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 25 Vdc, V_{BE} = 2 Vdc)	2N3021, 2N3024		—	0.2	
(V_{CE} = 40 Vdc, V_{BE} = 2 Vdc)	2N3022, 2N3025		—	0.2	
(V_{CE} = 54 Vdc, V_{BE} = 2 Vdc)	2N3023, 2N3026		—	0.2	
(V_{CE} = 15 Vdc, V_{BE} = 2 Vdc, T_C = 150°C)	2N3021, 2N3024		—	2.0	
(V_{CE} = 25 Vdc, V_{BE} = 2 Vdc, T_C = 150°C)	2N3022, 2N3025		—	2.0	
(V_{CE} = 35 Vdc, V_{BE} = 2 Vdc, T_C = 150°C)	2N3023, 2N3026		—	2.0	
Collector-Emitter Breakdown Voltage*		BV_{CEO}*			Vdc
(I_C = 100 mAdc, I_B = 0)	2N3021, 2N3024		30	—	
(I_C = 50 mAdc, I_B = 0)	2N3022, 2N3025		45	—	
(I_C = 20 mAdc, I_B = 0)	2N3023, 2N3026		60	—	
DC Current Gain		h_{FE}			—
(I_C = 1.0 Adc, V_{CE} = 2 Vdc)	2N3021, 2N3022, 2N3023		20	60	
	2N3024, 2N3025, 2N3026		50	180	
Collector-Emitter Saturation Voltage		V_{CE} (sat)			Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3021, 2N3022, 2N3023		—	1.5	
	2N3024, 2N3025, 2N3026		—	1.0	
Base-Emitter Saturation Voltage (I_C = 3 Adc, I_B = 0.3 Adc)		V_{BE} (sat)	—	1.5	Vdc
Small Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 15 Vdc, f = 30 MHz)		h_{fe}	2.0	—	—
Switching Times (I_C = 1 Adc, I_{B1} = I_{B2} = 100 mAdc)		$t_d + t_r$	—	100	ns
		t_s	—	325	
		t_f	—	75	

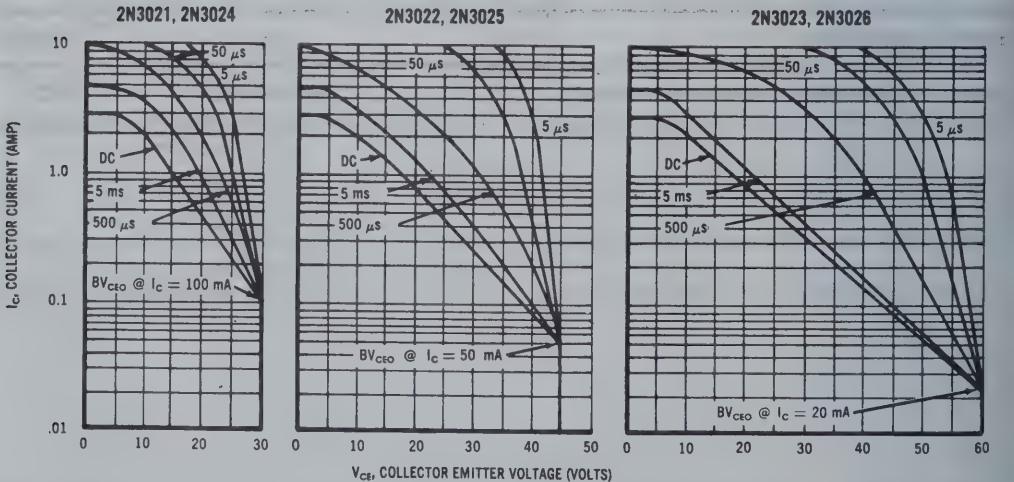
*Perform tests using sweep method to prevent heating.

POWER-TEMPERATURE DERATING CURVE

THESE TRANSISTORS ARE ALSO SUBJECT TO SAFE AREA CURVES AS INDICATED BOTH LIMITS ARE APPLICABLE AND MUST BE OBSERVED



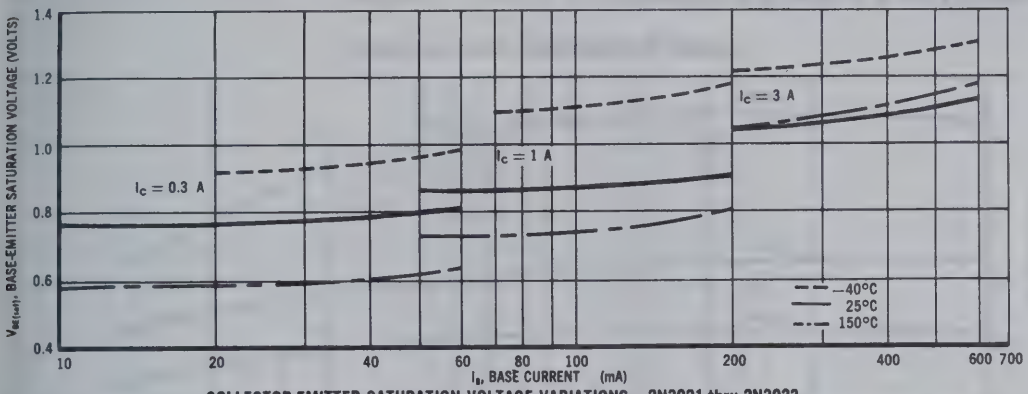
SAFE OPERATING AREAS



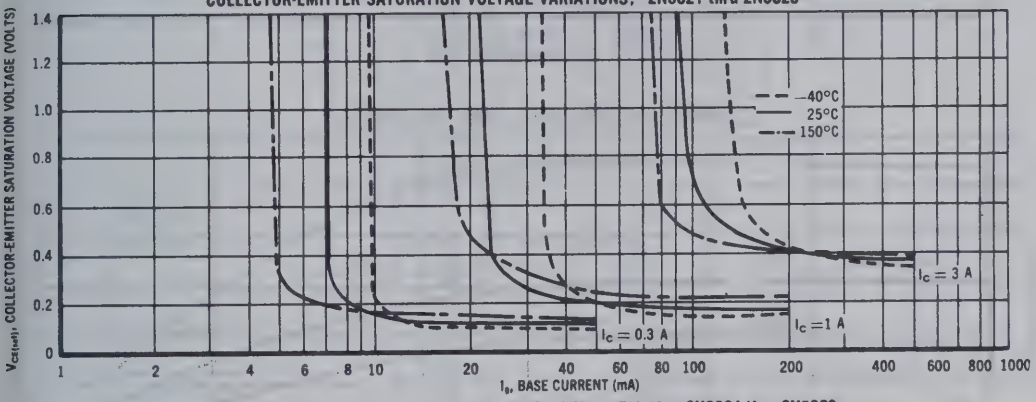
The Safe Operating Area Curves indicate Ic - Vce limits below which the devices will not go into secondary breakdown. As the safe operating areas shown are independent of temperature and duty cycle, these curves can be used as long as the average power derating curve is also taken into consideration to insure operation below the maximum junction temperature.

2N3021 thru 2N3026 (continued)

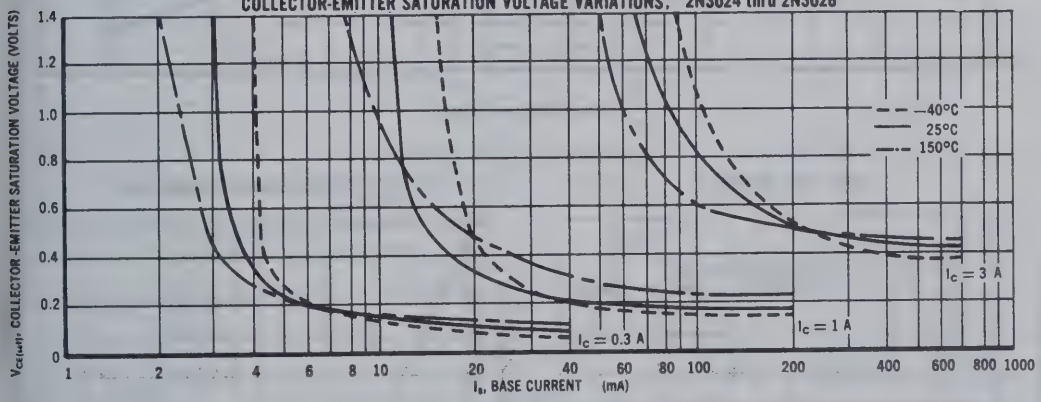
BASE-EMITTER SATURATION VOLTAGE VARIATIONS



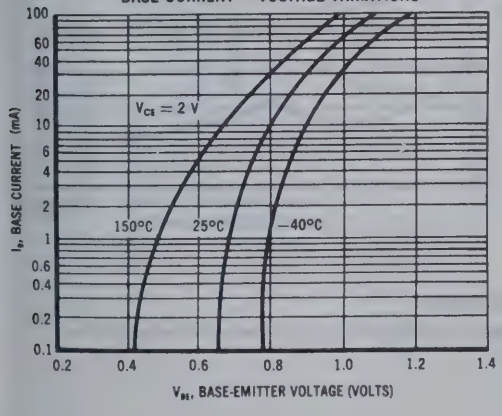
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS, 2N3021 thru 2N3023



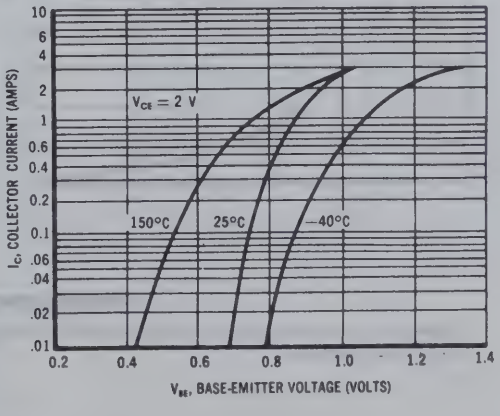
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS, 2N3024 thru 2N3026



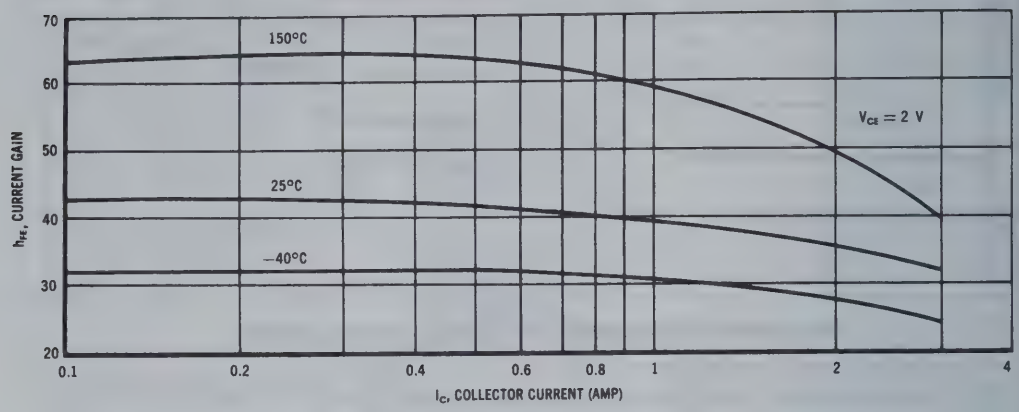
BASE CURRENT — VOLTAGE VARIATIONS



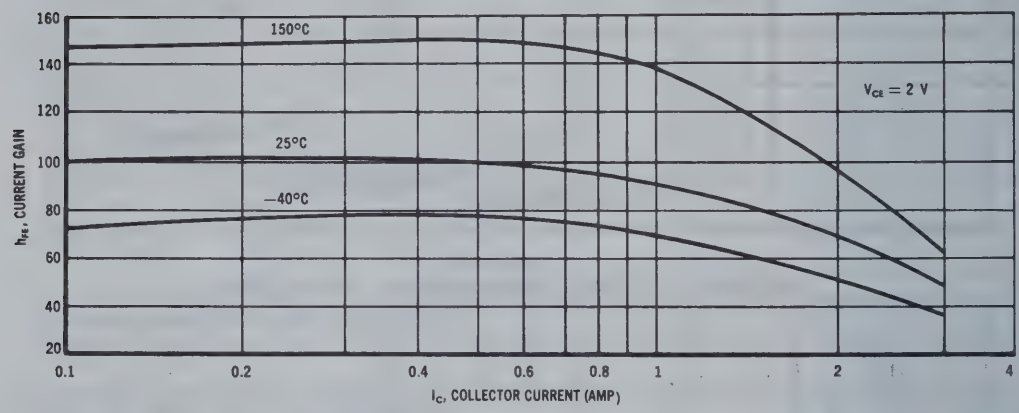
COLLECTOR CURRENT vs BASE-EMITTER VOLTAGE



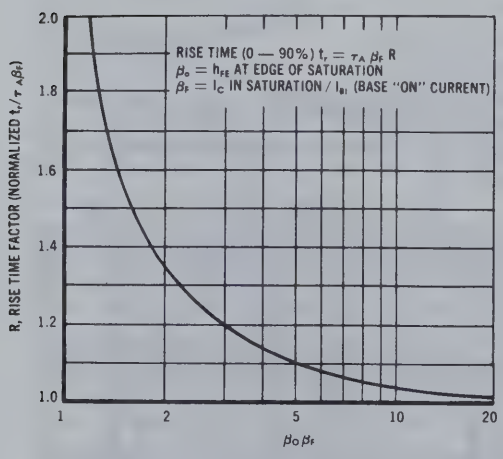
CURRENT GAIN VARIATIONS, 2N3021 thru 2N3023



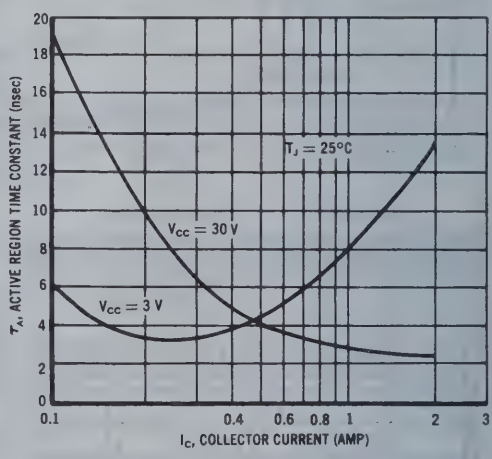
CURRENT GAIN VARIATIONS, 2N3024 thru 2N3026



RISE TIME FACTOR

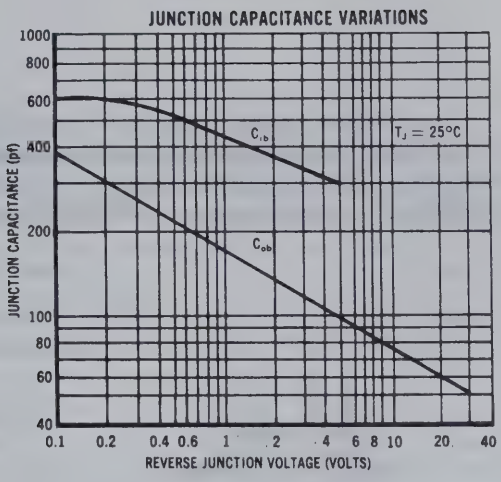


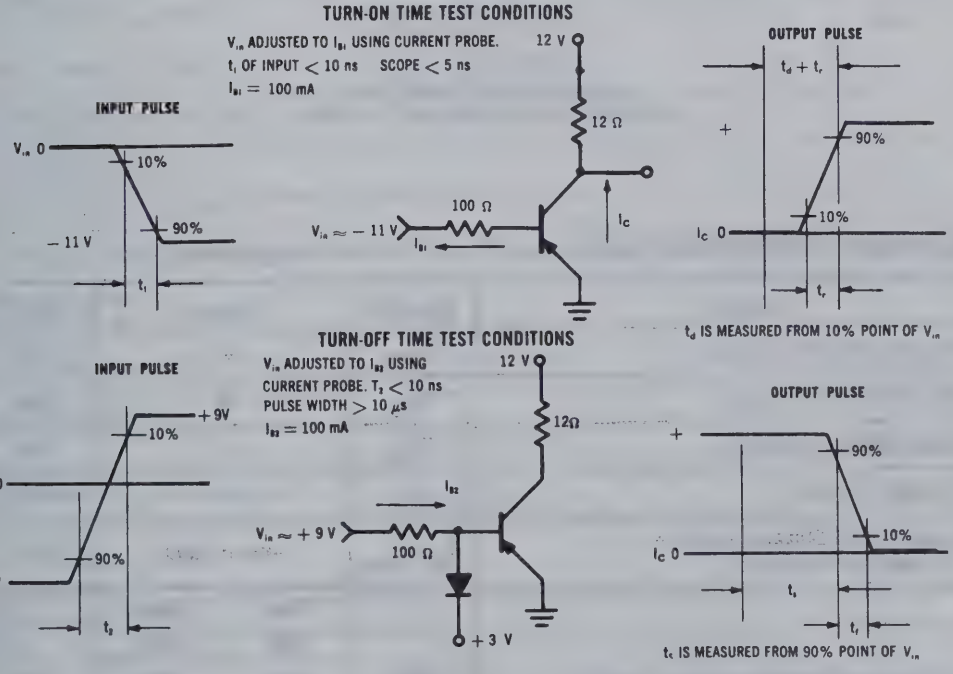
ACTIVE REGION TIME CONSTANT



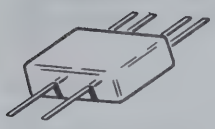
SWITCHING TIME EQUATIONS

Using charge control theory and data given with this transistor, switching times for a wide variety of conditions can be readily computed.


JUNCTION CAPACITANCE VARIATIONS
JUNCTION CAPACITANCE (pf)
1000
800
600
400
200
100
80
60
40
C_{ib}
C_{ob}
$T_J = 25°C$
0.1
0.2
0.4
0.6
1
2
4
6
8
10
20
40
REVERSE JUNCTION VOLTAGE (VOLTS)

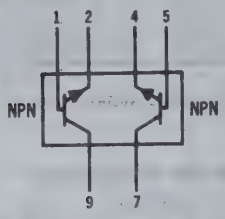

TURN-ON TIME TEST CONDITIONS
V_{in} ADJUSTED TO I_{B1} USING CURRENT PROBE.
t_r OF INPUT < 10 ns SCOPE < 5 ns
I_{B1} = 100 mA
INPUT PULSE
V_{in} 0
10%
90%
− 11 V
t_1
12 V
12 Ω
100 Ω
$V_{in} \approx -11$ V
I_{B1}
I_C
OUTPUT PULSE
$t_d + t_r$
+
90%
10%
I_C 0
t_r
t_d IS MEASURED FROM 10% POINT OF V_{in}
TURN-OFF TIME TEST CONDITIONS
V_{in} ADJUSTED TO I_{B2} USING CURRENT PROBE. T_2 < 10 ns PULSE WIDTH > 10 μs
I_{B2} = 100 mA
INPUT PULSE
+ 9V
10%
V_{in} 0
90%
− 11 V
t_2
12 V
12Ω
I_{B2}
$V_{in} \approx +9$ V
100 Ω
+ 3 V
OUTPUT PULSE
+
90%
10%
I_C 0
t_s
t_f
t_s IS MEASURED FROM 90% POINT OF V_{in}

2N3043 thru 2N3048 (SILICON)



CASE 33
(TO-89)

Dual NPN silicon annular transistors designed for low-level, low-noise differential amplifier applications. Can be used in complementary circuits with 2N3049, 2N3050, for metal can see 2N2639-2N2644 series.



Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CB}	45		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	30		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	250	350	mW
Derate above 25°C		1.43	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	700	1400	mW
Derate above 25°C		4.0	8.0	mW/°C

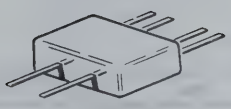
ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	45	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	I_{CBO}	—	0.010	μAdc
(V_{CB} = 45 Vdc, I_E = 0, T_A = +150°C)		—	10	
Emitter-Base Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)	I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 μAdc, V_{CE} = 5 Vdc) 2N3043, 2N3044, 2N3045	h_{FE}*	100	300	—
2N3046, 2N3047, 2N3048		50	200	
(I_C = 1 mAdc, V_{CE} = 5 Vdc) 2N3043, 2N3044, 2N3045		130	—	
2N3046, 2N3047, 2N3048		65	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5 Vdc)	$V_{BE(on)}$	0.6	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)	f_T	30	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	8	pF
Input Impedance (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz) 2N3043, 2N3044, 2N3045	h_{ie}	3.2k	19k	Ohms
2N3046, 2N3047, 2N3048		1.6k	13k	
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz) 2N3043, 2N3044, 2N3045	h_{fe}	130	600	—
2N3046, 2N3047, 2N3048		65	400	
Output Admittance (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz) 2N3043, 2N3044, 2N3045	h_{oe}	—	100	μmhos
2N3046, 2N3047, 2N3048		—	70	
Noise Figure (I_C = 10 μAdc, V_{CE} = 5 Vdc, R_S = 10k ohms, Bandwidth = 10 Hz to 15.7 kHz)	NF	—	5	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio** (I_C = 10 μAdc, V_{CE} = 5 Vdc) 2N3043, 2N3046	h_{FE1}/h_{FE2}**	0.9	1.0	—
2N3044, 2N3047		0.8	1.0	
Base Voltage Differential (I_C = 10 μAdc, V_{CE} = 5 Vdc) 2N3043, 2N3046	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5	mVdc
2N3044, 2N3047		—	10	
Base Voltage Differential Temperature Gradient (I_C = 10 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +125°C) 2N3043, 2N3046	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C
2N3044, 2N3047		—	20	

*Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%

**The lowest h_{FE} reading is taken as h_{FE1} for this test.

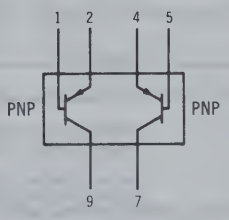
2N3049 (SILICON)
2N3050



Dual PNP silicon annular transistors designed for low-level, low-noise differential amplifier applications. Can be used in complementary circuits with 2N3043 thru 2N3048 series.

CASE 33
(TO-89)

All Leads Electrically Isolated From Case



Pin Connections, Bottom View

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CB}	25		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	100		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	250	350	mW
Derate above 25°C		1.43	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	700	1400	mW
Derate above 25°C		4.0	8.0	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	20	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	0.010	μAdc
(V_{CB} = 25 Vdc, I_E = 0, T_A = +150°C)		—	10	
Emitter-Base Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 μAdc, V_{CE} = 5 Vdc)	h_{FE}*	20	120	—
(I_C = 100 μAdc, V_{CE} = 5 Vdc)		30	120	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)		30	120	
(I_C = 10 mAdc, V_{CE} = 5 Vdc)		30	120	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)		20	—	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.2	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	0.7	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)	f_T	60	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	8	pF
Input Impedance (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	h_{ie}	750k	4500k	Ohms
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	h_{fe}	30	130	—
Output Admittance (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	h_{oe}	—	50	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5 Vdc, R_S = 1k ohm, Bandwidth = 10 Hz to 15.7 kHz)	NF	—	6	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 5 Vdc) 2N3049	h_{FE1}/h_{FE2}**	0.9	1.0	—
2N3050		0.8	1.0	
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 5 Vdc) 2N3049	$\lvert V_{BE1} - V_{BE2}\rvert$	—	5	mVdc
2N3050		—	10	
Base Voltage Differential Temperature Gradient (I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +125°C) 2N3049	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C
2N3050		—	20	

*Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%

**The lowest h_{FE} reading is taken as h_{FE1} for this test.

2N3053 (SILICON)



CASE 31
(TO-5)

NPN silicon annular transistor designed for medium current switching and amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current-Continuous	I_C	700	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5 28.6	Watts mW/°C
Operating Junction Temperature Range	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CEO}	40	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, R_{BE} = 10 ohms)	BV_{CER}	50	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{CEX}	—	0.25	μAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{BL}	—	0.25	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 150 mAdc, V_{CE} = 2.5 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)*	h_{FE}	25 50	— 250	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	1.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	1.7	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	$V_{BE(on)}$	—	1.7	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	—	80	pF

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%

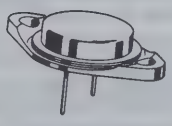
2N3055 (SILICON)

NPN SILICON POWER TRANSISTOR

. . . designed for general-purpose, moderate speed, switching and amplifier applications.

- DC Current Gain — h_{FE} = 20–70 @ I_C = 4.0 Adc
- Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 4.0 Adc
- Excellent Safe Operating Area

15 AMPERE
POWER TRANSISTOR
NPN SILICON
60 VOLTS
115 WATTS



*MAXIMUM RATINGS

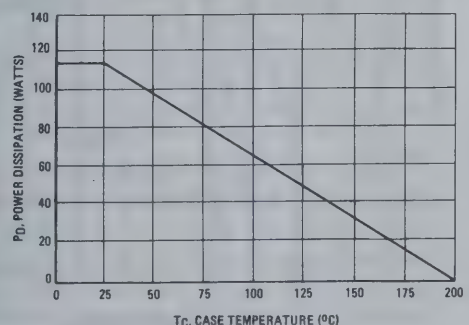
Rating	Symbol	Value	Unit
#Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Emitter Voltage	V_{CER}	70	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	15	Adc
Base Current — Continuous	I_B	7.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	115 0.657	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

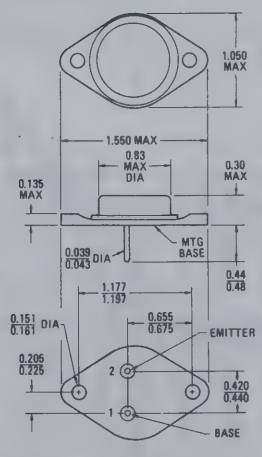
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.52	°C/W

*Indicates JEDEC Registered Data.
#Motorola guarantees this value in addition to JEDEC Registered Data.

FIGURE 1 — POWER TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 9. Both limits are applicable and must be observed.



CASE 11
(TO-3)

Collector Connected to Case

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	–	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, R_{BE} = 100 Ohms)	BV_{CER}	70	–	Vdc
Collector-Emitter Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	0.7	mAdc
Collector Cutoff Current	I_{CEX}			mAdc
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc)		–	5.0	
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)		–	30	
Emitter-Base Cutoff Current (V_{EB} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (Note 1)	h_{FE}			–
(I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)		20	70	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)		5.0	–	
Collector-Emitter Saturation Voltage (Note 1)	$V_{CE(sat)}$			Vdc
(I_C = 4.0 Adc, I_B = 0.4 Adc)		–	1.1	
(I_C = 10 Adc, I_B = 3.3 Adc)		–	8.0	
Base-Emitter Voltage (Note 1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	V_{BE}	–	1.8	Vdc
DYNAMIC CHARACTERISTICS				
Small Signal Current Gain (Note 1) (V_{CE} = 4.0 Vdc, I_C = 1.0 Adc, f = 1.0 kHz)	h_{fe}	15	120	–
Small Signal Current Gain Cutoff Frequency (V_{CE} = 4.0 Vdc, I_C = 1.0 Adc, f = 1.0 kHz)	$f_{\alpha e}$	10	–	kHz

Note 1: Pulse Width ≈ 300 μs, Duty Cycle ≤ 2.0%.

*Indicates JEDEC Registered Data.

FIGURE 2 – BASE CURRENT-VOLTAGE VARIATIONS

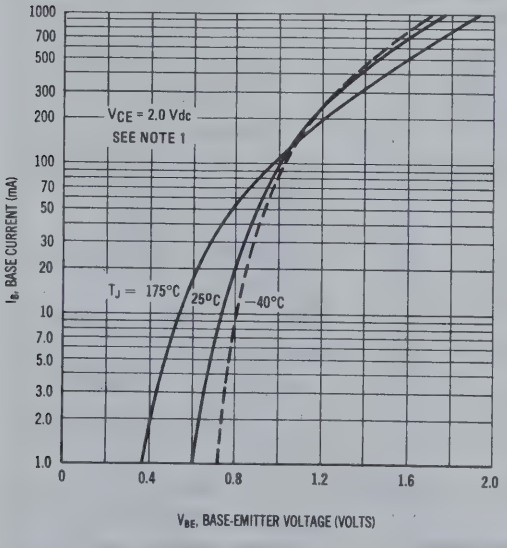
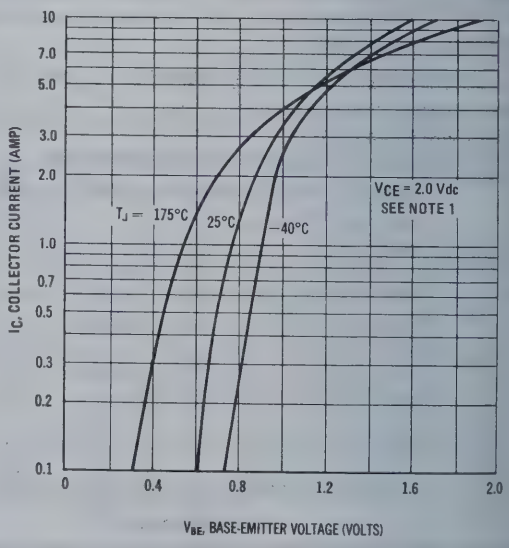


FIGURE 3 – COLLECTOR CURRENT-VOLTAGE VARIATIONS



Note 1. Pulse Test: Pulse Width ≈ 200 μs, Duty Cycle ≈ 1.5%.

FIGURE 4 – COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS

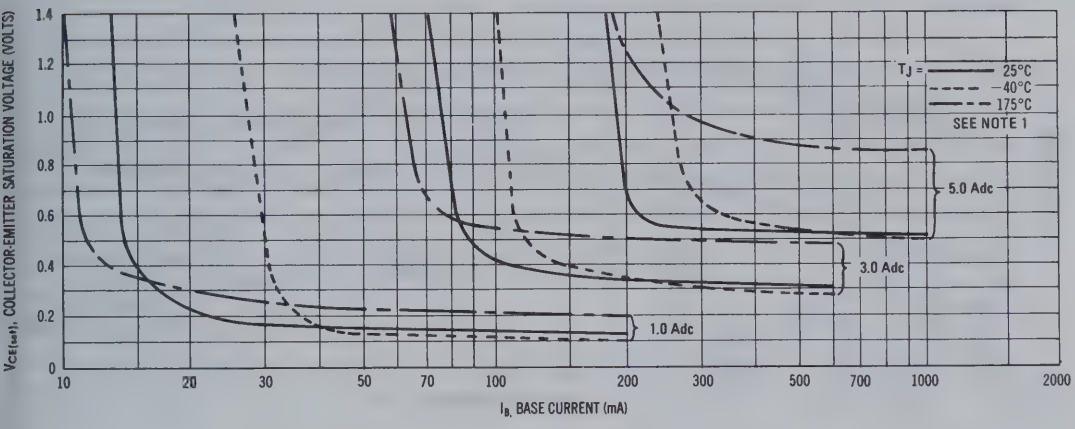


FIGURE 5 – BASE-EMITTER SATURATION VOLTAGE VARIATIONS

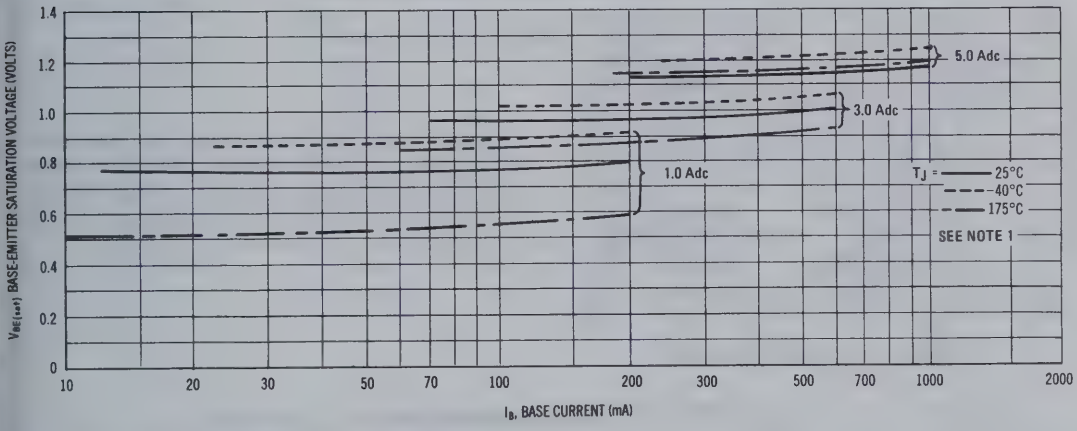


FIGURE 6 – COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

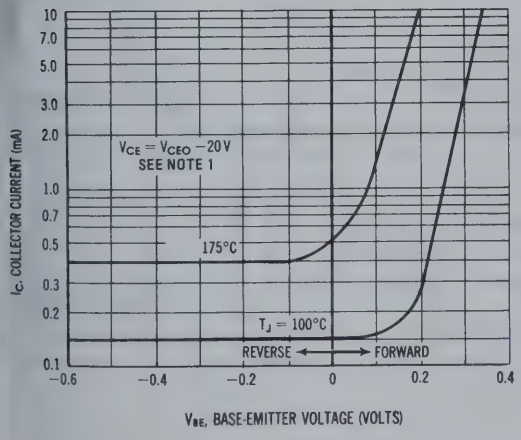


FIGURE 7 – COLLECTOR CURRENT versus BASE-EMITTER RESISTANCE

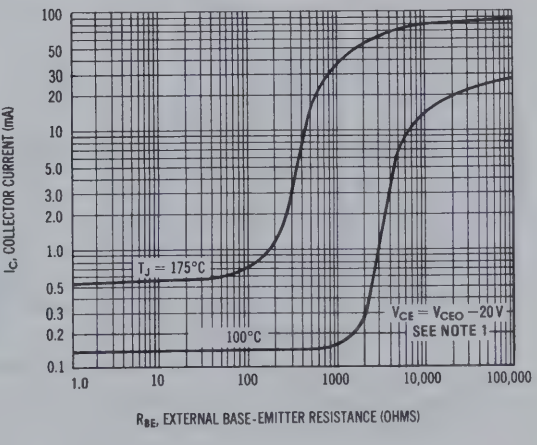


FIGURE 8 – CURRENT GAIN VARIATIONS

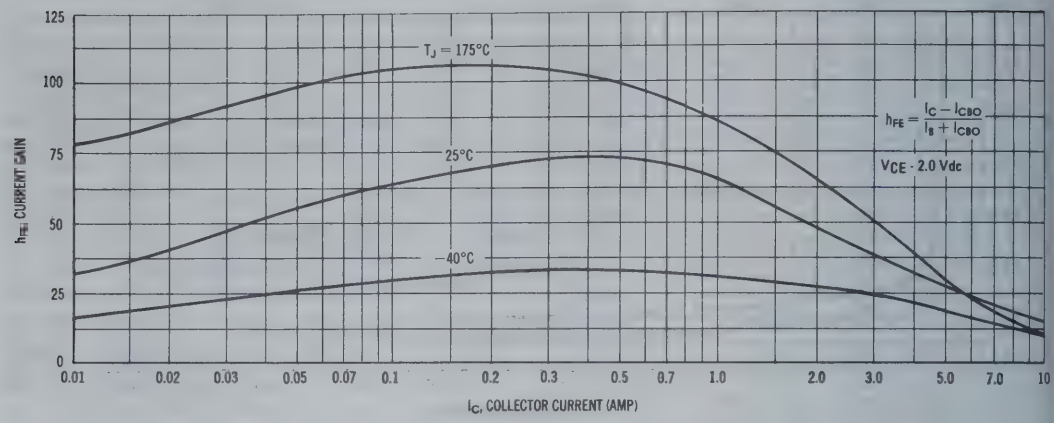
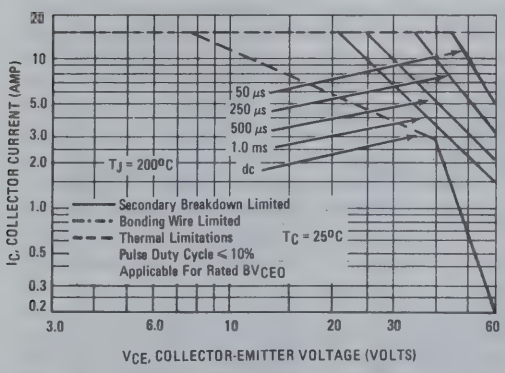
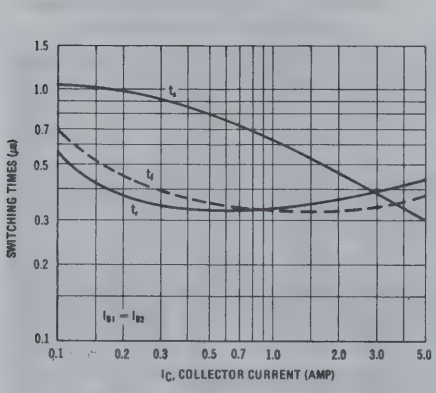


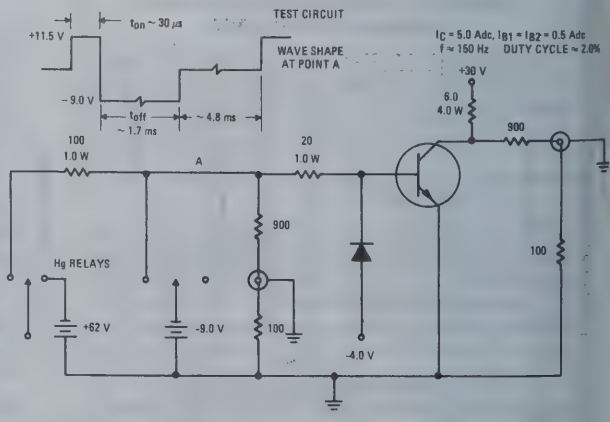
FIGURE 9 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 10 – TYPICAL SWITCHING TIMES





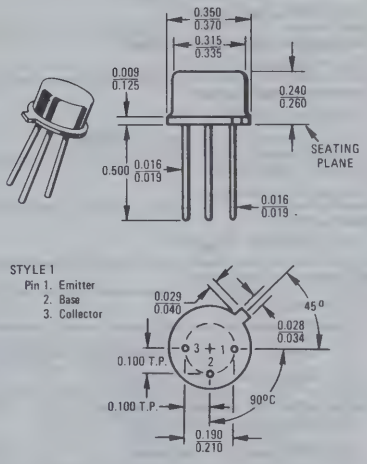
2N3072 (SILICON)
2N3073

PNP SILICON ANNULAR TRANSISTORS

. . . designed for medium-speed, industrial switching applications.

- Choice of Package and Power Ratings
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 50 mAdc
- High Small-Signal Current Gain — h_{fe} = 180 (Max) @ I_C = 10 mAdc

PNP SILICON TRANSISTORS



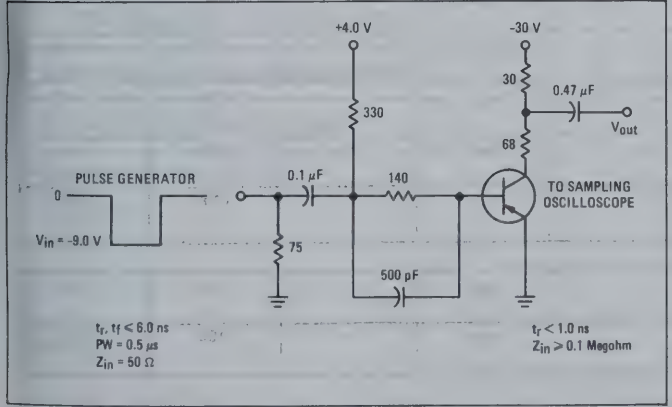
2N3072 CASE 79(1) TO-39

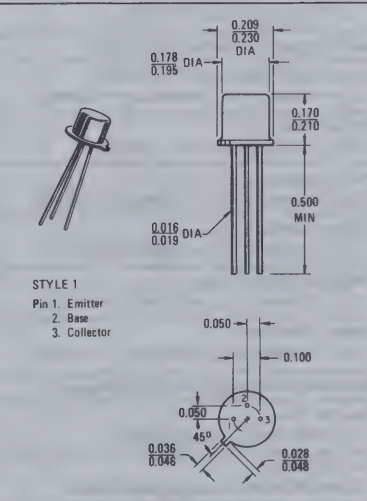
*MAXIMUM RATINGS

Rating	Symbol	2N3072	2N3073	Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 4.56	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.1	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +200		°C

*Indicates JEDEC Registered Data.

FIGURE 1 — TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT





Collector Connected to Case

2N3073 CASE 22(1) TO-18

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	60	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current	I_{CES}			
(V_{CE} = 30 Vdc, V_{BE} = 0)		–	10	nAdc
(V_{CE} = 30 Vdc, V_{BE} = 0, T_A = 125°C)		–	10	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
Base Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_B	–	10	nAdc
ON CHARACTERISTICS				
DC Current Gain(1)	h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		30	130	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		12	–	
(I_C = 300 mAdc, V_{CE} = 2.0 Vdc)		15	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)		–	0.25	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	1.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)		–	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	2.0	
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	–	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	130	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	10	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	–	1.5	k ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	–	26	X 10^{-4}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	25	180	–
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	–	1200	μmhos
SWITCHING CHARACTERISTICS (Figure 1)				
Turn-On Time ($I_C \approx$ 300 mAdc, $I_{B1} \approx$ 30 mAdc)	t_{on}	–	40	ns
Turn-Off Time ($I_C \approx$ 300 mAdc, $I_{B1} \approx I_{B2} \approx$ 30 mAdc)	t_{off}	–	100	ns

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N3114 (SILICON)



NPN silicon annular transistor designed for high-voltage, low-power video amplifier applications.

CASE 31
(TO-5)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	150	Vdc
Collector-Emitter Voltage*	V_{CEO}	150*	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	5 28.6	Watts mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Between 0 and 30 mA.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	150	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_B = 0)	BV_{CEO}*	150	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{CE(sat)}$*	—	1	Vdc
Base-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{BE(sat)}$*	—	0.9	Vdc
DC Current Gain*	h_{FE}*			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)		15	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		30	120	
(I_C = 30 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)		12	—	
Collector Cutoff Current	I_{CBO}			μAdc
(V_{CB} = 100 Vdc, I_E = 0)		—	0.010	
(V_{CB} = 100 Vdc, I_E = 0, T_A = 150°C)		—	10	
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)	I_{EBO}	—	0.10	μAdc
Small Signal Current Gain (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 20 MHz)	$\|h_{fe}\|$	2.0	—	—
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	9	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	—	80	pF
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 5 V, f = 1 kHz)	h_{fe}	25	—	—
Real Part of Input Impedance (I_C = 10 mA, V_{CE} = 10 V, f = 100 MHz)	$Re(h_{ie})$	—	30	ohms

*PW ≤ 300 μsec, Duty Cycle ≤ 1%

2N3115 (SILICON)

2N3116

For Specifications, See 2N2958 Data.

JAN 2N3127 (GERMANIUM)

2N3127



CASE 20
(TO-72)

Active Elements Isolated From Case

PNP germanium mesa transistor designed for industrial and commercial VHF/UHF amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	0.75	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	100 1.33	mW $mW/^oC$
Operating & Storage Junction Temperature	T_J, T_{stg}	-65 to +100	^oC

TABLE I – GROUP A INSPECTION (T_A = 25°C unless otherwise noted) (LTPD applies to JAN 2N3127 only)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 1						
Visual and Mechanical Examination	2071	—	—	—	—	10
SUBGROUP 2						
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	3001 Condition D	BV_{CBO}	25	—	Vdc	5
Collector-Emitter Breakdown Voltage (I_C = 2 mAdc, I_B = 0)	3011 Condition D	BV_{CEO}	20	—	Vdc	
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	3011 Condition C	BV_{CES}	25	—	Vdc	
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036 Condition D	I_{CBO}	—	3	μAdc	
Emitter-Base Cutoff Current (V_{BE} = 0.75 Vdc, I_C = 0)	3061 Condition D	I_{EBO}	—	100	μAdc	
DC Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc)	3076	h_{FE}	20	100	—	
Base-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 1 mAdc)	3066 Condition A	$V_{BE(sat)}$	—	0.6	Vdc	
Collector-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 1 mAdc)	3071	$V_{CE(sat)}$	—	0.3	Vdc	
SUBGROUP 3						
Small-Signal Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	3206	h_{fe}	20	125	—	10
Current-Gain — Bandwidth Product (I_C = 2 mAdc, V_{CE} = 6 Vdc, f = 100 MHz)	3261	f_T	400	—	MHz	
Collector - Base Capacitance* (V_{CB} = 10 Vdc, I_E = 0, f ≥ 0.1 ≤ 1.0 MHz)	3236	C_{cb}*	—	1.2	pF	
SUBGROUP 4						
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0, T_A = 85°C)	3036 Condition D	I_{CBO}	—	50	μAdc	10
DC Current Gain ‡ (I_C = 3 mAdc, V_{CE} = 10 Vdc, T_A = $-55\,^{+0}_{-3}$ °C)	3076	h_{FE}‡	7	—	—	
SUBGROUP 5						
Power Gain (Figure 1) (I_C = 3 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 200 MHz)	3256	G_{pe}	17	25	dB	15
Noise Figure (Figure 1) (I_C = 3 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 200 MHz)	3246	NF	—	5	dB	

STANDARD UNIT ONLY

Collector-Base Time Constant (Figure 2) (I_C = 3 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	r'_bC_c	1	12	ps	—

* Measured in a guarded circuit, such that the can capacitance is not included.

‡ Applies to JAN unit only.

TABLE II – GROUP B INSPECTION – JAN 2N3127 only (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 1						
Physical Dimensions	2066	—	—	—	—	20
SUBGROUP 2						
Solderability (Omit aging)	2026	—	—	—	—	15
Temperature Cycling (T_{high} = 100 $^{+3}_{-0}$ °C)	1051 Condition B	—	—	—	—	
Thermal Shock (Glass Strain)	1056 Condition A	—	—	—	—	
Seal (Leak Rate)**	** Condition C, Procedure IIIa. Condition B for Gross Leaks	—	—	10^{-7}	atm cc/s	
Moisture Resistance	1021	—	—	—	—	
End-Point Tests: (Subgroups 2, 3)						
Collector-Base Cutoff Current (V_{CB} = 10 Vdc)	3036 Condition D	I_{CBO}	—	3	μAdc	
DC Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc)	3076	h_{FE}	20	100	—	
SUBGROUP 3						
Shock (Non-operating; 1500 G; 5 blows of 0.5 ms each in Orientations X_1, Y_1, Y_2, and Z_1) (total = 20 blows)	2016	—	—	—	—	15
Vibration Fatigue (Non-operating; 20G)	2046	—	—	—	—	
Vibration, Variable Frequency	2056	—	—	—	—	
Constant Acceleration (Centrifugal) (20,000G, Orientations X_1, Y_1, Y_2, and Z_1)	2006	—	—	—	—	
End-Point Tests: Same as Subgroup 2						
SUBGROUP 4						
Lead Fatigue	2036 Condition E	—	—	—	—	15
SUBGROUP 5						
High-Temperature Life (Non-operating) (T_{stg} = 100°C)	1031	—	—	—	—	λ = 15
End-Point Tests: (Subgroups 5, 6)						
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036 Condition D	I_{CBO}	—	6	μAdc	
DC Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc)	3076	h_{FE}	17	125	—	
SUBGROUP 6						
Steady State Operation Life (I_C = 10 mAdc, V_{CB} = 10 Vdc)	1026	—	—	—	—	λ = 15
End-Point Tests: Same as Subgroup 5						

**Per Method 112 of MIL-STD-202

TABLE III – GROUP C INSPECTION‡ – JAN 2N3127 only (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Limits		Unit	LTPD
			Min	Max		
SUBGROUP 1						
Collector-Base Time Constant (Figure 2) (I_C = 3 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)		r'_bC_c	—	12	ps	20
Salt Atmosphere (Corrosion)	1041	—	—	—	—	
End-Point Tests:						
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036 Condition D	I_{CBO}	-	3	μAdc	
DC Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc)	3076	h_{FE}	20	100	—	
SUBGROUP 3						
Output Conductance (I_C = 2 mAdc, V_{CE} = 6 Vdc, f = 30 MHz)	3216	$Re(h_{oe})$	1.0	3.5	mmhos	10
Input Conductance (I_C = 2 mAdc, V_{CE} = 6 Vdc, f = 30 MHz)	3221	$Re(y_{ie})$	1.25	5.0	mmhos	

‡ Group C tests shall be performed on the initial lot and every six months thereafter.

FIGURE 1 – TEST CIRCUIT FOR POWER GAIN AND NOISE FIGURE

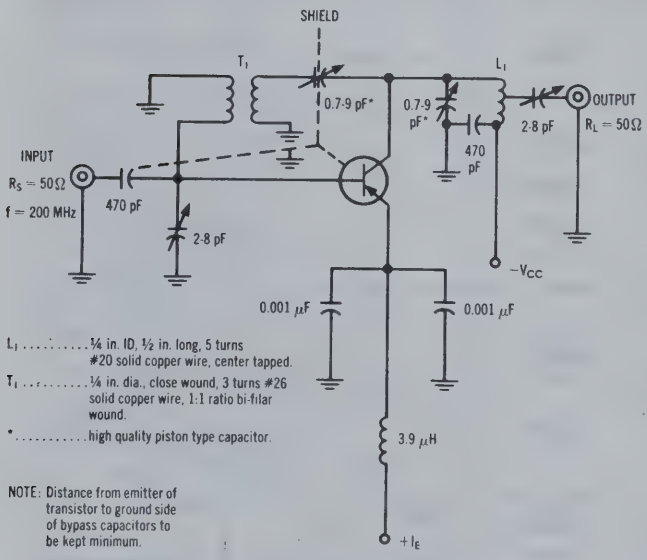
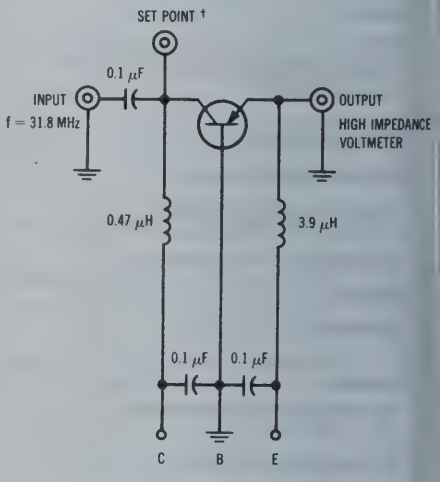


FIGURE 2 – TEST CIRCUIT FOR COLLECTOR-BASE TIME CONSTANT



† NOTE: E_{in} = 0.5 V measured at set point.
$r_bC_c = E_{out}$ (in mV) × 10

2N3133 thru 2N3136 (SILICON)





PNP silicon annular Star transistors for high-speed switching and DC to UHF amplifier applications.

CASE 31 (TO-5)
2N3133
2N3134

CASE 22 (TO-18)
2N3135
2N3136

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N3133 2N3134 (TO-5)	2N3135 2N3136 (TO-18)	Unit
Collector-Base Voltage	V_{CB}	50	50	Vdc
Collector-Emitter Voltage	V_{CEO}	35	35	Vdc
Emitter-Base Voltage	V_{EB}	4	4	Vdc
Collector Current	I_C	600	600	mA
Total Device Dissipation @25°C Case Temperature Derate Above 25°C	P_D	3 17.3	1.8 10.3	Watts mW/°C
Total Device Dissipation @25°C Ambient Temperature Derate Above 25°C	P_D	0.6 3.43	0.4 2.28	Watts mW/°C
Junction Temperature	T_J	-65 to +200		°C
Storage Temperature	T_{stg}	-65 to +200		°C

SWITCHING CHARACTERISTICS (At 25°C unless otherwise noted)

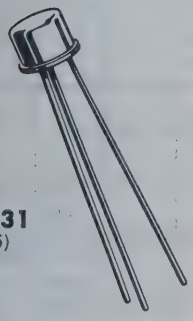
Characteristic	Symbol	Typ	Max	Unit
Turn-On Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_{on}	26	75	ns
Turn-Off Time (V_{CC} = 6V, I_{CS} = 150 mA, I_{B1} = I_{B2} = 15 mA)	t_{off}	70	150	ns

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	--- ---	0.05 30	μAdc
Collector Cutoff Current (V_{CE} = 30 V, V_{BE} = 0.5 V)		I_{CEX}	---	0.1	μAdc
Base Cutoff Current (V_{CE} = 30 V, V_{BE} = 0.5 V)		I_{BL}	---	0.1	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	50	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	35	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4	---	Vdc
Collector Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE\ (sat)}$*	---	0.6	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE\ (sat)}$*	---	1.5	Vdc
DC Forward Current Transfer Ratio		h_{FE}			---
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N3133, 2N3135		25	---	
	2N3134, 2N3136		50	---	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*	2N3133, 2N3135		40	120	
	2N3134, 2N3136		100	300	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	---	10	pF
Input Capacitance (V_{BE} = 2 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	---	40	pF
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	---	MHz

*Pulse Test: Pulse Width ≤ 300 μs, duty cycle ≤ 2%

2N3137 (SILICON)
MM1803



CASE 31
(TO-5)

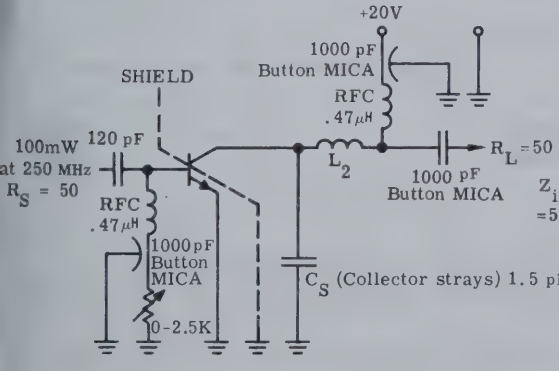
NPN silicon annular transistors for large signal VHF and UHF applications.

Collector connected to case

MAXIMUM RATINGS

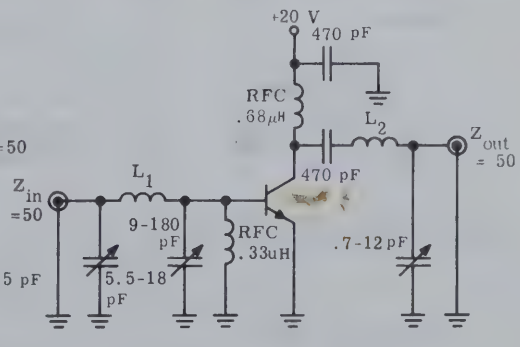
Rating	Symbol	2N3137	MM1803	Units
Collector-Base Voltage	V_{CB}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	20	25	Vdc
Emitter-Base Voltage	V_{EB}	4	5	Vdc
Collector Current (Continuous)	I_C	150	150	mAdc
Power Dissipation @25°C Case Temperature @25°C Ambient Temperature	P_D	2.0 0.8		Watts
Operating Junction Temperature Storage Temperature Range	T_J, T_{stg}	-65 to +200		°C
Thermal Resistance Junction to Case	θ_{JC}	87.5		°C/ Watt
Thermal Resistance Junction to Ambient	θ_{JA}	153		°C/ Watt

250 MHz POWER GAIN TEST CIRCUIT (2N3137)



L_2 = .075 μH (5.5 turns #16ga. ID = 3/16" length 1/2")

250 MHz POWER GAIN TEST CIRCUIT (MM1803)



L_1 = 3/4 turn No. 14 tinned wire 3/8" ID
L_2 = 4 turns No. 18 tinned wire 1/4" ID 7/16" long

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristic		Symbol	Min	Typical	Max	Unit
Collector-Base Breakdown Voltage I_C = 0.1mAdc, I_E = 0	2N3137 MM1803	V_{CBO}	40 50			Vdc
Collector-Emitter Open Base Sus. Voltage I_C = 15mAdc, I_B = 0	2N3137 MM1803	$V_{CEO(sus)}$	20 25			Vdc
Collector Cutoff Current V_{CB} = 20Vdc, I_E = 0, T_C = +150°C		I_{CBO}			50	μAdc
Collector Cutoff Current V_{CB} = 20Vdc, I_E = 0		I_{CBO}			.05	μAdc
Emitter-Base Breakdown Voltage I_E = 100μA, I_C = 0	2N3137 MM1803	V_{EBO}	4 5			Vdc
DC Current Gain V_{CE} = 5Vdc, I_C = 50mAdc	2N3137 MM1803	h_{FE}	20 40		120 160	
Collector-Emitter Saturation Voltage I_C = 50mAdc, I_E = 5mAdc		$V_{CE(sat)}$			0.3	Vdc
Small Signal Current Gain V_{CE} = 10Vdc, I_C = 50mAdc, f = 100 MHz		$\|h_{fe}\|$	5.0			
Common-base Output Capacitance V_{CB} = 10Vdc, I_C = 0, f = 100 kHz		C_{ob}			3.5	pF
Power Output		P_{out}	400	600		mWatts
Power Gain P_{in} = 100mw, f = 250 MHz	2N3137	G_e	6.0	7.7		dB
Efficiency V_{CE} = 20Vdc		η	40	65		%
Power Output		P_{out}	560	700		mWatts
Power Gain P_{in} = 100mw, f = 250 MHz	MM1803	G_e	7.5	8.5		db
Efficiency V_{CE} = 20V		η	45	60		%

*Pulse Width ≈ 300 μs, Duty cycle = 1%

2N3209 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for medium-speed saturated switching applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.15 Vdc (Max) @ I_C = 10 mAdc
- Low Output Capacitance –
  C_{ob} = 5.0 pF (Max) @ V_{CB} = 5.0 Vdc
- DC Current Gain Specified – 10 mAdc to 100 mAdc

PNP SILICON TRANSISTOR

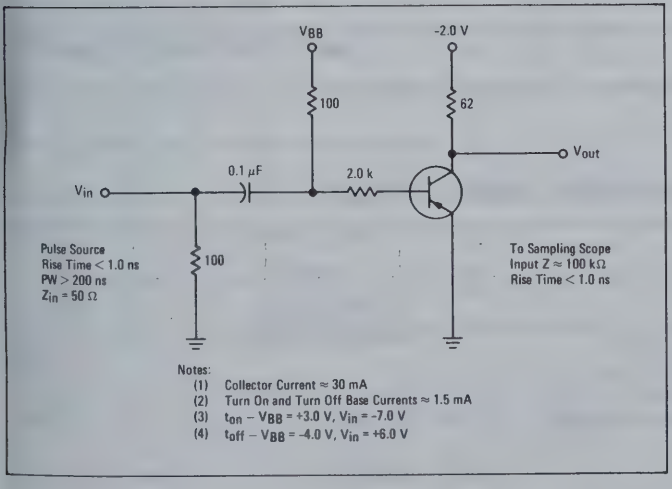


*MAXIMUM RATINGS

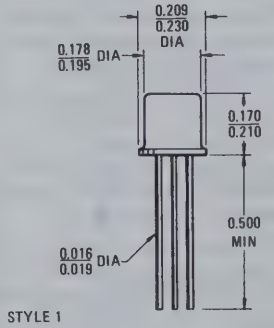
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.

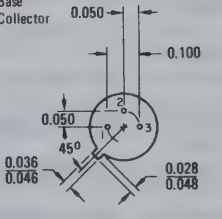
FIGURE 1 – SWITCHING TIME TEST CIRCUIT



Notes:
(1) Collector Current ≈ 30 mA
(2) Turn On and Turn Off Base Currents ≈ 1.5 mA
(3) t_{on} – V_{BB} = +3.0 V, V_{in} = -7.0 V
(4) t_{off} – V_{BB} = -4.0 V, V_{in} = +6.0 V



STYLE 1
Pin 1. Emitter
2. Base
3. Collector



To convert to millimeters multiply by 25.4.
All JEDEC TO-18 dimensions and notes apply.

Collector Connected to Case
CASE 22(1)
TO-18

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	20	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current	I_{CES}			
(V_{CE} = 10 Vdc, V_{BE} = 0)		–	80	nAdc
(V_{CE} = 10 Vdc, V_{BE} = 0, T_A = 125°C)		–	10	μAdc
Base Current (V_{CE} = 10 Vdc, V_{BE} = 0)	I_B	–	80	nAdc
ON CHARACTERISTICS				
DC Current Gain(1)	h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)		25	–	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc)		30	120	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C)		12	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		15	–	
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		–	0.15	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		–	0.2	
(I_C = 100 mAdc, I_B = 10 mAdc)		–	0.6	
Base-Emitter Saturation Voltage(1)	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.78	0.98	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		0.85	1.2	
(I_C = 100 mAdc, I_B = 10 mAdc)		–	1.7	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product(2) (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	5.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	6.0	pF
SWITCHING CHARACTERISTICS (Figure 1)				
Turn-On Time ($I_C \approx$ 30 mAdc, $I_{B1} \approx$ 1.5 mAdc)	t_{on}	–	60	ns
Turn-Off Time ($I_C \approx$ 30 mAdc, $I_{B1} = I_{B2} \approx$ 1.5 mAdc)	t_{off}	–	90	ns

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N3210 (SILICON)



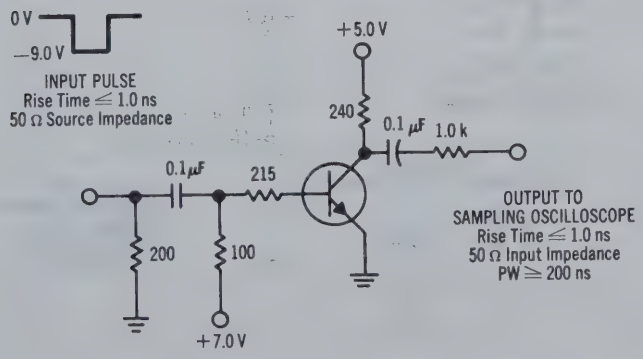
CASE 22
(TO-18)

NPN silicon high frequency switching transistor is designed for high speed, saturated switching applications for industrial service.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage Applicable from 0 to 500 mAdc	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D	0.36	Watt
Derate above 25°C		2.06	mW/°C
Total Device Dissipation @ $T_C = 25°C$	P_D	1.2	Watts
Derate above 25°C		6.9	mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — STORAGE TIME TEST CIRCUIT



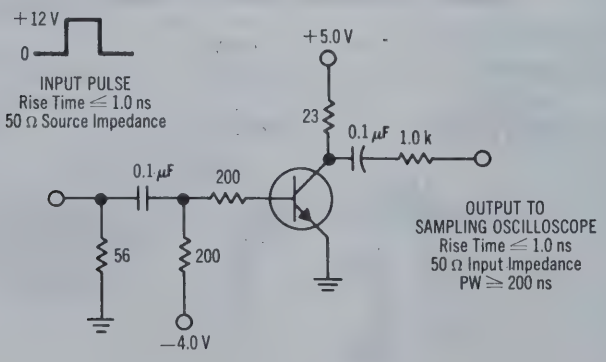
2N3210 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 2.0 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{CEX}	-	25	nAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	0.010 15	μAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
Base Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{BL}	-	0.025	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}*	30	120	-
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc, T_A = +125°C) (I_C = 200 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	- -	0.25 0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 200 mAdc, I_B = 20 mAdc)	$V_{BE(sat)}$	0.7 -	0.8 1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	6.0	pF
Turn-On Time ($V_{BE(off)}$ ≅ 0.2 Vdc, I_C = 200 mAdc, I_{B1} = 40 mAdc) (Figure 2)	t_{on}	-	40	ns
Turn-Off Time (I_C = 200 mAdc, I_{B1} = 40 mAdc, I_{B2} = 20 mAdc) (Figure 2)	t_{off}	-	40	ns
Storage Time ($I_C \approx I_{B1} \approx I_{B2} \approx$ 20 mAdc) (Figure 1)	t_s	-	20	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 — TURN-ON AND TURN-OFF TEST CIRCUIT



2N3211 (SILICON)



CASE 22
(TO-18)

NPN silicon high frequency switching transistor designed for high speed, saturated switching applications for industrial service.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	0.36	Watt
Derate above 25°C		2.06	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.2	Watts
Derate above 25°C		6.9	mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{CEX}	-	25	nAdc
Base Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{BL}	-	0.025	μAdc
(V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc, T_A = 85°C)		-	10	
ON CHARACTERISTICS				
DC Current Gain*	h_{FE}*			-
(I_C = 100 μAdc, V_{CE} = 1.0 Vdc)		20	-	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		50	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		50	150	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		20	-	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		40	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		30	-	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)		10	-	
Collector-Emitter Saturation Voltage*	$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		-	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		-	0.3	
(I_C = 100 mAdc, I_B = 10 mAdc)		-	0.4	
Base-Emitter Saturation Voltage*	$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		-	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		-	1.0	
(I_C = 100 mAdc, I_B = 10 mAdc)		-	1.2	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3211 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	350	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	7.0	pF
Charge-Storage Time Constant ($I_C \approx I_{B1} \approx I_{B2} \approx$ 10 mAdc)	(Figure 1)	τ_s	-	15	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1.0 mAdc)	(Figure 2)	Q_T	-	60	pC
Active Region Time Constant (I_C = 10 mAdc, I_B = 1.0 mAdc)	(Figure 3)	τ_A	-	2.5	ns

FIGURE 1 — CHARGE STORAGE TIME CONSTANT TEST CIRCUIT

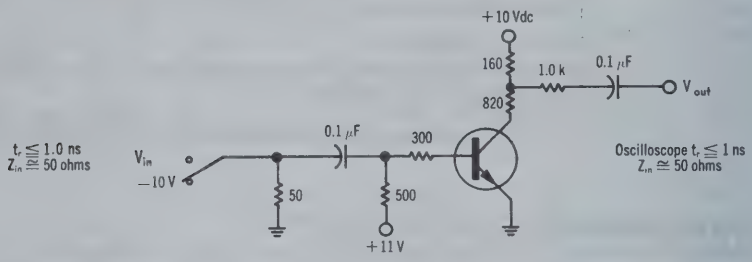


FIGURE 2 — TOTAL CONTROL CHARGE TEST CIRCUIT

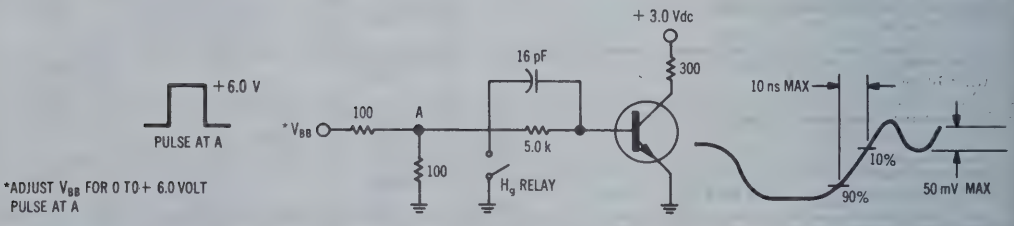
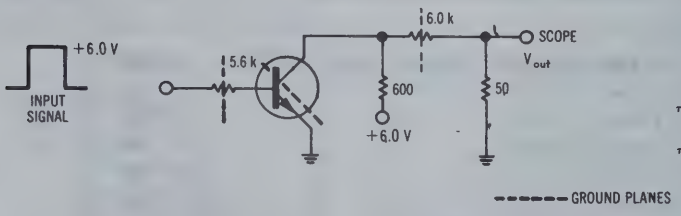


FIGURE 3 — ACTIVE REGION TIME CONSTANT TEST CIRCUIT

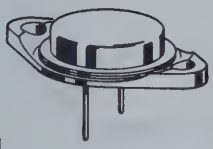


NOTES FOR FIGURES 2, 3

INPUT PULSE – TRANSITION TIME TO +6.0 Vdc ≦ 2.0 ns
INPUT PULSE – OPTIONAL GENERATOR OUTPUT IMPEDANCE: ADJUST FOR + 6.0 Vdc
SCOPE INPUT CAPACITANCE = 3.0 pF MAX
SCOPE INPUT IMPEDANCE = 10 MEGOHMS
SCOPE RISE TIME ≦ 0.7 ns

2N3227 (SILICON) For Specifications, See 2N2369 Data.

2N3232 (SILICON)
2N3235



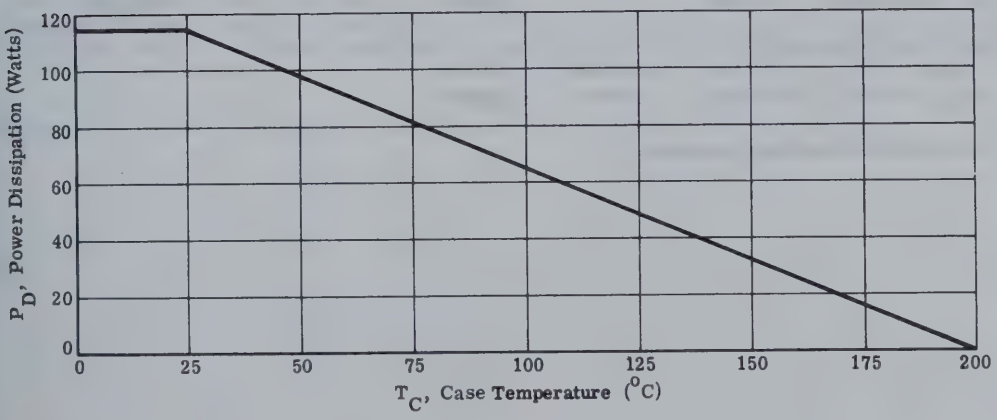
NPN silicon power transistors designed for switching and amplifier applications.

CASE 11
(TO-3)

MAXIMUM RATINGS

Rating	Symbol	2N3232	2N3235	Units
Collector-Base Voltage	V_{CB}	60	55	Vdc
Collector-Emitter Voltage	V_{CEO}	60	55	Vdc
Emitter-Base Voltage	V_{EB}	6.0	7.0	Vdc
Collector Current (Continuous)	I_C	7.5	15	Adc
Base Current (Continuous)	I_B	3.0	7.0	Adc
Power Dissipation	P_D	117		Watts
Thermal Resistance, Junction to Case	θ_{JC}	1.5		$^oC/W$
Junction Operating Temperature Range	T_J	-65 to +200		^oC

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = 6.0 Vdc)	2N3232		-	1.0	
(V_{EB} = 7.0 Vdc)	2N3235		-	5.0	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc)	2N3232		-	1.0	
	2N3235		-	1.0	
(V_{CE} = 30 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3232		-	5.0	
	2N3235		-	5.0	
Collector-Emitter Sustaining Voltage*		$V_{CEO(sus)}$*			Vdc
(I_C = 100 mAdc, I_B = 0)	2N3232		60	-	
	2N3235		55	-	
Collector Current		I_{CEO}			mAdc
(V_{CE} = 60 Vdc, I_B = 0)	2N3232		-	10	
(V_{CE} = 55 Vdc, I_B = 0)	2N3235		-	10	
DC Current Gain*		h_{FE}			-
(I_C = 1.5 Adc, V_{CE} = 10 Vdc)	2N3232		18	-	
(I_C = 3.0 Adc, V_{CE} = 10 Vdc)	2N3232		18	55	
(I_C = 2 Adc, V_{CE} = 4 Vdc)	2N3235		20	-	
(I_C = 4 Adc, V_{CE} = 4 Vdc)	2N3235		20	70	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 3.0 Adc, I_B = 0.2 Adc)	2N3232		-	2.5	
(I_C = 4.0 Adc, I_B = 0.4 Adc)	2N3235		-	1.1	
Base-Emitter Voltage*		V_{BE}			Vdc
(I_C = 3.0 Adc, V_{CE} = 10 Vdc)	2N3232		-	3.5	
(I_C = 4.0 Adc, V_{CE} = 4 Vdc)	2N3235		-	1.8	
Small Signal Current Gain		h_{fe}			-
(V_{CE} = 10 Vdc, I_C = 3.0 Adc, f = 1.0 MHz)	2N3232		1.0	-	
(V_{CE} = 4 Vdc, I_C = 4.0 Adc, f = 1.0 MHz)	2N3235		1.0	-	

*Use sweep test to prevent overheating.

2N3244 (SILICON)
2N3245



CASE 31
(TO-5)

PNP silicon annular transistors for medium-current, high-speed switching and driver applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N 3244	2N 3245	Unit
Collector-Base Voltage	V_{CB}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	1		Adc
Total Device Dissipation @ 25° C Ambient Temperature Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ 25 ° C Case Temperature Derating Factor Above 25°C	P_D	5 28.6		Watts mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
Thermal Resistance, Junction to Ambient Thermal Resistance, Junction to Case	θ_{JA} θ_{JC}	0.175 35		°C/mW °C/W

ELECTRICAL CHARACTERISTICS (at T_A = 25°C unless otherwise specified)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)			I_{CBO}	— —	.050 10	μAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3 Vdc)			I_{CEX}	—	50	nAdc
Emitter-Base Leakage Current (V_{EB} = 3 Vdc, I_C = 0)			I_{EBO}	—	30	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3 Vdc)			I_{BL}	—	80	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3244 2N3245		BV_{CBO}	40 50	— —	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3244 2N3245		BV_{CEO}*	40 50	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	5	—	Vdc
Collector Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)	2N3244 2N3245 2N3244 2N3245 2N3244 2N3245	2,3	$V_{CE(sat)}$*	— — — — — —	0.3 0.35 0.5 0.6 1.0 1.2	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)		3	$V_{BE(sat)}$*	— 0.75 —	1.1 1.5 2.0	Vdc
DC Forward Current Transfer Ratio* (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1 Adc, V_{CE} = 5 Vdc)	2N3244 2N3245 2N3244 2N3245 2N3244 2N3245	1	h_{FE}*	60 35 50 30 25 20	— — 150 90 — —	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		5	C_{ob}	—	25	pF
Input Capacitance (V_{OB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		5	C_{ib}	—	100	pF
Current-Gain - Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3244 2N3245		f_T	175 150	— —	MHz
Delay Time	(I_C = 500 mA, I_{B1} = 50 mA V_{OB} = 2 V, V_{CC} = 30 V)	6,8	t_d	—	15	ns
Rise Time	2N3244 2N3245		t_r	— —	35 40	ns
Storage Time	(I_C = 500 mA, V_{CC} = 30 V I_{B1} = I_{B2} = 50 mA)	2N3244 2N3245 6,9	t_s	—	140 120	ns
Fall Time			t_f	—	45	ns
Total Control Charge (I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)	2N3244 2N3245	7,10	Q_T	— —	14 12	nC

* Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

FIGURE 1 — MINIMUM CURRENT GAIN CHARACTERISTICS

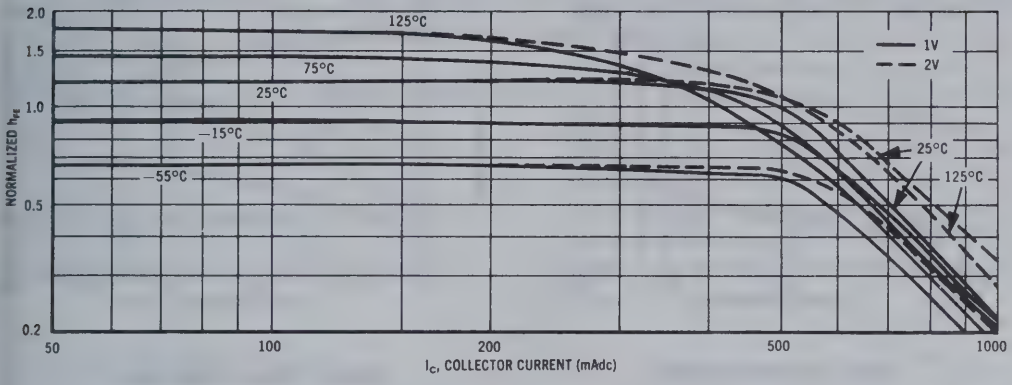
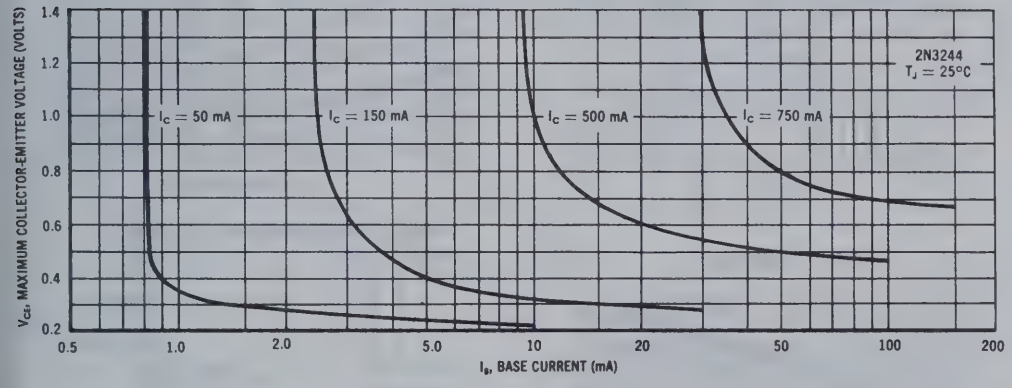


FIGURE 2 — COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS



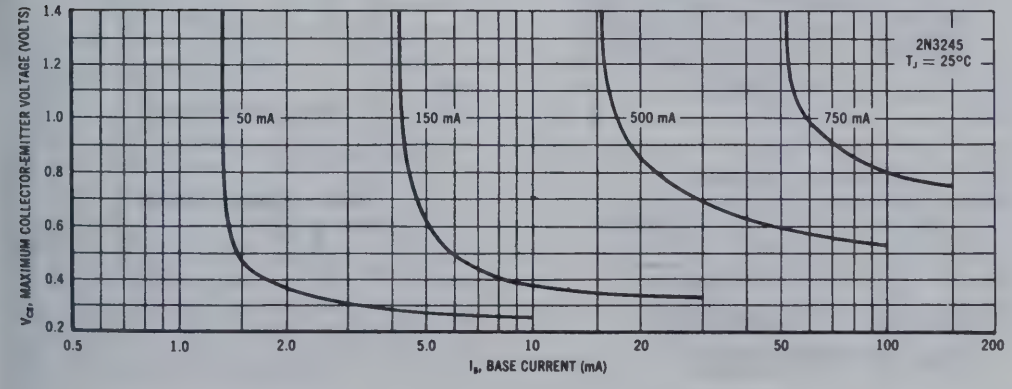


FIGURE 3 — MAXIMUM SATURATION VOLTAGES

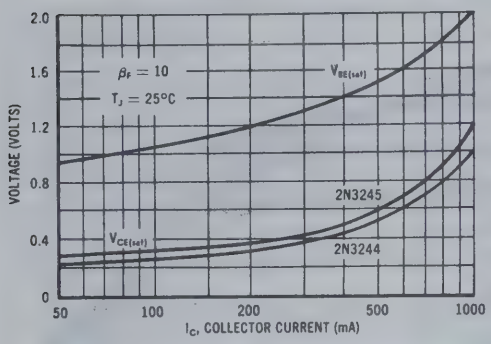


FIGURE 4 — TYPICAL TEMPERATURE COEFFICIENTS

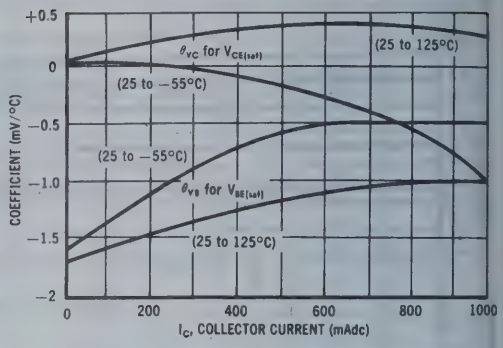


FIGURE 5 — JUNCTION CAPACITANCE

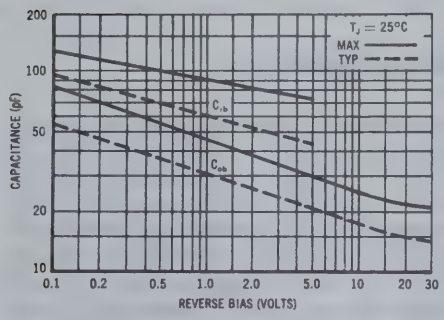


FIGURE 6 — TYPICAL SWITCHING TIMES

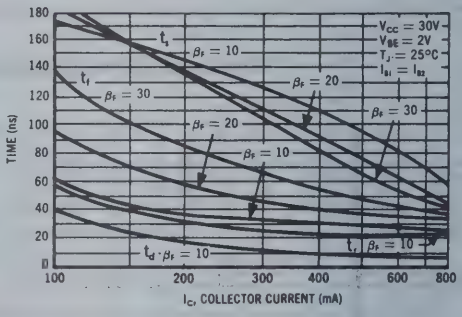


FIGURE 7 — CHARGE DATA

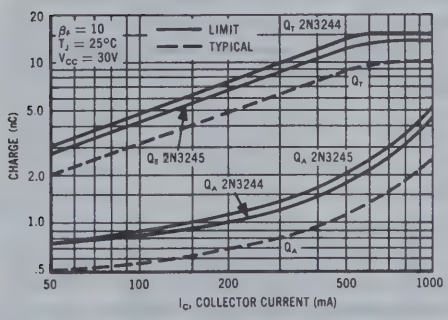


FIGURE 8 — TURN-ON EQUIVALENT TEST CIRCUIT

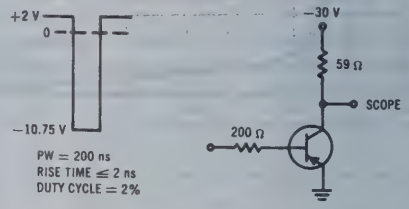


FIGURE 9 — TURN-OFF EQUIVALENT TEST CIRCUIT

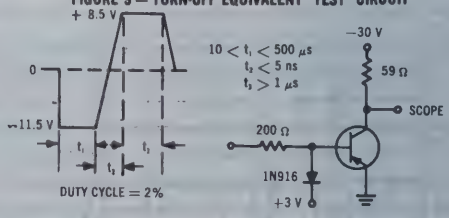


FIGURE 10 — Q_T TEST CIRCUIT

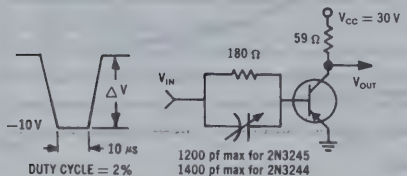


FIGURE 11 — TURN-OFF WAVEFORM



2N3248 (SILICON)
2N3249



CASE 22
(TO-18)

PNP silicon annular transistors for low-level, high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Total Device Dissipation @ 25°C Ambient Temperature Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 – t_{on} CIRCUIT

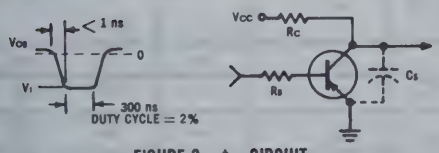
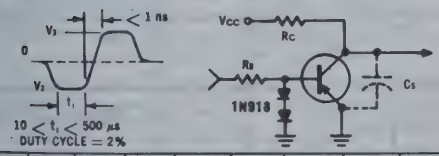


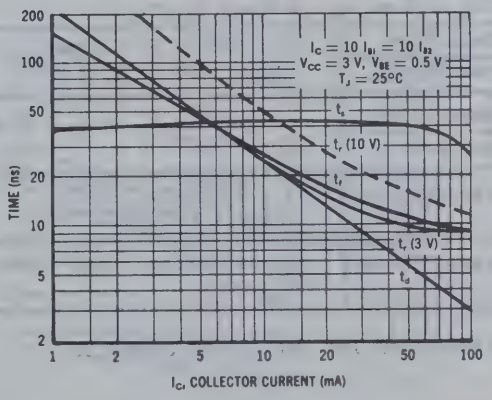
FIGURE 2 – t_{off} CIRCUIT



I_C mA	V_{CC} volts	R_s ohms	R_C ohms	$C_{s(max)}$* pF	V_{os} volts	V_1 volts	V_2 volts	V_3 volts
10	3	10 K	285	4	+0.5	−10.6	−10.9	+9.1
100	10	1 K	95	12	+0.5	−10.7	−11.3	+8.7

*Total shunt capacitance of test jig and connectors.

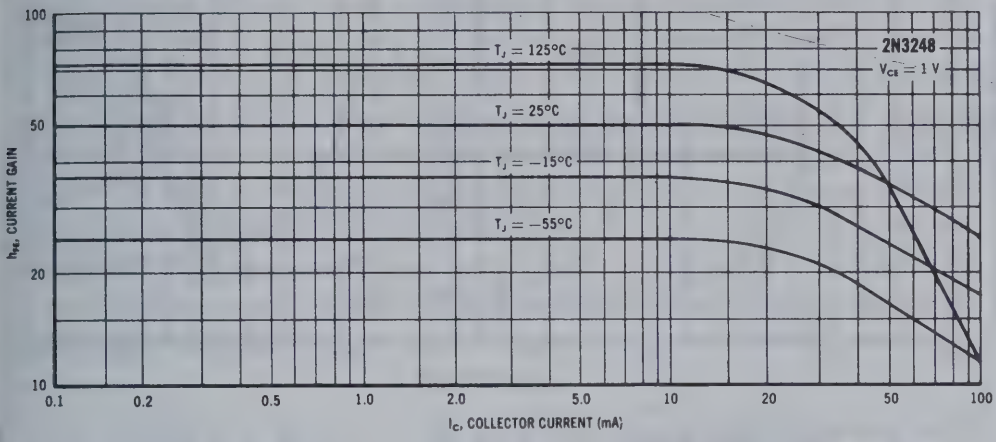
FIGURE 3 – TYPICAL SWITCHING TIMES



Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector-Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 1 Vdc) (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 1 Vdc, T_A = 100°C)			I_{CEX}	— —	.05 5	μAdc
Base Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 1 Vdc)			I_{BL}	—	50	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	15	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)			BV_{CEO}*	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	5	—	Vdc
Collector Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	 2N3248 2N3249	7,8	$V_{CE(sat)}$*	 — — —	 0.125 0.25 0.4 0.45	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		8	$V_{BE(sat)}$*	0.6 — 0.7	0.9 1.1 1.3	Vdc
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 1 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 50 mAdc, V_{CE} = 1 Vdc) (I_C = 100 mAdc, V_{CE} = 1 Vdc)	 2N3248 2N3249 2N3248 2N3249 2N3248 2N3249 2N3248 2N3249 2N3248 2N3249	4	h_{FE}*	 50 100 50 100 50 100 35 75 25 35	 — — — — 150 300 — — — —	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		6	C_{ob}	—	8	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kHz)		6	C_{ib}	—	8	pF
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3248 2N3249		f_T	250 300	— —	MHz
Total Control Charge (I_C = 10 mA, I_B = 0.25 mA, V_{CC} = 3 V)		5,10	Q_T	—	150	pC
Delay Time	I_C = 100 mA, I_B = 10 mA, $V_{BE(off)}$ = 0.5 V, V_{CC} = 10 V	1,3	t_d	—	5	ns
Rise Time			t_r	—	15	ns
Storage Time	I_C = 100 mA, I_{B1} = I_{B2} = 10 mA, V_{CC} = 10 V	2,3	t_s	—	60	ns
Fall Time			t_f	—	20	ns
Turn-On Time	I_C = 10 mA, I_{B1} = 1 mA, $V_{BE(off)}$ = 0.5 V, V_{CC} = 3 V	1,3	t_{on}	—	90	ns
Turn-Off Time	I_C = 10 mA, I_{B1} = I_{B2} = 1 mA, V_{CC} = 3 V	2,3	t_{off}	—	100	ns

*Pulse Test: PW = 300 μs, Duty Cycle ≤ 2%

FIGURE 4 — MINIMUM CURRENT GAIN CHARACTERISTICS



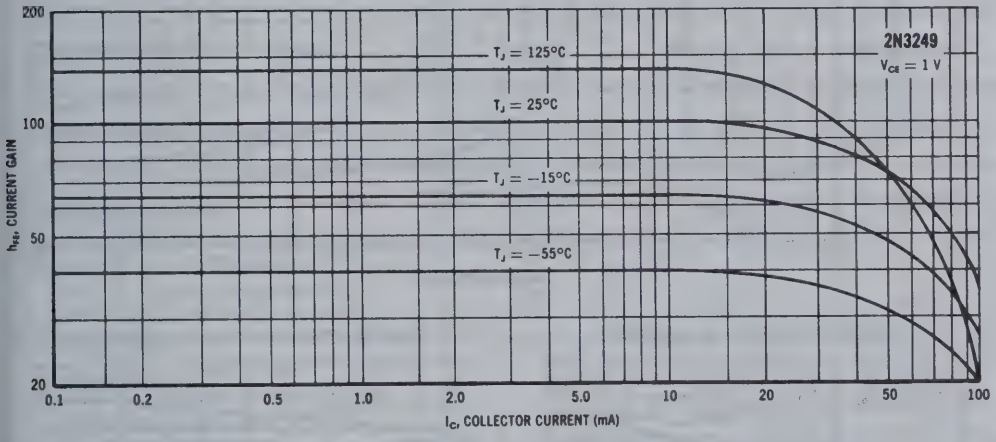


FIGURE 5 — MAXIMUM CHARGE DATA

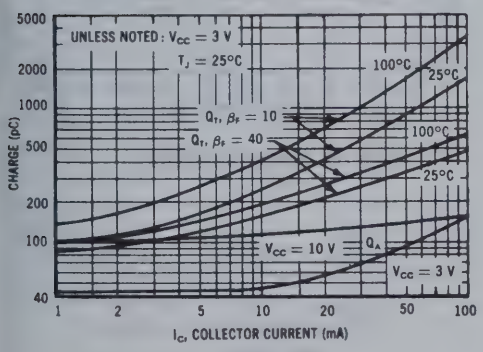


FIGURE 6 — JUNCTION CAPACITANCE

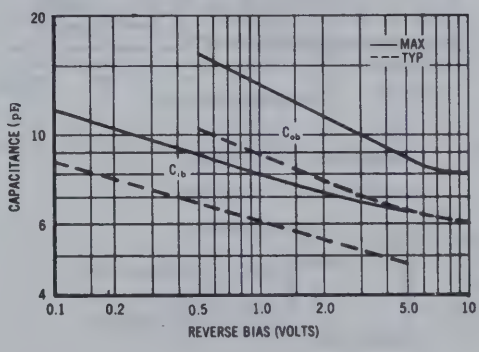
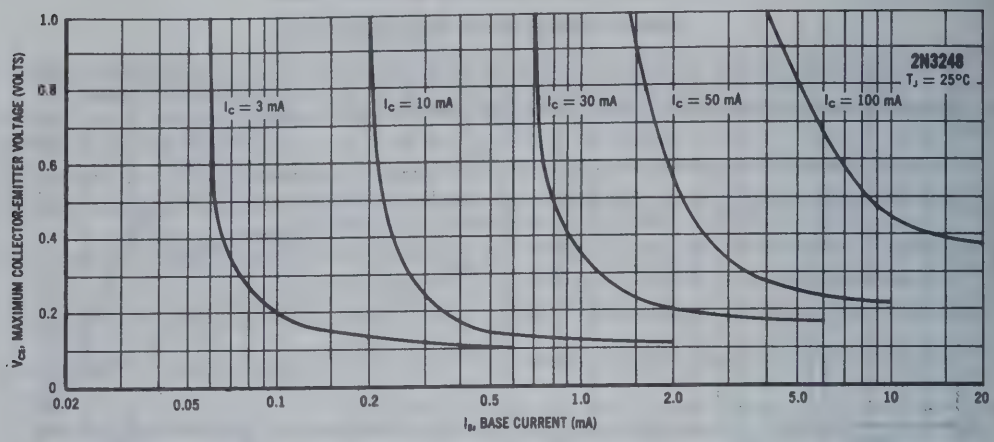


FIGURE 7 COLLECTOR SATURATION VOLTAGE CHARACTERISTICS



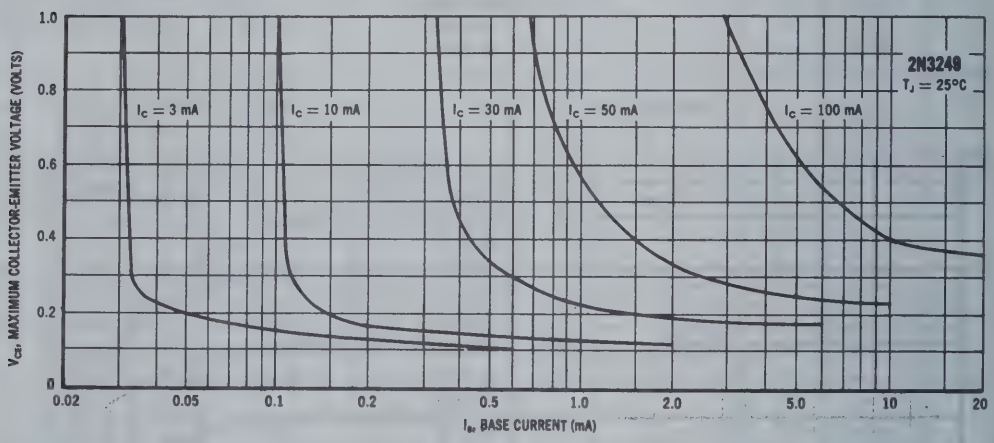


FIGURE 8 — SATURATION VOLTAGE LIMITS

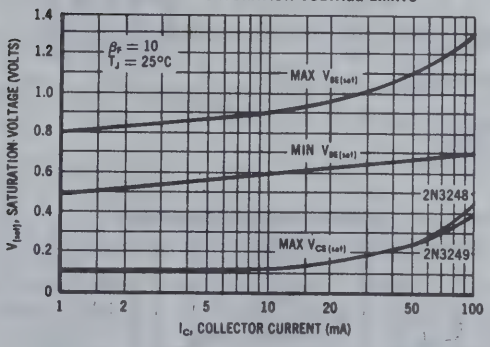


FIGURE 9 — TYPICAL TEMPERATURE COEFFICIENTS

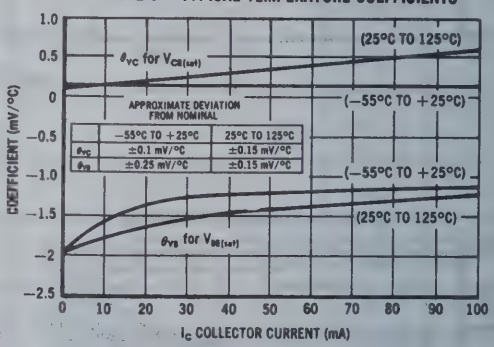


FIGURE 10 — Q_T TEST CIRCUIT

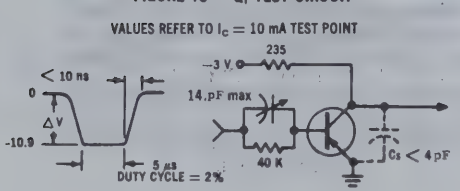
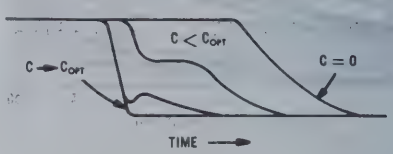


FIGURE 11 — TURN-OFF WAVE FORM



2N3250, A (SILICON)
2N3251, A



PNP silicon annular transistors for high-speed switching and amplifier applications.

Collector connected to case

CASE 22
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	2N3250 2N3251	2N3250A 2N3251A	Unit
Collector-Base Voltage	V_{CB}	50	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	1.2 6.9		Watts mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.36 2.06		Watts mW/°C
Junction Operating Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	−65 to +200		°C
Thermal Resistance, Junction to Ambient Thermal Resistance, Junction to Case	θ_{JA} θ_{JC}	0.49 0.15		°C/mW °C/mW

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{CEX}	--	20	nAdc
Base Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{BL}	--	50	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	2N3250, 2N3251 2N3250A, 2N3251A	BV_{CBO}	50 60	--	Vdc
Collector-Emitter Breakdown Voltage * (I_C = 10 mAdc)	2N3250, 2N3251 2N3250A, 2N3251A	BV_{CEO} *	40 60	--	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)		BV_{EBO}	5	--	Vdc
Collector Saturation Voltage * (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$ *	--	0.25	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)			--	0.5	
Base-Emitter Saturation Voltage * (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$ *	0.6	0.9	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)			--	1.2	
DC Forward Current Transfer Ratio * (I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A	h_{FE} *	40 80	-- --	--
(I_C = 1 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		45 90	-- --	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		15 30	-- --	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	--	6	pF
Input Capacitance (V_{CB} = 1 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	--	8	pF
Current-Gain - Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3250, 2N3250A 2N3251, 2N3251A	f_T	250 300	-- --	MHz

SMALL SIGNAL CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{fe}	50 100	200 400	--
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{re}	-- --	10 20	$X10^{-4}$
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{ie}	1 2	6 12	kohms
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{oe}	4 10	40 60	μ mhos
Collector-Base Time Constant (I_C = 10 mA, V_{CE} = 20 V)		r'_bC_C	--	250	ps
Noise Figure (I_C = 100 μA, V_{CE} = 5 V, R_S = 1 kΩ, f = 100 Hz)		NF	--	6	dB

*Pulse Test: PW = 300 μs, Duty Cycle = 2%

SWITCHING CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic			Symbol	Max	Unit
Delay Time	(V_{CC} = 3 Vdc, V_{BE} = 0.5 Vdc I_C = 10 mAdc, I_{B1} = 1 mA)		t_d	35	ns
Rise Time			t_r	35	ns
Storage Time	(I_{B1} = I_{B2} = 1 mAdc V_{CC} = 3V)	2N3250, 2N3250A 2N3251, 2N3251A	t_s	175 200	ns
Fall Time			t_f	50	ns

SWITCHING TIME CHARACTERISTICS

FIGURE 1 — DELAY AND RISE TIME

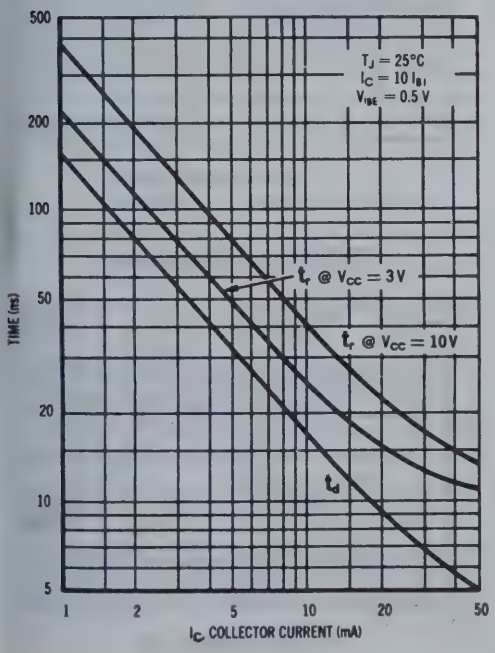
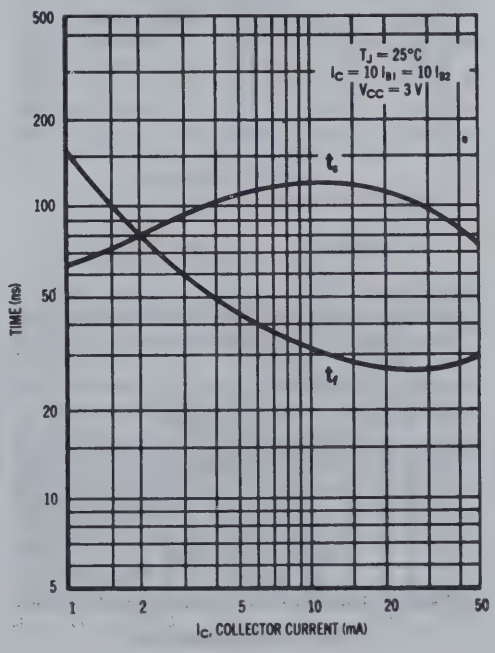


FIGURE 2 — STORAGE AND FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS
(V_{CE} = 6V, T_A = 25°C)

FIGURE 3 — FREQUENCY

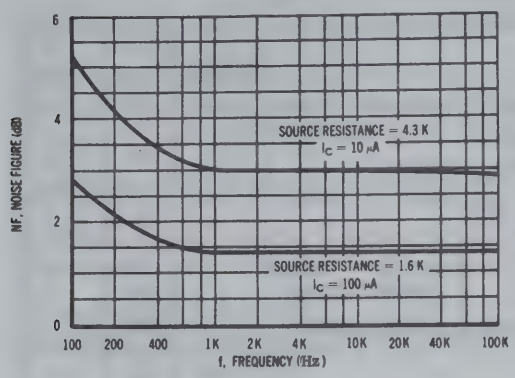
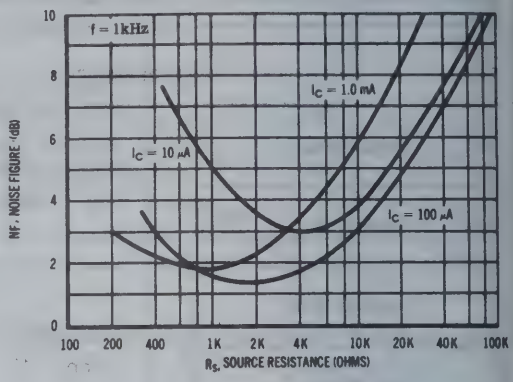


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS
V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

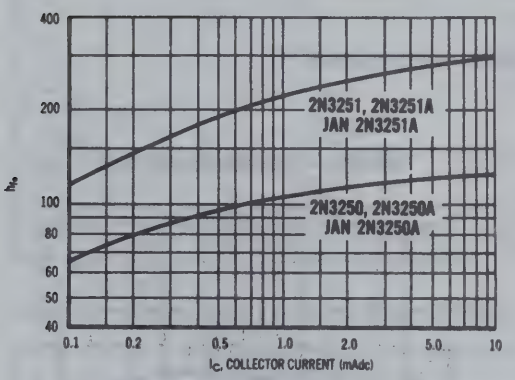


FIGURE 6 — OUTPUT ADMITTANCE

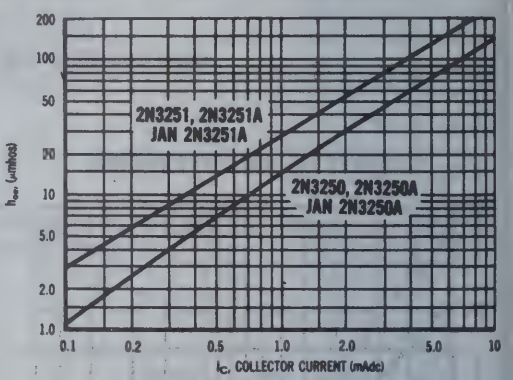


FIGURE 7 — VOLTAGE FEEDBACK RATIO

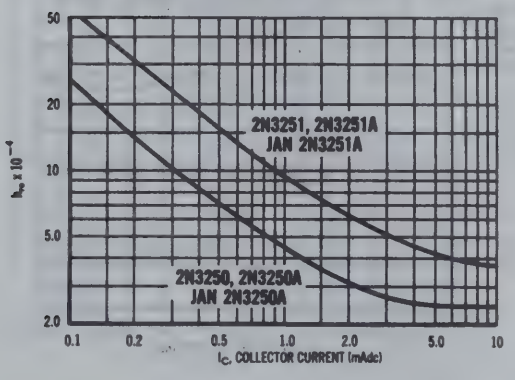


FIGURE 8 — INPUT IMPEDANCE

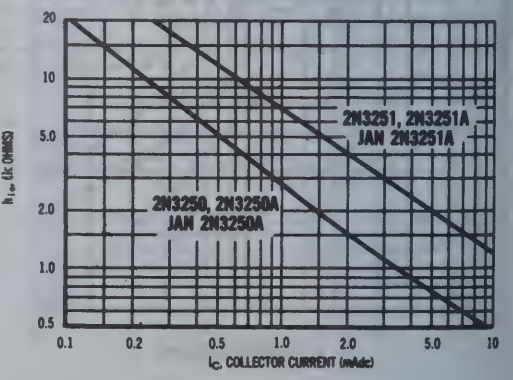


FIGURE 9 — NORMALIZED CURRENT GAIN CHARACTERISTICS

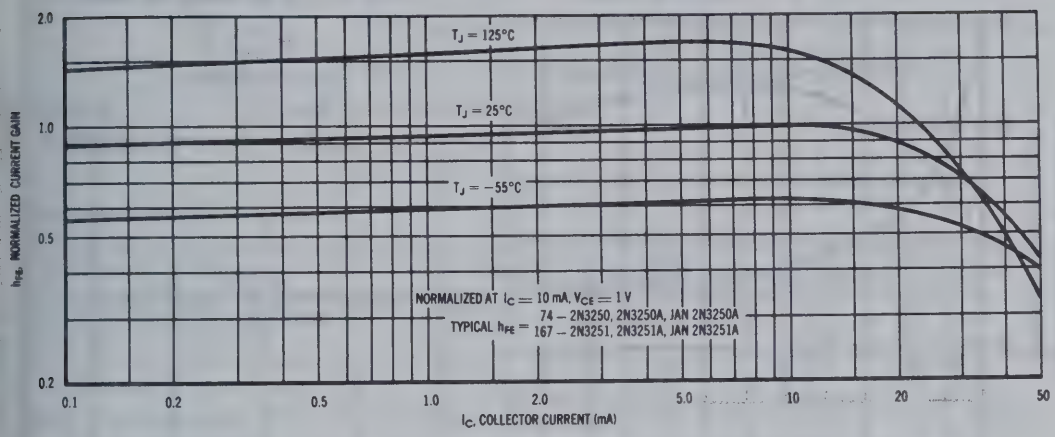
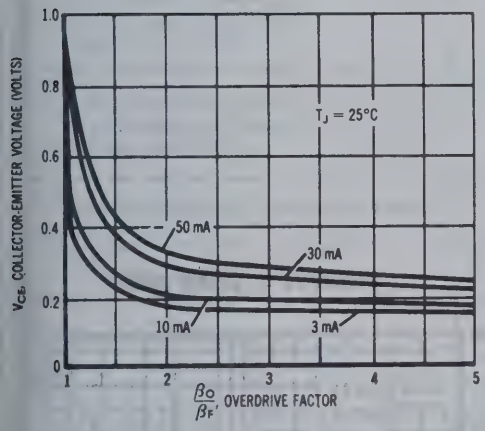


FIGURE 10 — COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3251, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 10 mA.

Observe that at I_C = 10 mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 9, it is seen that h_{FE} @ 1 volt is typically 167 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design) . . .

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\ \text{Volt}}{I_C/I_{BF}} \qquad 2.5 = \frac{167}{10\ \text{mA}/I_{BF}} \qquad I_{BF} \approx 6.68\ \text{mA typ}$$

FIGURE 11 — SATURATION VOLTAGES

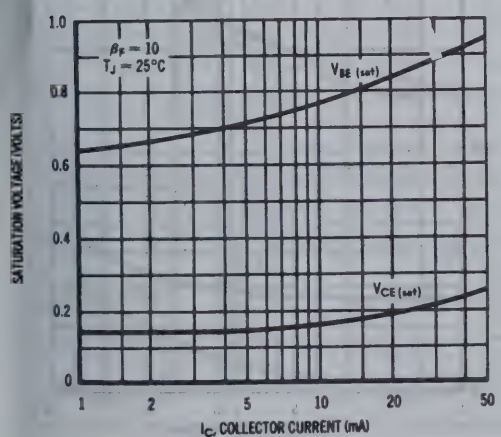


FIGURE 12 — TEMPERATURE COEFFICIENTS

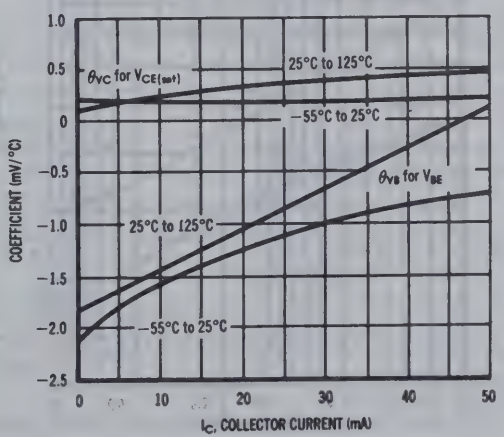


FIGURE 13 — f_T AND $r_b'C_C$ versus I_C

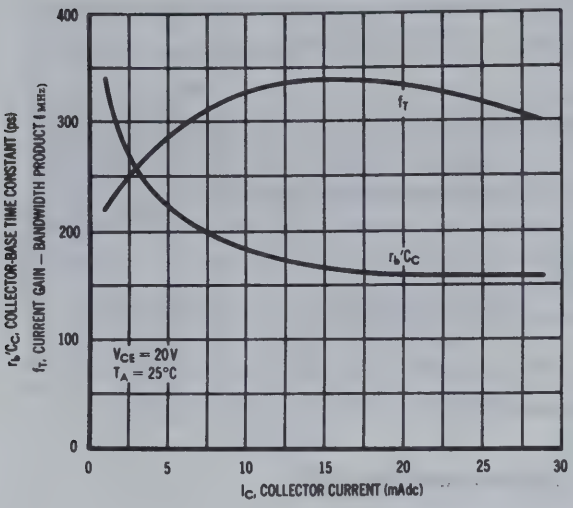


FIGURE 14 — 30 MC EQUIVALENT CIRCUIT

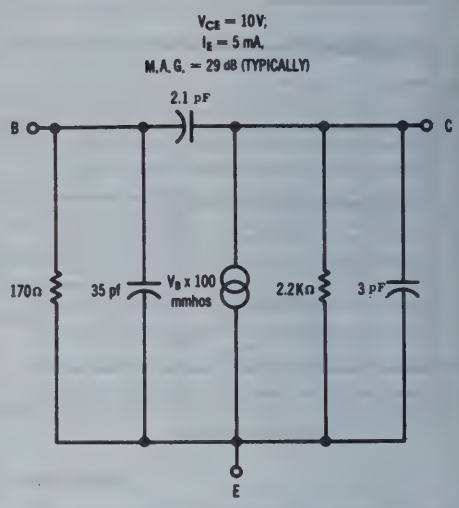


FIGURE 15 — JUNCTION CAPACITANCE

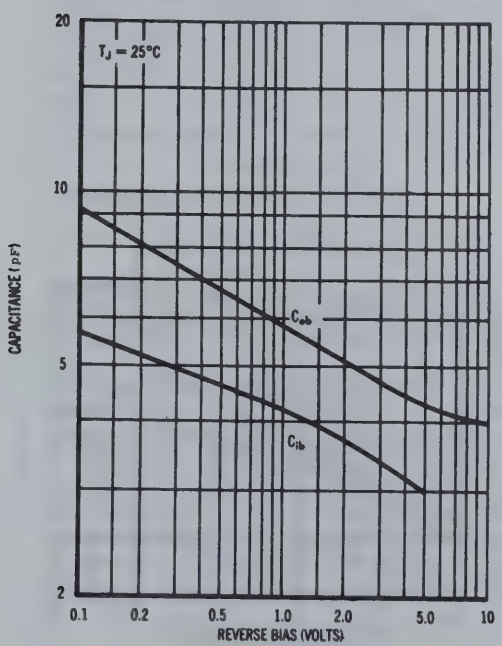
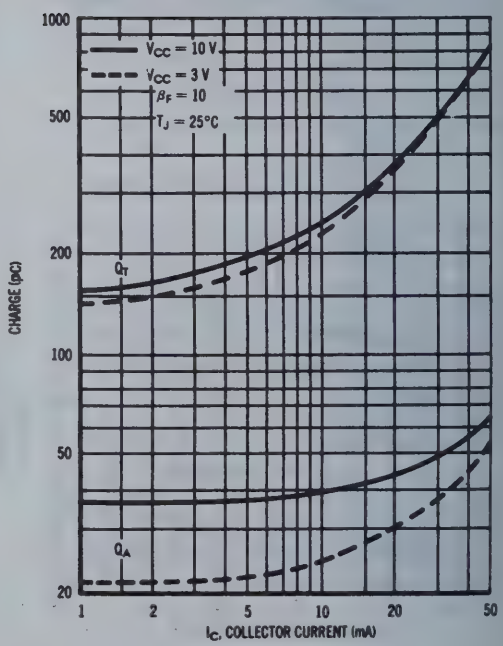


FIGURE 16 — CHARGE DATA



2N3252, 2N3253 (SILICON)
2N3444



CASE 31
(TO-5)

NPN silicon annular transistors for high-current saturated switching and core driver applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N3252	2N3253	2N3444	Unit
Collector-Base Voltage	V_{CB}	60	75	80	Vdc
Collector-Emitter Voltage	V_{CEO}	30	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5			Vdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	5 28.6			Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	1.0 5.71			Watt mW/°C
Junction Operating Temperature Range	T_J	-65 to +200			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C
Thermal Resistance:	θ_{JC} θ_{JA}	35 0.175			°C/W °C/mW

SWITCHING CHARACTERISTICS

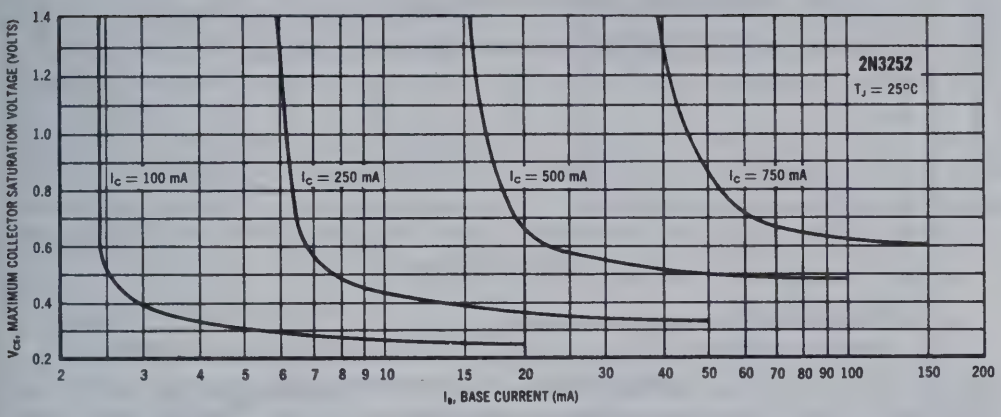
Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	80	pF
Current Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3252 2N3253, 2N3444	f_T	200 175	— —	MHz
Total Control Charge (I_C = 500 mAdc, I_{B1} = 50 mAdc, V_{CC} = 30 V)		Q_T	—	5	nC
Delay Time	I_C = 500 mAdc, I_{B1} = 50 mAdc	t_d	—	15	ns
Rise Time	V_{CC} = 30 V, V_{BE} = 2 V 2N3252 2N3253, 2N3444	t_r	— —	30 35	ns
Storage Time	I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc	t_s	—	40	ns
Fall Time	V_{CC} = 30 V	t_f	—	30	ns

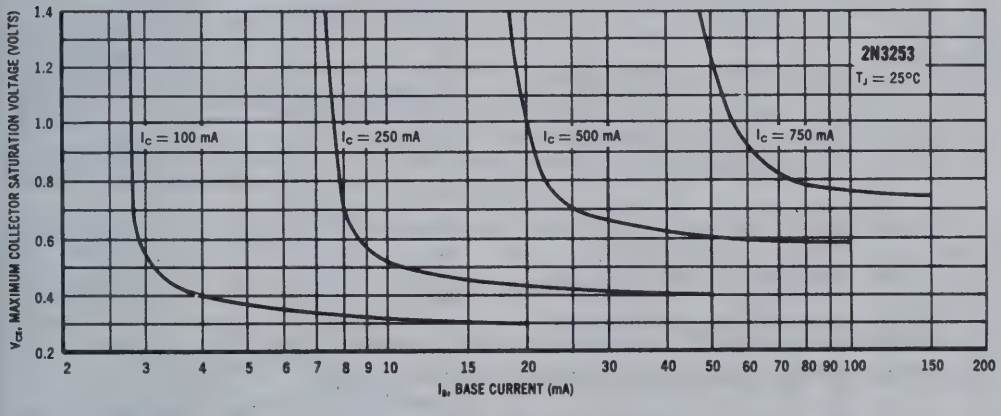
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

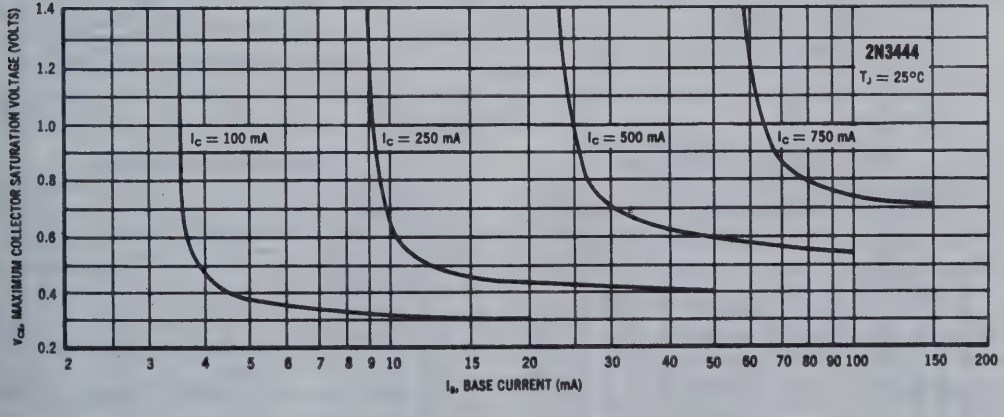
Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N3252		—	0.50	
(V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	2N3252			75.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N3253, 2N3444			0.50	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	2N3253, 2N3444			75.0	
Emitter Cutoff Current		I_{EBO}			μAdc
(V_{BF} = 4 Vdc, I_C = 0)			—	0.05	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3252		—	0.5	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3253, 2N3444,		—	0.5	
Base Cutoff Current		I_{BL}			μAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3252		—	0.50	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3253, 2N3444		—	0.50	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 10 μAdc, I_E = 0)	2N3252		60	—	
	2N3253		75	—	
	2N3444		80	—	
Collector-Emitter Breakdown Voltage *		BV_{CEO}*			Vdc
(I_C = 10 mAdc, pulsed, I_B = 0)	2N3252		30	—	
	2N3253		40	—	
	2N3444		50	—	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0)			5	—	
Collector Saturation Voltage *		$V_{CE(sat)}$*			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3252		—	0.3	
	2N3253, 2N3444		—	0.35	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3252		—	0.5	
	2N3253, 2N3444		—	0.60	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3252		—	1.0	
	2N3253, 2N3444		—	1.2	
Base-Emitter Saturation Voltage *		$V_{BE(sat)}$*			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.7	1.3	
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	1.8	
DC Forward Current Transfer Ratio *		h_{FE}*			—
(I_C = 150 mAdc, V_{CE} = 1 Vdc)	2N3252		30	—	
	2N3253		25	—	
	2N3444		20	—	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)	2N3252		30	90	
	2N3253		25	75	
	2N3444		20	60	
(I_C = 1 Adc, V_{CE} = 5 Vdc)	2N3252		25	—	
	2N3253		20	—	
	2N3444		15	—	

* Pulse Test: Pulse width = 300 μs, duty cycle = 2%

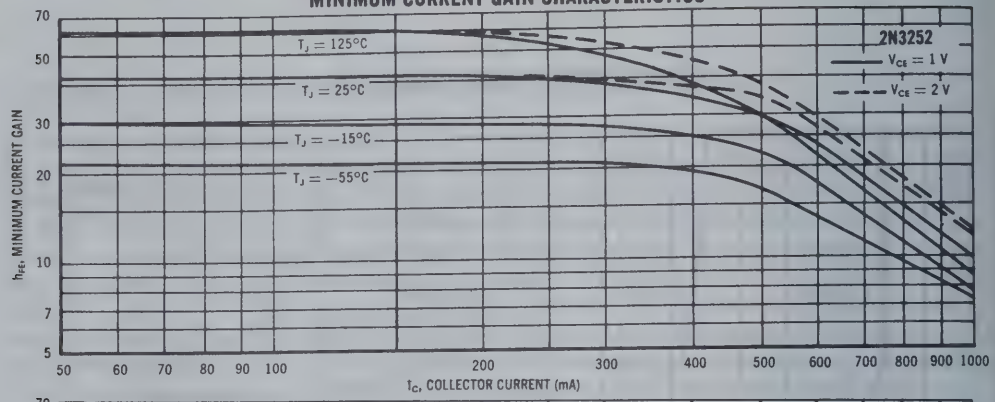
COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

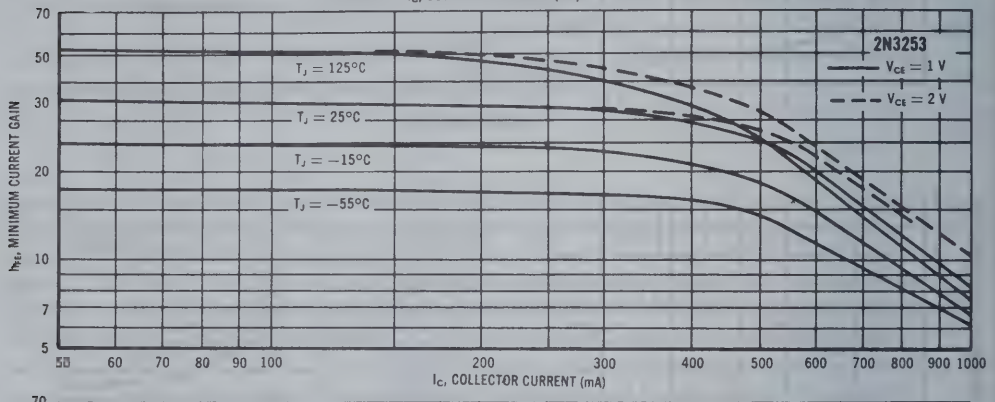


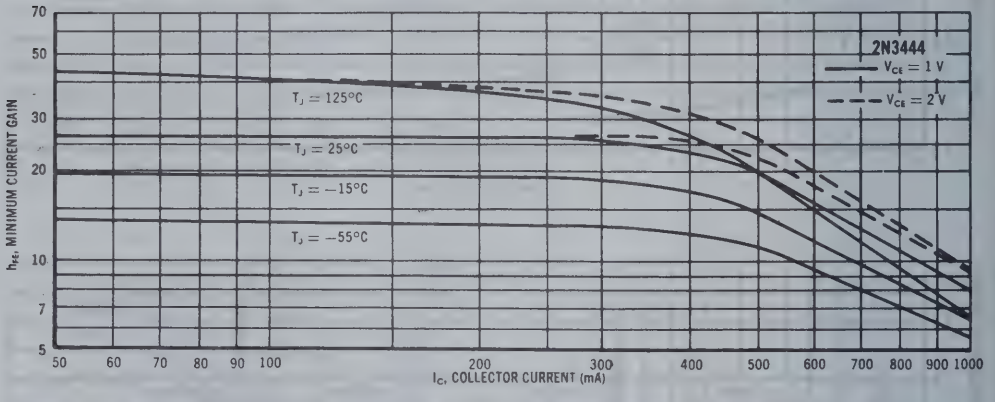




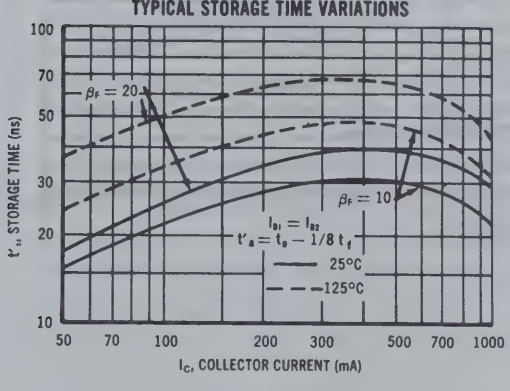
MINIMUM CURRENT GAIN CHARACTERISTICS



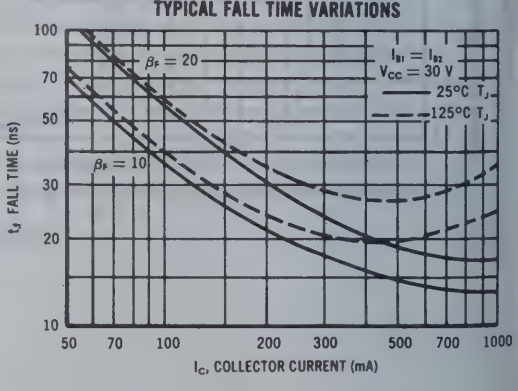




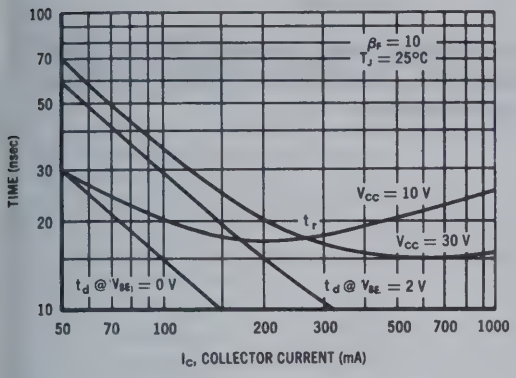
TYPICAL STORAGE TIME VARIATIONS



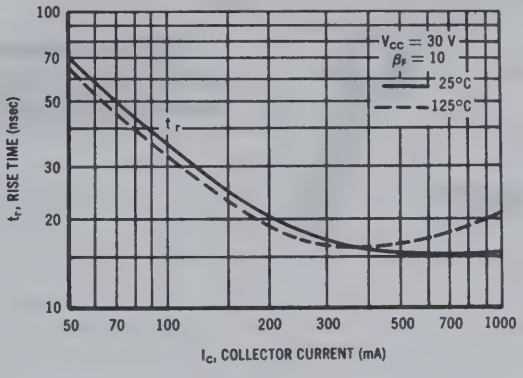
TYPICAL FALL TIME VARIATIONS



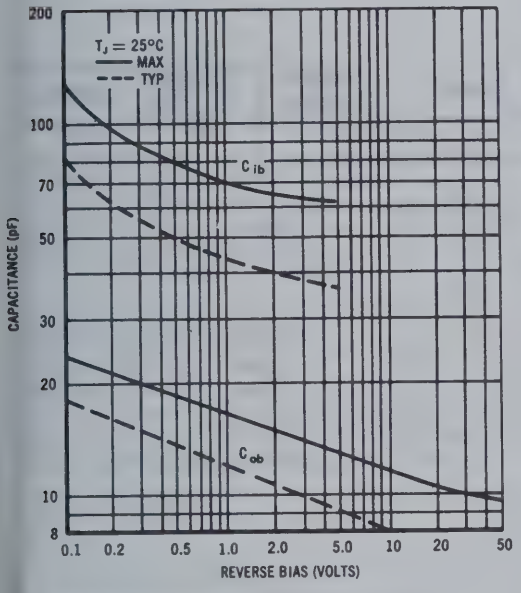
TYPICAL TURN-ON TIME VARIATIONS WITH VOLTAGE



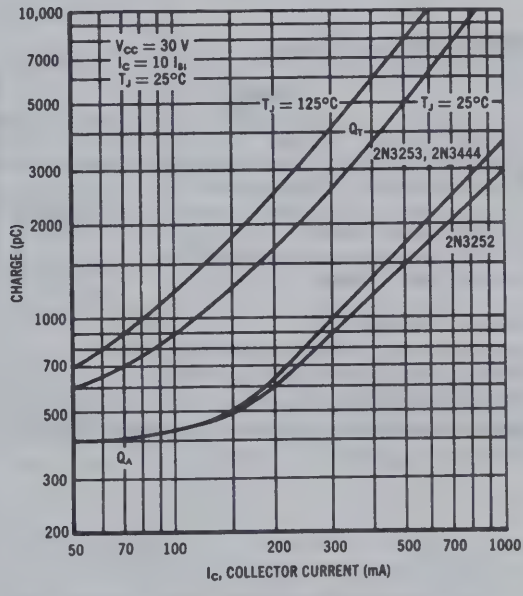
TYPICAL RISE TIME VARIATIONS WITH TEMPERATURE



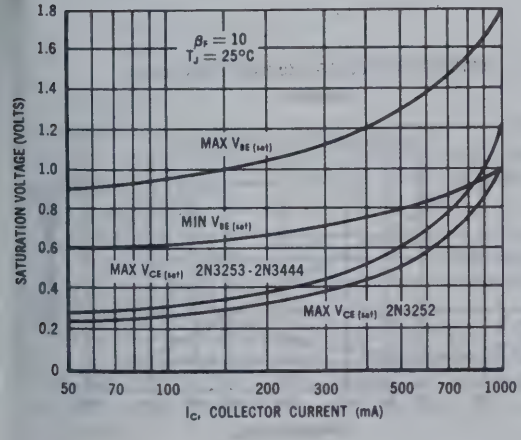
JUNCTION CAPACITANCE VARIATIONS



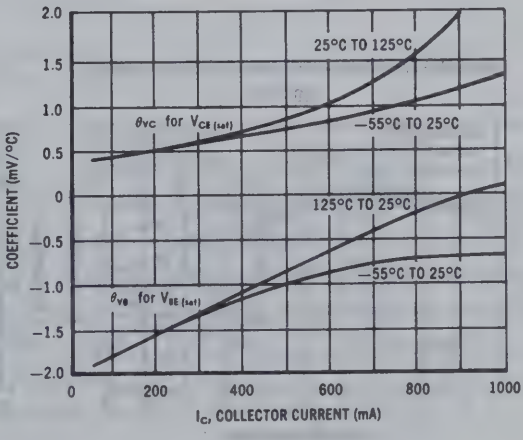
MAXIMUM CHARGE DATA



LIMITS OF SATURATION VOLTAGES



TYPICAL TEMPERATURE COEFFICIENTS



2N3279 thru 2N3282 (GERMANIUM)



CASE 20
(TO-72)

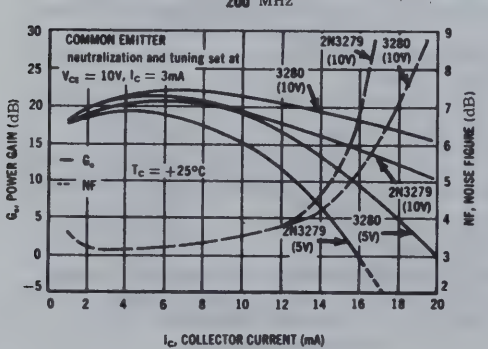
PNP germanium epitaxial mesa transistors for high-gain, low-noise amplifier, oscillator, mixer and frequency multiplier applications.

MAXIMUM RATINGS

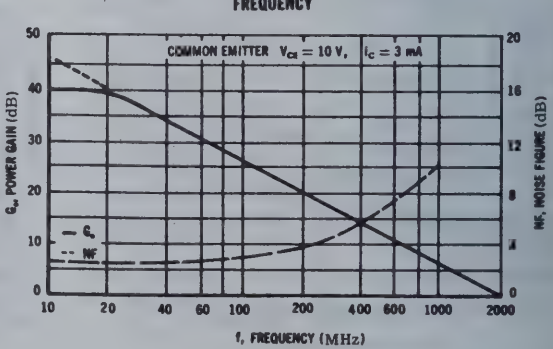
Rating	Symbol	2N3279 2N3280	2N3281 2N3282	Unit
Collector-Emitter Voltage	V_{CEO}	20	15	Vdc
Collector-Emitter Voltage	V_{CES}	30		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	1.0	0.5	
Collector Current	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	100 1.33		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		°C

POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

200 MHz



NEUTRALIZED POWER GAIN AND NOISE FIGURE versus FREQUENCY



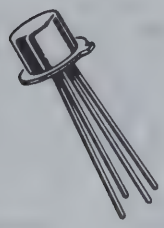
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	2N3279, 2N3280	BV_{CEO}	20	-	-	Vdc
	2N3281, 2N3282		15	-	-	
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		BV_{CES}	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	30	-	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	All Types	I_{CBO}	-	1.0	5.0	μAdc
(V_{CB} = 10 Vdc, I_E = 0, T_A = +55°C)	2N3279, 2N3280		-	-	50	
Emitter Cutoff Current (V_{BE} = 0.5 Vdc, I_C = 0)	2N3281, 2N3282	I_{EBO}	-	-	100	μAdc
(V_{BE} = 0.75 Vdc, I_C = 0)	2N3279, 2N3280		-	-	100	
ON CHARACTERISTICS						
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)	2N3279, 2N3280	h_{FE}	10	-	70	-
	2N3281, 2N3282		10	-	100	
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 1.0 mAdc)	2N3279, 2N3280	$V_{CE(sat)}$	-	-	0.3	Vdc
	2N3281, 2N3282		-	-	0.5	
Base-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 1.0 mAdc)	2N3279, 2N3280	$V_{BE(sat)}$	-	-	1.0	Vdc
	2N3281, 2N3282		-	-	1.5	
DYNAMIC CHARACTERISTICS						
Current-Gain-Bandwidth Product (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)	2N3279, 2N3280	f_T	400	500	800	MHz
	2N3281, 2N3282		300	400	800	
Maximum Frequency of Oscillation (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)		f_{max}	-	2000	-	MHz
Output Capacitance* (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	2N3279	C_{ob}*	-	0.9	1.0	pF
	2N3280 thru 2N3282		-	1.0	1.2	
Small-Signal Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3279, 2N3280	h_{fe}	10	-	100	-
	2N3281, 2N3282		10	-	150	
Collector-Base Time Constant (I_E = 3.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	2N3279, 2N3280	$r_b'C_c$	3.0	5.0	10	ps
	2N3281, 2N3282		3.0	5.0	15	
Noise Figure (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)	2N3279, 2N3280	NF	-	2.9	3.5	dB
	2N3281, 2N3282		-	4.0	5.0	
FUNCTIONAL TESTS						
Power Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)	2N3279, 2N3280	G_{pe}	17	-	23	dB
	2N3281, 2N3282		16	-	23	
Power Gain (AGC)** (I_C = 20 mAdc, V_{CE} = 5.0 Vdc, f = 200 MHz)	2N3279, 2N3281	G_{pe}(AGC)**	-	-	0	dB
	2N3280, 2N3282		-	0	-	

*C_{ob} is measured in a guarded circuit such that the can capacitance is not included.

**AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = 10 Vdc and I_C = 3.0 mAdc operation.

2N3283 thru 2N3286 (GERMANIUM)

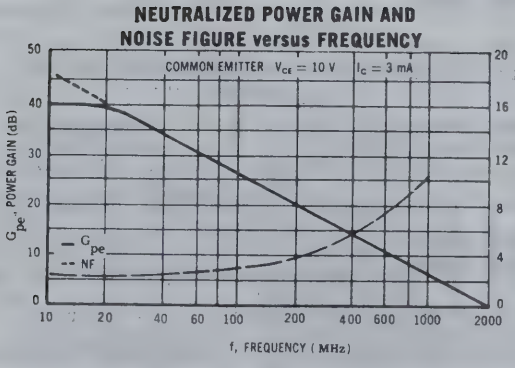


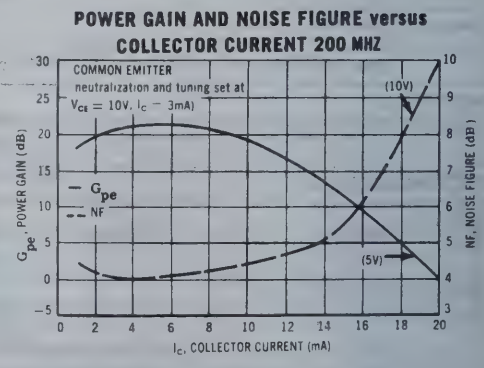
CASE 20
(TO-72)

PNP germanium epitaxial mesa transistors for TV and FM, RF and IF amplifier, oscillator and general purpose high-gain, low-noise amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	2N3283 2N3284	2N3285 2N3286	Unit
Collector-Emitter Voltage	V_{CES}	25	20	Vdc
Collector-Base Voltage	V_{CB}	25	20	Vdc
Emitter-Base Voltage	V_{EB}	0.5		Vdc
Collector Current	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	100 1.33		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		°C





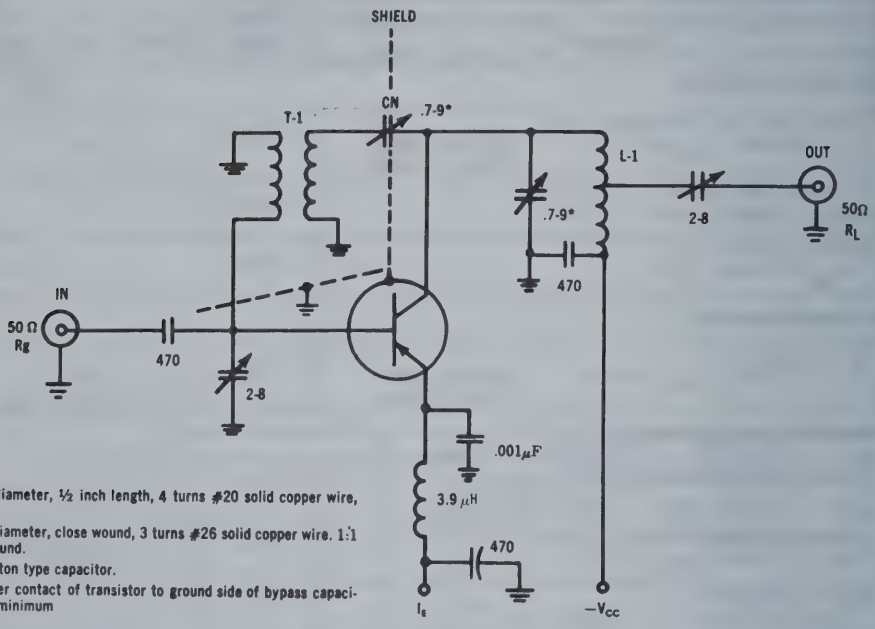
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	2N3283, 2N3284 2N3285, 2N3286	BV_{CES}	25 20	30 25	- -	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	-	2.0	10	μAdc
Emitter Cutoff Current (V_{BE} = 0.5 Vdc, I_C = 0)		I_{EBO}	-	-	100	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)	2N3283, 2N3284 2N3285, 2N3286	h_{FE}	10 5.0	30 15	- -	-
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	250	400	800	MHz
Maximum Frequency of Oscillation (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)		f_{max}	-	2000	-	MHz
Output Capacitance* (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}*	-	1.0	1.5	pF
Small-Signal Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3283, 2N3284 2N3285, 2N3286	h_{fe}	10 5.0	- -	200 200	-
Collector-Base Time Constant (I_E = 3.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)		$r_b'C_c$	-	10	25	ps
Noise Figure (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)	2N3283 2N3284 2N3286	NF	- - -	4.0 5.0 5.0	5.0 6.0 -	dB
FUNCTIONAL TESTS						
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 3.0 mAdc, f = 200 MHz)	2N3283, 2N3284 2N3286	G_{pe}	16 14	20 -	23 -	dB
Power Gain (AGC)** (V_{CE} = 5.0 Vdc, I_C = 20 mAdc, f = 200 MHz, Figure 1)	2N3283 2N3284	G_{pe}(AGC)**	- -	- 0	0 -	dB
Power Output (V_{EE} = 12 Vdc, f = 247 MHz)	2N3285	P_{out}	2.0	-	-	mW

* C_{ob} is measured in a guarded circuit such that the can capacitance is not included.

** AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = 10 Vdc and I_C = 3.0 mAdc operation.

FIGURE 1 — 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



NOTES:

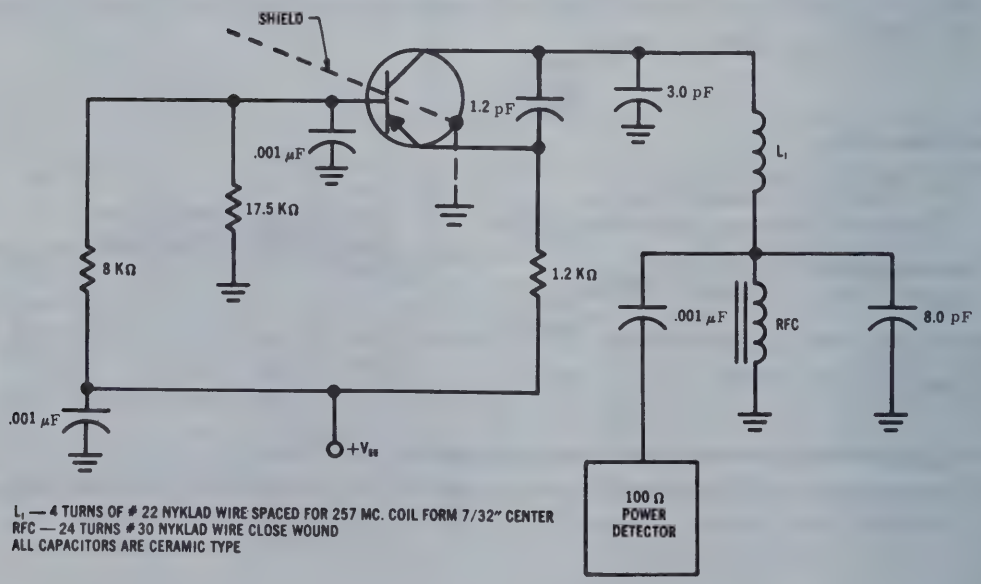
L-1 ¼ inch inside diameter, ½ inch length, 4 turns #20 solid copper wire, center tapped.

T-1 ¼ inch inside diameter, close wound, 3 turns #26 solid copper wire. 1:1 ratio bi-filler wound.

* High Quality piston type capacitor.

Distance from emitter contact of transistor to ground side of bypass capacitor should be kept minimum

FIGURE 2 — 257 MHz OSCILLATOR POWER OUTPUT TEST CIRCUIT



L_1 — 4 TURNS OF # 22 NYKLAD WIRE SPACED FOR 257 MC. COIL FORM 7/32" CENTER
RFC — 24 TURNS # 30 NYKLAD WIRE CLOSE WOUND
ALL CAPACITORS ARE CERAMIC TYPE

2N3287 thru 2N3290 (SILICON)



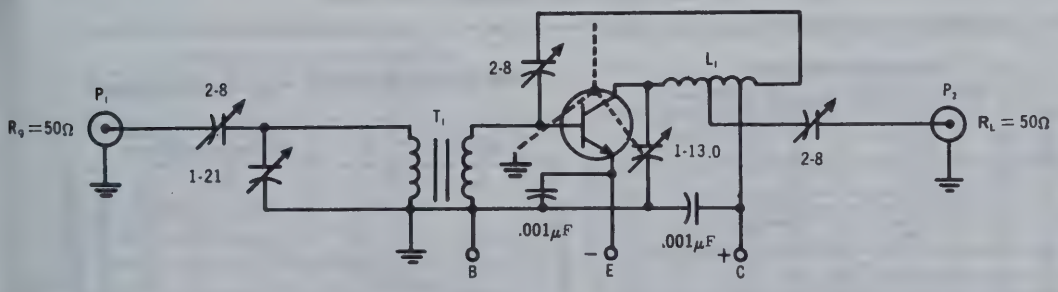
CASE 20
(TO-72)

NPN silicon annular transistors for high-gain, low-noise amplifier, oscillator, mixer and frequency multiplier applications.

MAXIMUM RATINGS

Rating	Symbol	2N3287 2N3288	2N3289 2N3290	Unit
Collector - Base Voltage	V_{CB}	40	30	Volts
Collector - Emitter Voltage	V_{CES}	40	30	Volts
Collector - Emitter Voltage	V_{CEO}	20	15	Volts
Emitter - Base Voltage	V_{EB}	3.0	3.0	Volts
Collector Current	I_C	50	50	mA
Power Dissipation at 25°C Case Above 25°C derate 1.71 mW/°C	P_D	300	300	mW
Power Dissipation at 25° C amb. Above 25°C derate 1.14 mW/°C	P_D	200	200	mW
Junction Temperature	T_J,	+200	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	-65 to +200	°C

200 MHz TEST CIRCUIT: POWER GAIN, NOISE FIGURE, & AGC



L_1-6 turns of #16 tinned wire; 3/8" ID; Air wound; winding length 3/4"; V_{CC} feeds tap 4 3/4 turns from collector end; output tap 3 1/2 turns from collector end.

T_1-3 turns primary and secondary Bifilar wound (close wound) on 1/4" ceramic form (cambion type) with brass slug. #22 enameled wire.

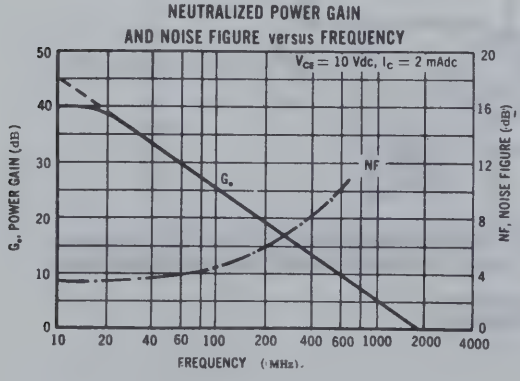
P_1-General Radio 874 G6 Pad (6dB)
P_2-General Radio 874 G6 Pad (6dB)

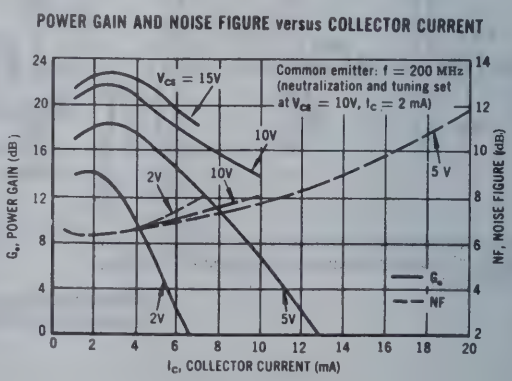
ELECTRICAL CHARACTERISTICS (At 25°C Ambient unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 10 μAdc, I_E = 0				Vdc
		2N3287, 2N3288	40	—	—	
		2N3289, 2N3290	30	—	—	
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 10 μAdc, V_{BE} = 0				Vdc
		2N3287, 2N3288	40	—	—	
		2N3289, 2N3290	30	—	—	
Collector-Emitter Breakdown Voltage	BVCEO	I_C = 2.0 mAdc, I_B = 0				Vdc
		2N3287, 2N3288	20	—	—	
		2N3289, 2N3290	15	—	—	
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E = 10 μAdc, I_C = 0	3.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc All Types	—	—	.010	μAdc
		V_{CB} = 15 Vdc, T = 150°C 2N3287, 2N3288	—	—	3.0	
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} = 10 Vdc, I_C = 2 mAdc				—
		2N3287, 2N3288	15	—	100	
		2N3289, 2N3290	10	—	150	
Collector-Emitter Saturation Voltage	V_{CE} (sat)	I_C = 5 mAdc, I_B = 0.5 mAdc				Vdc
		2N3287, 2N3288	—	—	0.3	
		2N3289, 2N3290	—	—	0.4	
Base-Emitter Saturation Voltage	V_{BE} (sat)	I_C = 5 mAdc, I_B = 0.5 mAdc				Vdc
		2N3287, 2N3288	—	—	0.9	
		2N3288, 2N3290	—	—	1.0	
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 1 kHz				—
		2N3287, 2N3288	15	—	150	
		2N3289, 2N3290	10	—	200	
Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz(Note 1)				pF
		2N3287	—	0.9	1.1	
		2N3288 thru 2N3290	—	1.2	1.5	
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 2 mAdc, f = 31.8 MHz				ps
		2N3287, 2N3288	3	8	15	
		2N3289, 2N3290	3	8	20	
Current Gain - Bandwidth Product	f_T	V_{CE} = 10 Vdc, I_C = 2 mAdc				MHz
		2N3287, 2N3288	350	600	1200	
		2N3289, 2N3290	300	500	1200	
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 2 mAdc	—	2000	—	MHz
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 MHz				dB
		All Types	17	—	24	
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 MHz				dB
		2N3287, 2N3288	—	4.9	6.0	
		2N3289, 2N3290	—	6.0	7.0	
Power Gain (AGC)	G_e	V_{CE} = 5.0 Vdc, I_C = 20 mAdc, f = 200MHz(Note 2)				dB
		2N3287	—	—	0	
		2N3289	—	—	+5	
		2N3288, 2N3290	—	0	—	

Note 1. C_{ob} is measured in guarded circuit such that the can capacitance is not included.

Note 2. AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = 10 Vdc, I_C = 2 mAdc operation.





2N3291 thru 2N3294 (SILICON)

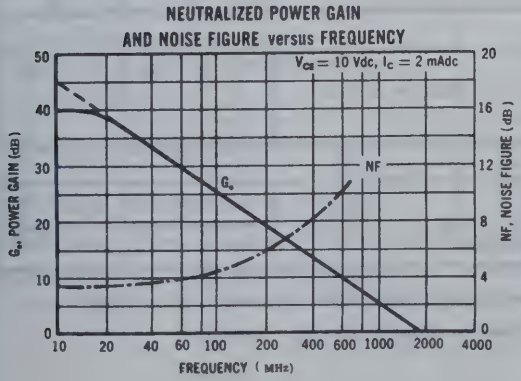
NPN silicon annular transistor for TV and FM mixer, RF and IF amplifier and general-purpose, low-noise, high-gain amplifier applications.

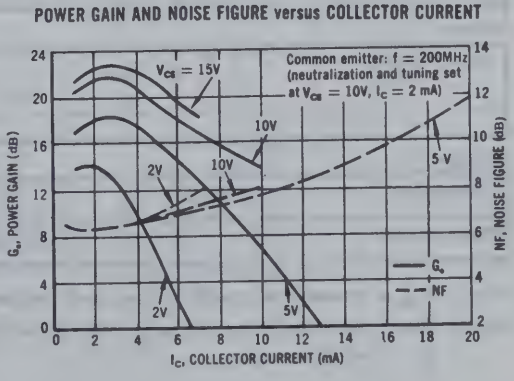


CASE 20
(TO-72)

MAXIMUM RATINGS

Rating	Symbol	2N3291 2N3292	2N3293 2N3294	Unit
Collector - Base Voltage	V_{CB}	25	20	Volts
Collector - Emitter Voltage	V_{CES}	25	20	Volts
Emitter - Base Voltage	V_{EB}	3.0	3.0	Volts
Collector Current	I_C	50	50	mA
Power Dissipation at 25°C Case Above 25°C derate 1.71 mW/°C	P_D	300	300	mW
Power Dissipation at 25°C Amb. Above 25°C derate 1.14 mW/°C	P_D	200	200	mW
Junction Temperature	T_J	+200	+200	°C
Storage Temperature Range	T_{stg}	← -65 to +200 →		°C





ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 25 μAdc, V_{BE} = 0 2N3291, 2N3292 2N3293, 2N3294	 25 20	 35 30	 — —	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 Vdc, I_E = 0	—	.01	0.1	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 0.5 Vdc, I_C = 0	—	—	100	μAdc
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} = 10 Vdc, I_C = 2 mAdc	10	—	—	—
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 1 kHz	10	—	200	—
Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz, Note 1	—	1.0	2.0	pF
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 10 Vdc, I_C = 2 mAdc f = 100 MHz	2.5	6.0	12	—
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 2 mAdc f = 31.8 MHz	—	15	30	ps
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 2 mA	—	2000	—	MHz
2N3291						
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 MHz	16	20	24	dB
Noise Figure	NF		—	6	8	dB
Power Gain (AGC)	G_e	Note 2 V_{CE} = 5 Vdc, I_C = 20 mAdc f = 200 MHz	—	—	0	dB
2N3292						
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc f = 200 MHz	16	20	24	dB
Noise Figure	NF		—	7	9	dB
Power Gain (AGC)	G_e	Note 2 V_{CE} = 5 Vdc, I_C = 20 mAdc f = 200 MHz	—	0	—	dB
2N3293						
Power Output	P_{out}	V_{EE} = -11 Vdc, f = 257 MHz	2	—	—	mW
2N3294						
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc f = 200 MHz	14	—	—	dB
Noise Figure	NF		—	7	—	dB

Note 1. C_{ob} is measured in guarded circuit such that the can capacitance is not included.

Note 2. AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = 10 Vdc, I_C = 2 mAdc operation.

2N3295 (SILICON)



CASE 31
(TO-5)

NPN silicon annular Star transistor for linear amplifier applications from 2 to 100 MHz.

Collector connected to case

MAXIMUM RATINGS*

Rating	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current (Continuous)	I_C	250	mAdc
Base Current (Continuous)	I_B	50	mAdc
Total Device Dissipation (25°C Case Temperature) Derate above 25°C	P_D	2 13.3	Watts mW/°C
Total Device Dissipation (25°C Ambient Temperature) Derate above 25°C	P_D	0.8 5.33	Watts mW/°C
Junction Temperature Range	T_J	-65 to 175	°C
Storage Temperature Range	T_{stg}	-65 to 175	°C

*The maximum ratings as given for DC conditions can be exceeded on a pulse basis. See Electrical Characteristics.

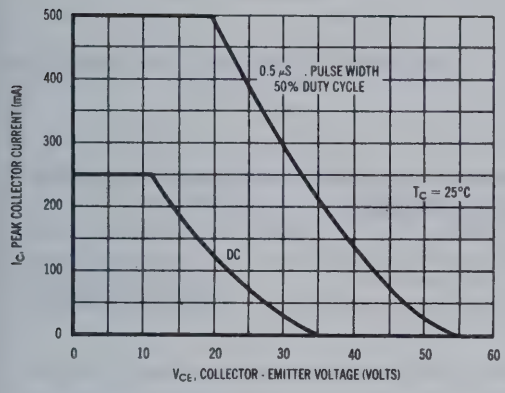
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Min	Typ	Max	Unit
Collector-Emitter Current	I_{CES}	V_{CE} = 60Vdc, V_{BE} = 0	--	--	100	μ Adc
		V_{CE} = 50Vdc, V_{BE} = 0, T_C = 175°C	--	--	500	μ Adc
Collector Cutoff Current	I_{CBO}	V_{CB} = 50Vdc, I_E = 0	--	--	0.1	μ Adc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 5 Vdc, I_C = 0	--	--	100	μ Adc
DC Current Gain	h_{FE}	I_C = 10mAdc, V_{CE} = 10Vdc	20	--	60	--
		I_C = 150mAdc, V_{CE} = 10Vdc *	20	--	--	--
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 150mAdc, I_B = 15mAdc	--	--	0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 150mAdc, I_B = 15mAdc	--	--	2.0	Vdc
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	I_C = 100mA, R_{BE} = 0	30	--	--	Volts
Collector-Emitter Open Base Sustain Voltage	$V_{CEO(sus)}$*	I_C = 100mA, I_B = 0	20	--	--	Volts
AC Current Gain	$\lvert h_{fe} \rvert$	V_{CE} = 10Vdc, I_C = 10mAdc, f=50 MHz	4.0	--	--	--
Collector Output Capacitance	C_{ob}	V_{CB} = 10Vdc, I_E = 0, f = 100 kHz	--	--	8	pF
Power Input (PEP) (Note 1)	P_{in}	P_{out} = 0.3 Watts PEP (0.15 W rms) f = 30MHz V_{CE} = 15.0Vdc $I_{C(max)}$ = 40mA	--	--	12	mW
Power Gain	G_e		14	17	--	dB
Intermodulation Distortion Ratio	I_m		30	32	--	dB
Efficiency	η		25	30	--	%

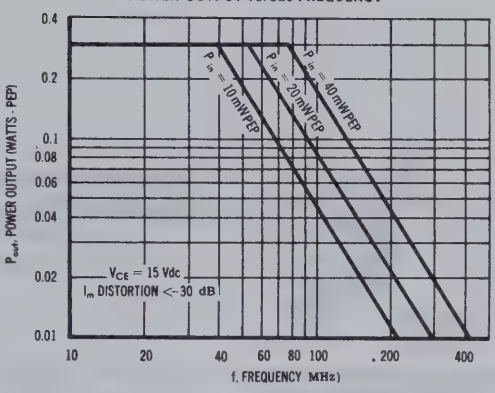
* Pulse Test: Pulse Width = 100μs, Duty Cycle = 2 %

Note 1. PEP. Peak Envelope Power

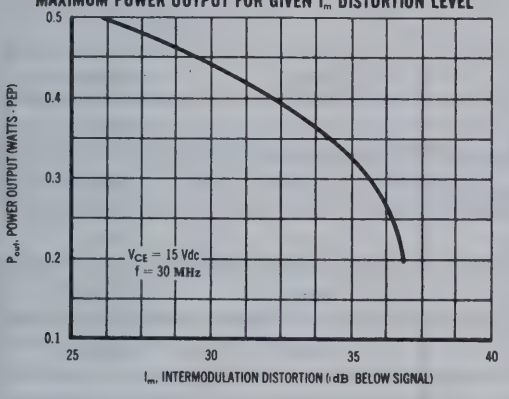
SAFE OPERATING AREA



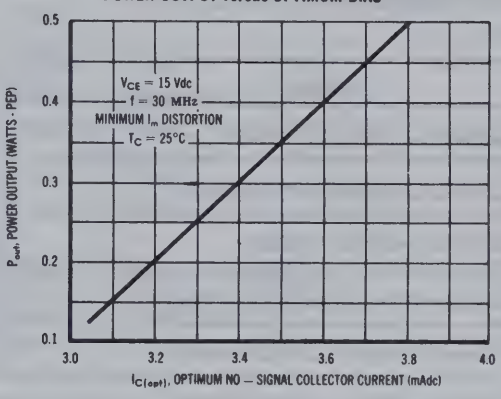
POWER OUTPUT versus FREQUENCY



MAXIMUM POWER OUTPUT FOR GIVEN I_m DISTORTION LEVEL

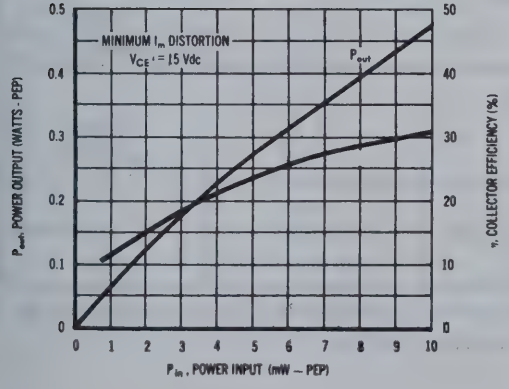


POWER OUTPUT versus OPTIMUM BIAS

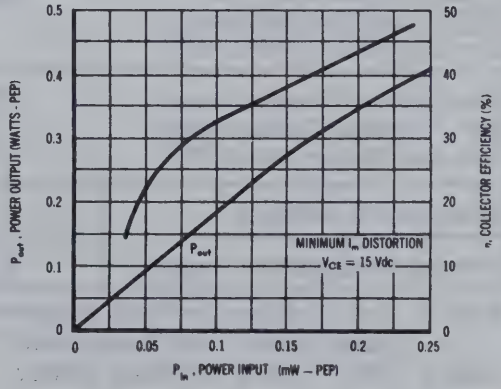


OUTPUT CHARACTERISTICS versus POWER INPUT

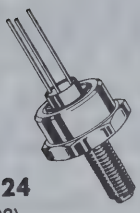
30 MHz



4 MHz



2N3296 (SILICON)



CASE 24
(TO-102)
Collector connected to case; stud isolated from case

NPN silicon annular transistor for linear amplifier applications from 2 to 100 MHz.

MAXIMUM RATINGS (Note 1)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current (Continuous)	I_C	700	mAdc
Base Current (Continuous)	I_B	100	mAdc
RF Input Power (Note 2)	P_{in}	1.0	Watt (PEP)
RF Output Power (Note 2)	P_{out}	5.0	Watts (PEP)
Total Device Dissipation (25°C Case Temperature) Derating Factor above 25°C	P_D	6.0 40	Watts mW/°C
Total Device Dissipation at (25°C Ambient Temperature) Derating Factor above 25°C	P_D	0.7 4.67	Watts mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

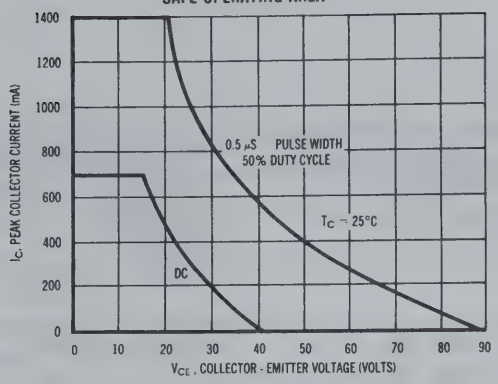
Note 1: The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See Electrical Characteristics.
Note 2: PEP = Peak Envelope Power.

ELECTRICAL CHARACTERISTICS

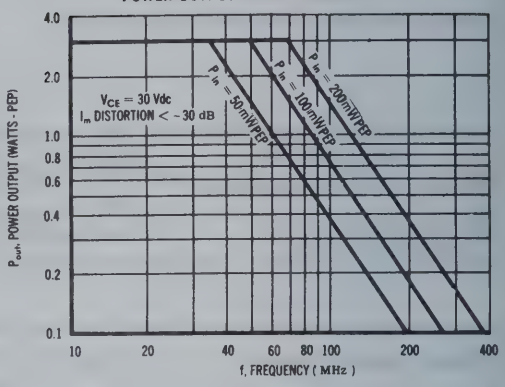
Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	I_C = 0.200A, R_{BE} = 0	85	120	--	Volts
Collector Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}$*	I_C = 0.200A, I_B = 0	40	--	--	Volts
Collector-Emitter Current	I_{CES}	V_{CE} = 60Vdc, V_{BE} = 0	--	--	100	μAdc
		V_{CE} = 50Vdc, V_{BE} = 0, T_C = +175°C	--	--	500	
Collector-Cutoff Current	I_{CBO}	V_{CB} = 50Vdc, I_E = 0	--	--	0.1	μAdc
Emitter-Cutoff Current	I_{EBO}	V_{EB} = 3Vdc, I_C = 0	--	--	100	μAdc
DC Current Gain	h_{FE}	V_{CE} = 2.0Vdc, I_C = 40mAdc	5.0	--	50	--
		V_{CE} = 2.0Vdc, I_C = 400mAdc	5.0	--	--	--
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 400mAdc, I_B = 80mAdc	--	--	0.5	Vdc
Emitter-Base Saturation Voltage	$V_{BE(sat)}$	I_C = 400mAdc, I_B = 80mAdc	--	--	2.0	Vdc
AC Current Gain	$\lvert h_{fe} \rvert$	V_{CE} = 2.0Vdc, I_C = 40mAdc, f = 50MHz	2.0	--	--	--
Collector Output Capacitance	C_{ob}	V_{CB} = 25Vdc, I_E = 0, f = 100kHz	--	--	20	pF
Power Input (PEP) (Note 2)	P_{in}	P_{out} = 3.0 Watts (PEP) (1.5 W rms) V_{CE} = 30 Volts, f = 30 MHz $I_{C(max)}$ = 125 mA	--	--	75	mW
Power Gain	G_e		16	19	--	dB
Intermodulation Distortion Ratio	I_m		30	35	--	dB
Efficiency	η		40	48	--	%

*Pulse Test. Pulse Width = 100 μsec. Duty Cycle = 2%.
Note 2 PEP. Peak Envelope Power.

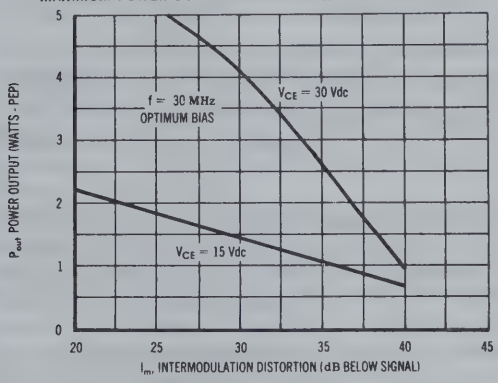
SAFE OPERATING AREA



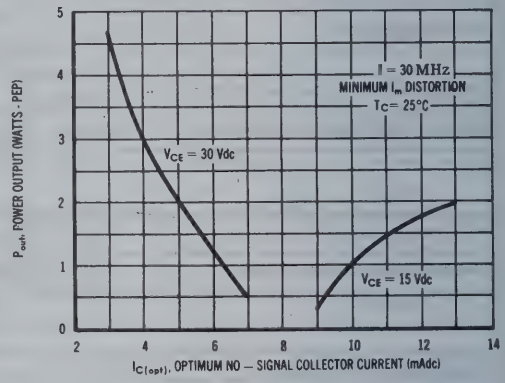
POWER OUTPUT versus FREQUENCY



MAXIMUM POWER OUTPUT FOR GIVEN I_m DISTORTION LEVEL

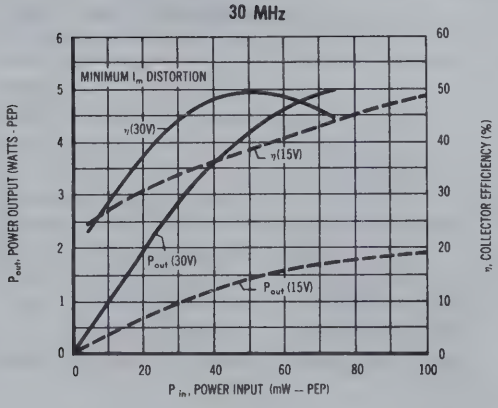


POWER OUTPUT versus OPTIMUM BIAS

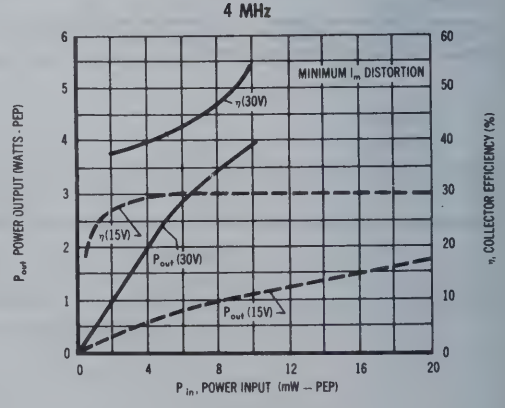


OUTPUT CHARACTERISTICS versus POWER INPUT

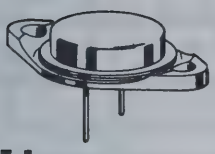
30 MHz



4 MHz



2N3297 (SILICON)



CASE 1
(TO-3)

NPN silicon annular transistor for linear amplifier applications for 2 to 100 MHz.

Collector connected to case

MAXIMUM RATINGS *

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	3	Vdc
Collector Current (Continuous)	I_C	1.5	Adc
Base-Current (Continuous)	I_B	500	mAdc
Power Input (PEP)	P_{in}	5.0	Watts (PEP)
Power Output (PEP)	P_{out}	20.0	Watts (PEP)
Total Device Dissipation @ 25°C Case Temperature Derating Factor above 25°C	P_D	25.0 167	Watts mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

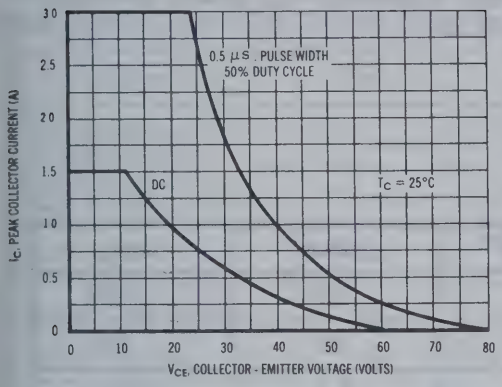
* The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See electrical characteristics

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

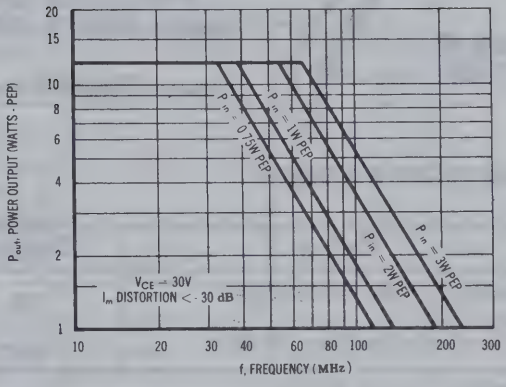
Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	I_C = 0.250A, R_{BE} = 0	80	100	--	Volts
Collector Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}$*	I_C = 0.250A, I_B = 0	40	--	--	Volts
Collector-Emitter Current	I_{CES}	V_{CE} = 60Vdc, V_{BE} = 0 V_{CE} = 50Vdc, V_{BE} = 0, T_C = +175°C	-- --	-- --	0.5 1.0	mAdc
Collector-Cutoff Current	I_{CBO}	V_{CB} = 50Vdc, I_E = 0	--	--	1.0	μAdc
Emitter-Cutoff Current	I_{EBO}	V_{EB} = 3Vdc, I_C = 0	--	--	100	μAdc
DC Current Gain	h_{FE}	I_C = 400mAdc, V_{CE} = 2Vdc I_C = 1Adc, V_{CE} = 2Vdc	2.5 2.5	-- --	35 --	--
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 1Adc, I_B = 500mAdc	--	--	0.5	Vdc
Emitter-Base Saturation Voltage	$V_{BE(sat)}$	I_C = 1Adc, I_B = 500mAdc	--	--	2.0	Vdc
AC Current Gain	$\lvert h_{fe} \rvert$	V_{CE} = 2Vdc, I_C = 400mAdc, f = 50MHz	2.0	--	--	--
Collector Output Capacitance	C_{ob}	V_{CB} = 25Vdc, I_E = 0, f = 100kHz	--	--	60	pF
Power Input (PEP) Note 2	P_{in}	P_{out} = 12 Watts PEP (6.0W rms) V_{CE} = 30 Volts, f = 30MHz $I_{C(max)}$ = 0.50 Amp	--	--	1.2	Watts PEP
Power Gain	G_e		10	13	--	dB
Intermodulation Distortion Ratio	I_m		30	33	--	dB
Efficiency	η		40	45	--	%

* Pulse Test: Pulse Width = 100μs, Duty Cycle = 2 %
Note 2. PEP. Peak Envelope Power

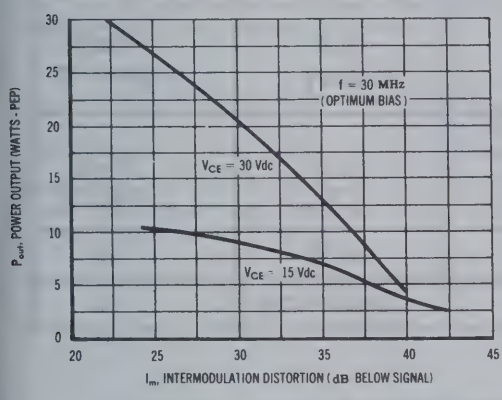
SAFE OPERATING AREA



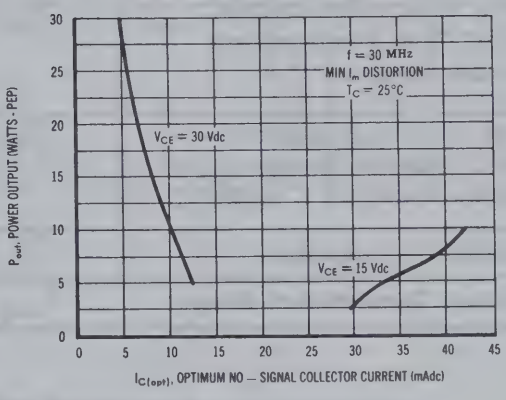
POWER OUTPUT versus FREQUENCY



MAXIMUM POWER OUTPUT FOR GIVEN I_m DISTORTION LEVEL

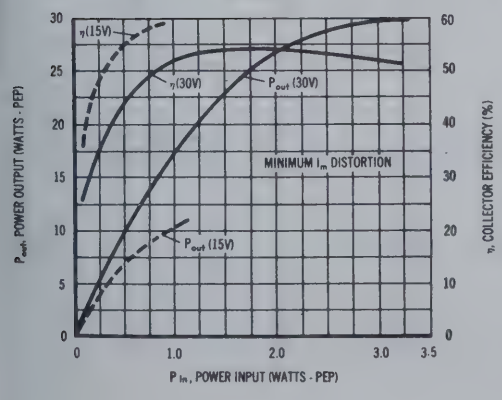


POWER OUTPUT versus OPTIMUM BIAS

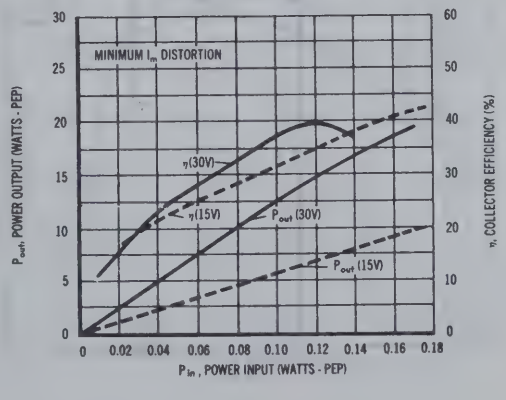


OUTPUT CHARACTERISTICS versus POWER INPUT

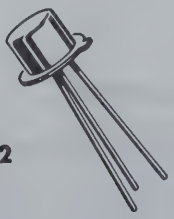
30 MHz



4 MHz



2N3298 (SILICON)



CASE 22
(TO-18)

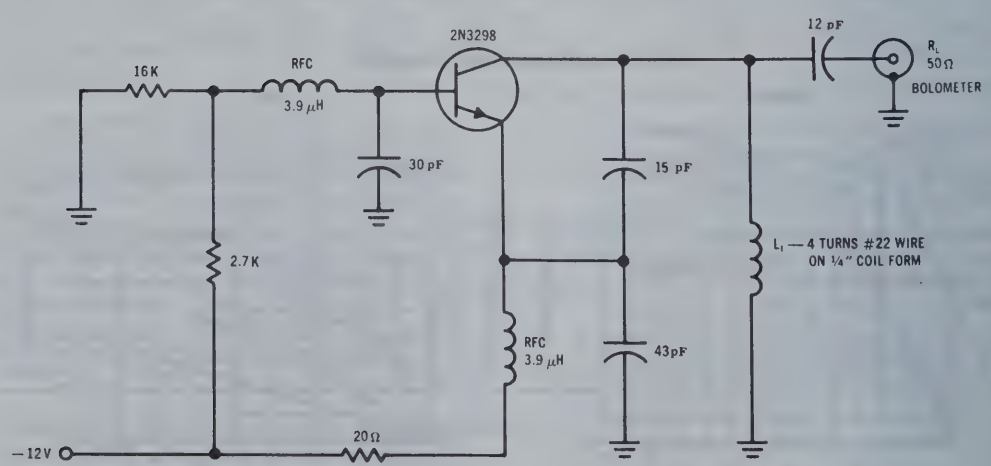
NPN silicon annular transistor for power oscillator applications to 150 MHz.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	100	mA
Total Device Dissipation (25°C Case Temperature) Derate Above 25°C	P_D	 1.0 6.67	 Watt mW/°C
Total Device Dissipation (25°C Ambient Temperature) Derate Above 25°C 2mW/°C	P_D	 0.3 2	 Watt mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

80 MHz OSCILLATOR POWER OUTPUT TEST CIRCUIT

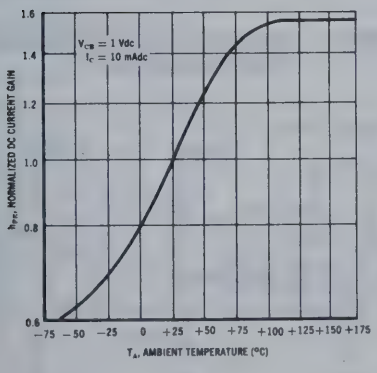


ELECTRICAL CHARACTERISTICS (At 25°C Ambient unless otherwise noted)

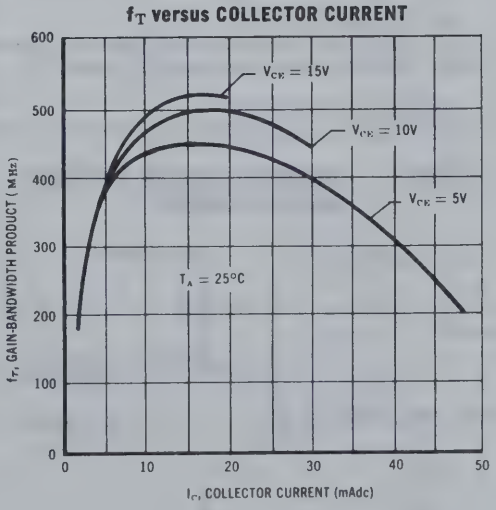
Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C=25 μAdc, V_{BE}=0	25	35	-	Vdc
Collector-Emitter Open Base Sustaining Voltage	$BV_{CEO(sus)}$*	I_C=10mA, I_B=0	15	24	-	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB}=10 Vdc, I_E=0 V_{CB}=10 Vdc, I_E=0, T_A=150°C	- -	0.01 10	0.5 50	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB}=3 Vdc, I_C = 0	-	-	10	μAdc
DC Current Gain	h_{FE}	V_{CE}=1 Vdc, I_C=10 mAdc	60	90	120	-
AC Current Gain	$\|h_{fe}\|$	V_{CE}=10 Vdc, I_C=10mAdc, f=100 MHz	2	-	-	-
Collector Output Capacitance	C_{ob}	V_{CB}=10 Vdc, I_E=0, f=100 kHz	-	5	6	pF
Power Output	P_{out}	f=80 MHz V_{CC}=12 Vdc $I_{C(max)}$=20 mA	60	-	100	mW
Efficiency	η		25	40	-	%

*Pulse Width = 300 μs, Duty Cycle = 2%

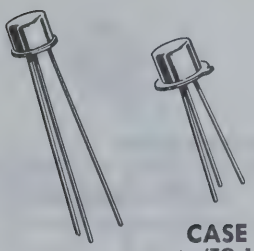
NORMALIZED DC CURRENT GAIN versus AMBIENT TEMPERATURE



f_T versus COLLECTOR CURRENT



2N3299 thru 2N3302 (SILICON)



CASE 31
(TO-5)
2N3299
2N3300

CASE 22
(TO-18)
2N3301
2N3302

NPN silicon annular transistors for high-speed switching circuits and DC to UHF amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage (Applicable 0 to 10 mAdc)	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	500		mAdc
Operating Junction Temperature Range	T_J	-65 to +200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		2N3299 2N3300	2N3301 2N3302	
Total Device Dissipation @ T_A = 25°C	P_D	0.8	0.36	Watt
Derate above 25°C		4.56	2.06	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	3.0	1.8	Watts
Derate above 25°C		17.2	10.3	mW/°C

FIGURE 1 — SATURATED TURN-ON SWITCHING TIME TEST CIRCUIT

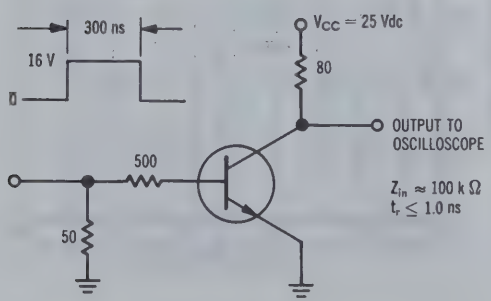
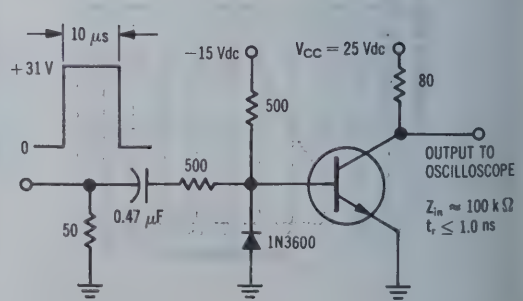


FIGURE 2 — SATURATED TURN-OFF SWITCHING TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	30	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, V_{BE} = 0)		I_{CES}	-	0.01	μAdc
(V_{CE} = 50 Vdc, V_{BE} = 0, T_A = 150°C)			-	10	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	10	nAdc
Base Current (V_{CE} = 50 Vdc, V_{BE} = 0)		I_B	-	10	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N3299, 2N3301		20	-	
	2N3300, 2N3302		35	-	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N3299, 2N3301		25	-	
	2N3300, 2N3302		50	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)*	2N3299, 2N3301		35	-	
	2N3300, 2N3302		75	-	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)*	2N3299, 2N3301		20	-	
	2N3300, 2N3302		50	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*	2N3299, 2N3301		40	120	
	2N3300, 2N3302		100	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)*	2N3299, 2N3301		20	-	
	2N3300, 2N3302		50	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			-	0.22	
(I_C = 300 mAdc, I_B = 30 mAdc)			-	0.45	
(I_C = 500 mAdc, I_B = 50 mAdc)			-	0.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			-	1.1	
(I_C = 300 mAdc, I_B = 30 mAdc)			-	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			-	1.5	
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	-	1.1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	250	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	-	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	-	20	pF
Turn-On Time (Figure 1) (V_{CC} = 25 Vdc, I_C ≈ 300 mAdc, I_{B1} ≈ 30 mAdc)		t_{on}	-	60	ns
Turn-Off Time (Figure 2) (V_{CC} = 25 Vdc, I_C ≈ 300 mAdc, I_{B1} = I_{B2} ≈ 30 mAdc)		t_{off}	-	150	ns

* Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%.

2N3303 (SILICON)



CASE 94

NPN silicon annular transistor designed for high-speed, high-current switching and driving applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current-Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.43	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3 17.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage* (I_C = 30 mAdc, I_B = 0)	BV_{CEO}*	12	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.5 mAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	4	-	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	-	100	μAdc
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_B	-	100	μAdc

*Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2%

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc)		20	-	
(I_C = 100 mAdc, V_{CE} = 0.5 Vdc)*		30	-	
(I_C = 300 mAdc, V_{CE} = 0.5 Vdc)*		30	120	
(I_C = 300 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C)*		10	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		-	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)*		-	0.23	
(I_C = 300 mAdc, I_B = 30 mAdc)*		-	0.33	
(I_C = 300 mAdc, I_B = 30 mAdc, T_A = 125°C)*		-	0.50	
(I_C = 1 Adc, I_B = 100 mAdc)*		-	0.70	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		-	0.78	
(I_C = 100 mAdc, I_B = 10 mAdc)*		-	1.10	
(I_C = 300 mAdc, I_B = 30 mAdc)*		-	1.30	
(I_C = 1 Adc, I_B = 100 mAdc)*		-	2.1	
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5 Vdc, f = 100 MHz)	f_T	450	-	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	25	pF
Turn-On Time (Figure 1) ($V_{EB(off)} \approx$ 4 Vdc, $I_C \approx$ 1 Adc, $I_{B1} \approx$ 100 mAdc)	t_{on}	-	15	ns
Turn-Off Time (Figure 1) ($I_C \approx$ 1 Adc, $I_{B1} \approx I_{B2} \approx$ 100 mAdc)	t_{off}	-	25	ns
Storage Time (Figure 2) ($I_C \approx$ 100 mAdc, $I_{B1} \approx I_{B2} \approx$ 100 mAdc)	t_s	-	15	ns

*Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2%

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT

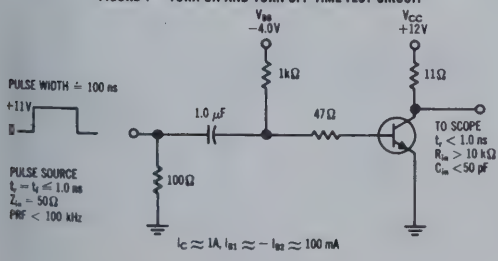
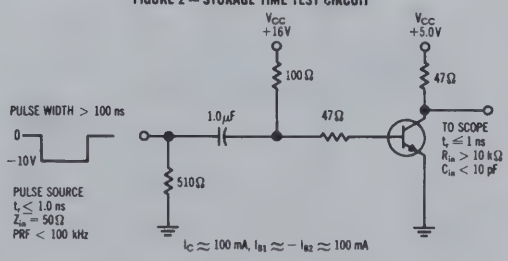


FIGURE 2 – STORAGE TIME TEST CIRCUIT



2N3304 (SILICON)



PNP silicon annular transistor designed for low-level, high-speed switching applications.

Collector connected to case

CASE 22
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	6	Vdc
Collector-Base Voltage	V_{CB}	6	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.72	mW mW/°C
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	500 5	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to+200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	6		Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	6	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	6	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4	—	Vdc
Collector-Cutoff Current (V_{CE} = 3 Vdc, V_{BE} = 0)	I_{CES}	—	0.01	μAdc
(V_{CE} = 3 Vdc, V_{BE} = 0, T_A = +125°C)		—	10	
Base Current (V_{CE} = 3 Vdc, V_{BE} = 0)	I_B	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 1 mAdc, V_{CE} = 0.5 Vdc)	h_{FE}*	15	—	—
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc, T_A = -55°C)		12	—	
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)		30	120	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		20	—	
Collector-Emitter Saturation Voltage (I_C = 1 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	—	0.15	Vdc
(I_C = 10 mAdc, I_B = 1 mAdc, T_A = +125°C)		—	0.23	
(I_C = 10 mAdc, I_B = 1 mAdc)		—	0.16	
(I_C = 50 mAdc, I_B = 5 mAdc)		—	0.5	
Base-Emitter Saturation Voltage (I_C = 1 mAdc, I_B = 0.1 mAdc)	$V_{BE(sat)}$	0.7	0.8	Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		0.8	1.0	
(I_C = 50 mAdc, I_B = 5 mAdc)		—	1.5	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	3.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	—	3.5	pF
Turn-On Time (Figure 1) (V_{CC} = 1.5 Vdc, V_{BB} = 6 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 0.5 mAdc)	t_{on}	—	60	ns
Turn-Off Time (Figure 1) (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 0.5 mAdc)	t_{off}	—	60	ns
Charge-Storage Time (Figure 2) (I_C = 10 mAdc, V_{CC} = 3 Vdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	—	30	ns

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

FIGURE 1 — TURN-ON & TURN-OFF TIME TEST CIRCUIT

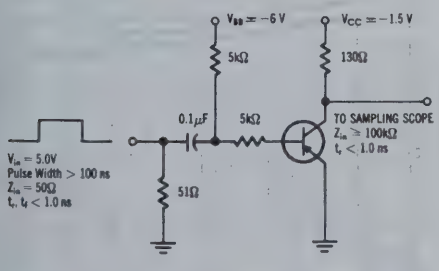
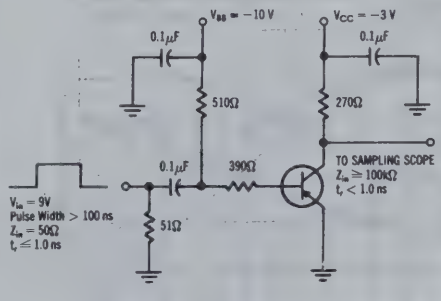


FIGURE 2 — CHARGE-STORAGE TIME TEST CIRCUIT



2N3307 (SILICON)
2N3308



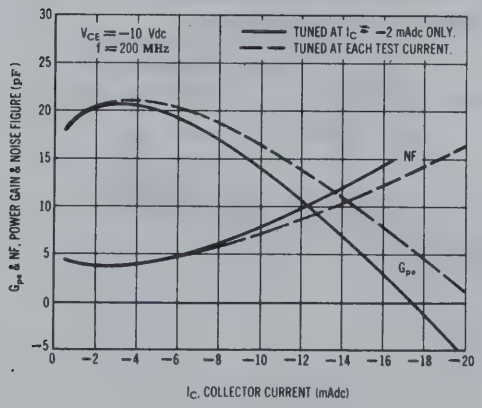
CASE 20
(TO-72)

PNP silicon annular transistors for high-gain, low-noise amplifier, oscillator, mixer and frequency multiplier applications.

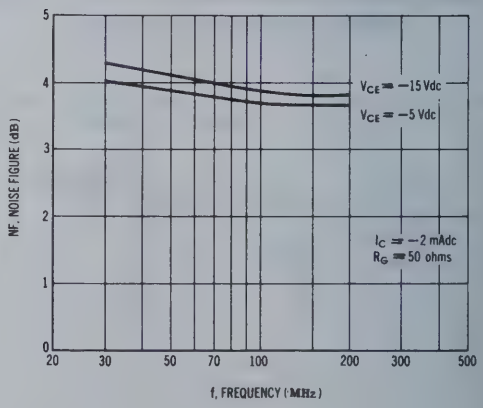
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		2N3307	2N3308	
Collector-Base Voltage	V_{CB}	40	30	Vdc
Collector-Emitter Voltage	V_{CES}	40	30	Vdc
Collector-Emitter Voltage	V_{CEO}	35	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current	I_C	50		mAdc
Power Dissipation at T_C = 25°C Derate above 25°C	P_D	300 1.71		mW mW/°C
Power Dissipation at T_A = 25°C Derate above 25°C	P_D	200 1.14		mW mW/°C
Junction Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

COMMON EMITTER AVERAGE SMALL POWER GAIN & NOISE FIGURE versus COLLECTOR CURRENT



NOISE FIGURE versus FREQUENCY



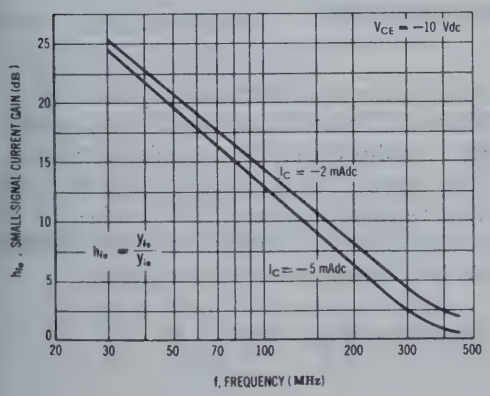
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions		Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 10 μAdc, I_E = 0	2N3307 2N3308	40 30	— —	— —	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 10 μAdc, V_{BE} = 0	2N3307 2N3308	40 30	— —	— —	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	I_C = 2.0 mAdc, I_B = 0	2N3307 2N3308	35 25	— —	— —	Vdc
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E = 10 μAdc, I_C = 0	Both Types	3.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc V_{CB} = 15 Vdc, T = 150 °C	Both Types 2N3307	— —	0.001 0.5	0.010 3.0	μAdc
DC Current Gain	h_{FE}	V_{CE} = 10 Vdc, I_C = 2 mAdc	2N3307 2N3308	40 25	— —	250 250	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 3 mAdc, I_B = 0.6 mAdc	Both Types	—	—	0.4	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 3 mAdc, I_B = 0.6 mAdc	Both Types	—	—	1.0	Vdc
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 1 kHz	2N3307 2N3308	40 25	— —	250 250	—
Output Capacitance •	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz	2N3307 2N3308	— —	1.0 1.2	1.3 1.6	pF
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 2 mAdc, f = 31.8 MHz	2N3307 2N3308	2 2	— —	15 20	ps
Current Gain-Bandwidth Product	f_T	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 100 MHz	Both Types	300	—	1200	MHz
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 2 mAdc	Both Types	—	2000	—	MHz
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 MHz	Both Types	17	—	24	dB
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 MHz	2N3307 2N3308	— —	4.0 5.0	4.5 6.0	dB
Power Gain (AGC) ••	G_e	V_{CE} = 5.0 Vdc, I_C = 20 mAdc, f = 200 MHz	2N3307 2N3308	— —	— 0	0 —	dB

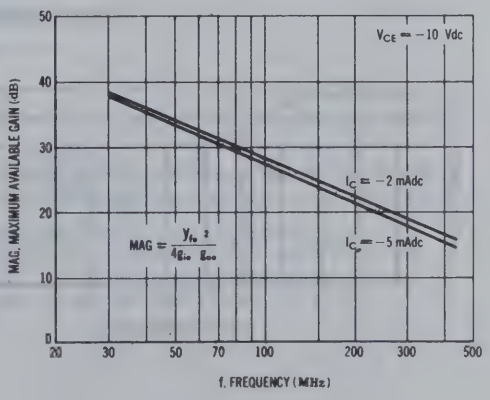
• C_{ob} is measured in guarded circuit such that the can capacitance is not included.

•• AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = -10 Vdc, I_C = -2 mAdc operation.

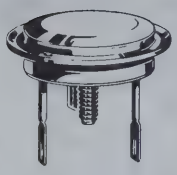
SMALL SIGNAL CURRENT GAIN versus FREQUENCY



MAXIMUM AVAILABLE GAIN versus FREQUENCY



2N3311 thru 2N3316 (GERMANIUM)



PNP germanium power transistors for high-power applications.

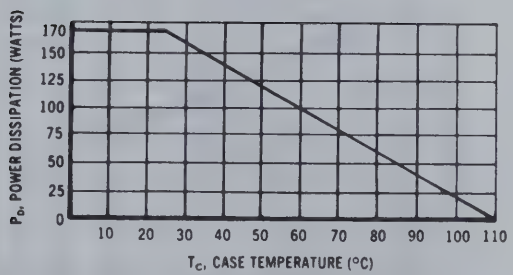
CASE 5
(TO-36)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N3311 2N3314	2N3312 2N3315	2N3313 2N3316	Unit
Collector-Base Voltage	V_{CB}	30	45	60	Volts
Collector-Emitter Voltage	V_{CES}	30	45	60	Volts
Collector-Emitter Voltage	V_{CEO}	20	30	40	Volts
Emitter-Base Voltage	V_{EB}	20	25	30	Volts
Collector Current (Continuous)	I_C	5.0			Amp
Power Dissipation at $T_C = 25^oC$	P_D	170			Watts
Junction Temperature Range	T_J	-65 to +110			^oC
Thermal Resistance	θ_{JC}	0.5			°C/W

POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 170 Watts at case temperatures of 25^oC and is 0 Watts at 110^oC with a linear relation between the two temperatures such that:

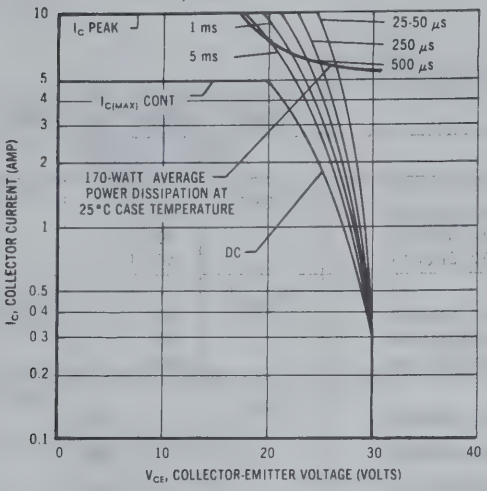
$$\text{allowable } P_D = \frac{110^o - Tc}{0.5}$$

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 500 mAdc, I_B = 0)	2N3311, 2N3314	BV_{CEO}*	20	-	Vdc
	2N3312, 2N3315		30	-	
	2N3313, 2N3316		40	-	
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc, V_{BE} = 0)	2N3311, 2N3314	BV_{CES}*	30	-	Vdc
	2N3312, 2N3315		45	-	
	2N3313, 2N3316		60	-	
Collector Cutoff Current (V_{CE} = 10 Vdc, I_B = 0)	2N3311, 2N3314	I_{CEO}	-	200	mAdc
(V_{CE} = 15 Vdc, I_B = 0)	2N3312, 2N3315		-	200	
(V_{CE} = 20 Vdc, I_B = 0)	2N3313, 2N3316		-	200	
Collector Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 1.0 Vdc, T_C = 100°C)	2N3311, 2N3314	I_{CEX}	-	35	mAdc
(V_{CE} = 40 Vdc, V_{BE} = 1.0 Vdc, T_C = 100°C)	2N3312, 2N3315		-	35	
(V_{CE} = 55 Vdc, V_{BE} = 1.0 Vdc, T_C = 100°C)	2N3313, 2N3316		-	35	
Collector-Base Cutoff Current (V_{CB} = $V_{CB\ max}$)		I_{CBO}	-	5.0	mAdc
(V_{CB} = 2.0 Vdc, I_E = 0)			-	0.3	
Emitter-Base Cutoff Current (V_{BE} = $V_{BE\ max}$, I_C = 0)		I_{EBO}	-	4.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CB} = 2.0 Vdc)	2N3311 thru 2N3313	h_{FE}	-	150	-
	2N3314 thru 2N3316		-	250	
(I_C = 3.0 Adc, V_{CB} = 2.0 Vdc)	2N3311 thru 2N3313		60	120	
	2N3314 thru 2N3316		100	200	
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc)		$V_{CE(sat)}$	-	0.1	Vdc
Base-Emitter Voltage (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N3311 thru 2N3313	$V_{BE(on)}$	-	0.6	Vdc
	2N3314 thru 2N3316		-	0.5	
DYNAMIC CHARACTERISTICS					
Common Emitter Cutoff Frequency (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		$f_{\alpha e}$	1.0	-	kHz
Small Signal Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc, f = 0.5 kHz)	2N3311 thru 2N3313	h_{fe}	30	90	-
	2N3314 thru 2N3316		40	120	

*To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.

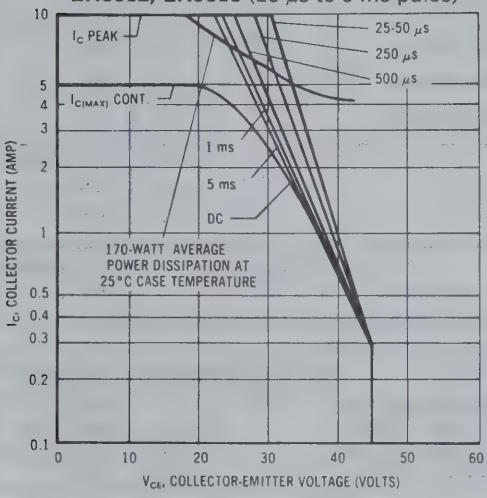
2N3311, 2N3314 (25 μsec to 5 msec pulse)



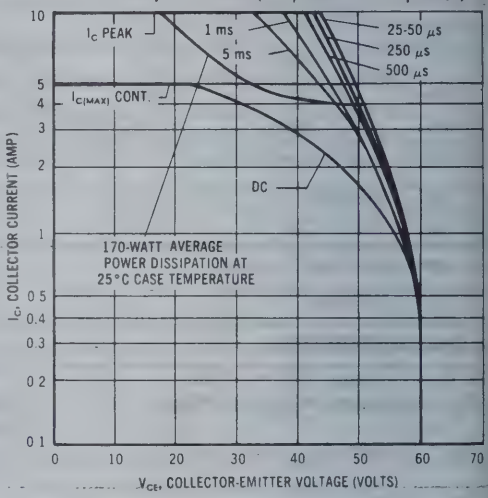
SAFE OPERATING AREA

The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. As the safe operating areas shown are independent of temperature and duty cycle, these curves can be used as long as the average power derating curve is also taken into consideration to insure operation below the maximum junction temperature.

2N3312, 2N3315 (25 μs to 5 ms pulse)

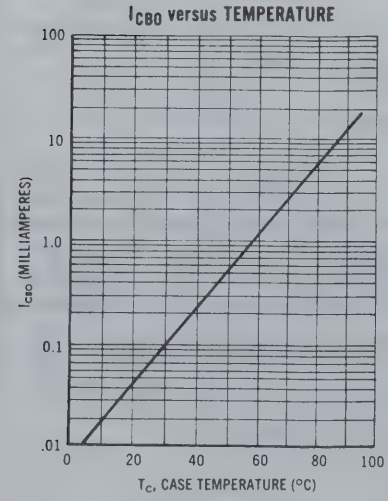


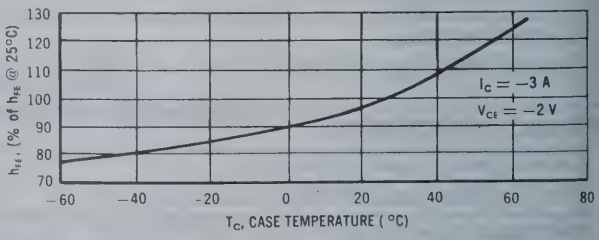
2N3313, 2N3316 (25 μs to 5 ms pulse)



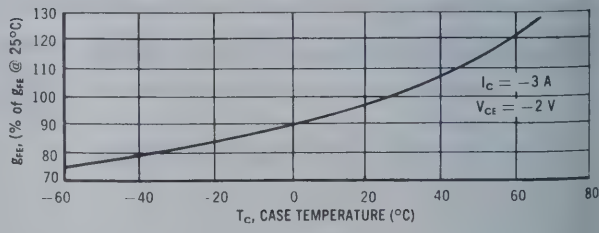
TEMPERATURE CHARACTERISTICS

I_{CBO} versus TEMPERATURE





DC TRANSCONDUCTANCE versus CASE TEMPERATURE



2N3323 (GERMANIUM)
2N3324
2N3325



CASE 22
(TO-18)

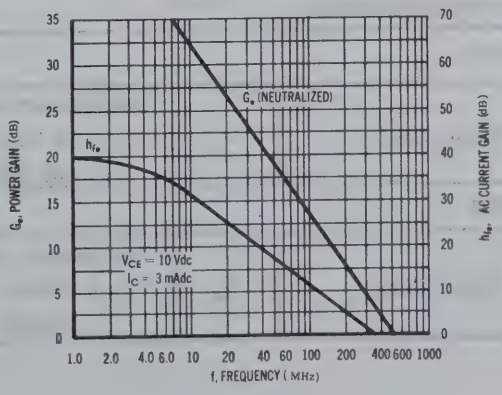
PNP germanium epitaxial transistors for FM RF, IF, mixer and oscillator and AM RF, IF and converter applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	35	Volts
Collector-Emitter Voltage	V_{CES}	35	Volts
Emitter-Base Voltage	V_{EB}	3.0	Volts
Collector Current	I_C	100	mA
Total Device Dissipation 25°C Case Temperature Derate Above 25°C	P_D	300 4	mW mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate Above 25°C	P_D	150 2	mW mW/°C
Junction Temperature	T_J	+100	°C
Storage Temperature Range	T_{stg}	-65 to +100	°C

POWER GAIN AND AC CURRENT GAIN versus FREQUENCY



ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CER}	I_C = 100 μAdc, R_{BE} = 10K	35	40	--	Vdc
Collector-Emitter Current	I_{CES}	V_{CE} = 35 Vdc, V_{BE} = 0	--	--	100	μAdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 Vdc, I_E = 0	--	0.5	10	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 2 Vdc, I_C = 0	--	--	100	μAdc
DC Current Gain	h_{FE}	V_{CE} = 10 Vdc, I_C = 3 mAdc	30	--	200	--
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 1 kHz	30	--	225	--
Current-Gain — Bandwidth Product	f_T	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 100 MHz	200	--	600	MHz
Collector-Base Time Constant	$r_b'C_C$	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 31.8 MHz	--	50	100	ps
Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz	--	2.2	3.0	pF
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 3mAdc	--	500	--	MHz
Input Resistance, Parallel Equivalent	R_{ie}	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 10 MHz	--	1200	--	ohms
Output Resistance, Parallel Equivalent	R_{oe}		--	11	--	kohms
Input Resistance, Parallel Equivalent	R_{ie}	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 100 MHz	--	100	--	ohms
Output Resistance, Parallel Equivalent	R_{oe}		--	1.0	--	kohms

2N3323

Power Gain	G_e	Test Circuit Figure 1, V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 100 MHz	11	--	15	dB

2N3324

Power Gain	G_e	Test Circuit Figure 2, V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 10 MHz	24	--	31	dB

FIGURE 1: 100 MHz POWER GAIN TEST CIRCUIT — 2N3323

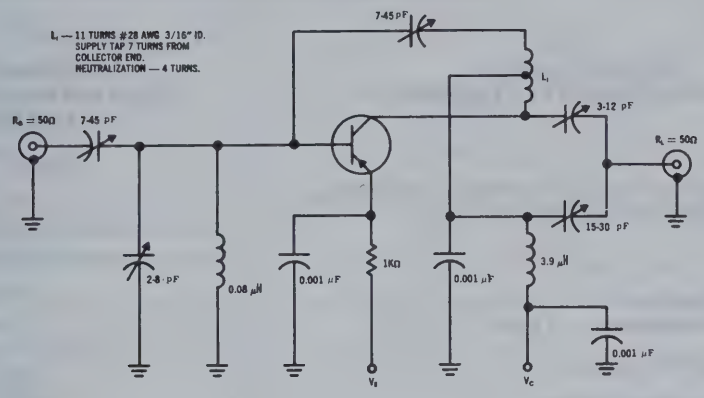
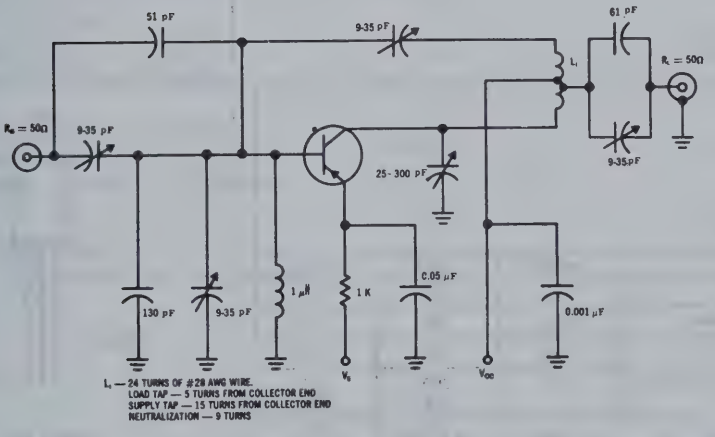


FIGURE 2: 10 MHz POWER GAIN TEST CIRCUIT — 2N3324



2N3330 (SILICON)

SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

Depletion Mode (Type A) Junction Field-Effect Transistor designed primarily for low-power audio-amplifier applications.

- High AC Input Resistance — Typically > 30 Megohms @ f = 1.0 kHz
- Drain and Source Interchangeable
- Active Elements Isolated from Case

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

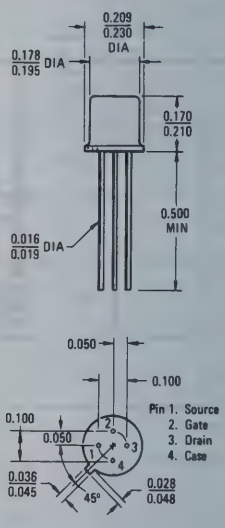
(Type A)



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
*Gate Current	I_G	10	mAdc
*Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
*Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



TO-72
CASE 20 (5)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	20	–	Vdc
Gate Reverse Current	I_{GSS}			nAdc
(V_{GS} = 10 Vdc, V_{DS} = 0)		–	10	
(V_{GS} = 10 Vdc, V_{DS} = 0, T_A = 150°C)		–	10	μAdc
Zero-Gate Voltage Drain Current (Note 1) (V_{DS} = -10 Vdc, V_{GS} = 0)	I_{DSS}	2.0	6.0	mAdc
ON CHARACTERISTICS				
Gate-Source Voltage (V_{DG} = -15 Vdc, I_D = 10 μAdc)	V_{GS}	–	6.0	Vdc
Drain-Source Resistance (I_D = 100 μAdc, V_{GS} = 0)	r_{DS}	–	800	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance (Note 1)	$\|y_{fs}\|$			μmhos
(V_{DS} = -10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)		1500	3000	
(V_{DS} = -10 Vdc, I_D = 2.0 mAdc, f = 10 MHz)		1350	–	
Output Admittance (V_{DS} = -10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)	$\|y_{os}\|$	–	40	μmhos
Reverse Transfer Conductance (V_{DS} = -10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)	$\|y_{rs}\|$	–	0.1	μmhos
Input Conductance (V_{DS} = -10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)	$\|y_{is}\|$	–	0.2	μmhos
Input Capacitance (V_{DS} = -10 Vdc, V_{GS} = 1.0 Vdc, f = 1.0 MHz)	C_{iss}	–	20	pF
Common-Source Noise Figure (V_{DS} = -5.0 Vdc, I_D = 1.0 mAdc, R_G = 1.0 Megohm, f = 1.0 kHz)	NF	–	3.0	dB

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤10%.

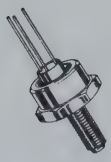
2N3375 (SILICON)

2N3553

2N3632

2N3961







*CASE 79 (TO-39) — 2N3553

**CASE 24 (TO-102) — 2N3961

***CASE 36 (TO-60) — 2N3375, 2N3632

* Collector Connected to Case

** Collector electrically connected to case; stud electrically isolated from case

*** Stud electrically isolated from case

NPN silicon RF Power transistors, optimized for large-signal power amplifier and driver applications to 400MHz, provide wide choice of power levels and guaranteed safe operating areas.

MAXIMUM RATINGS

Rating	Symbol	2N3375	2N3553	2N3632	2N3961	Unit
Collector-Emitter Voltage	V_{CEO}	← 40 →				Vdc
Collector-Base Voltage	V_{CB}	← 65 →				Vdc
Emitter-Base Voltage	V_{EB}	← 4.0 →				Vdc
Collector Current	I_C	1.5	1.0	3.0	1.0	Adc
Total Device Dissipation @ T_C = 25°C	P_D	11.6	7.0	23	10	Watts
Derate above 25°C		66.4	40	131	57.2	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	40	-	Vdc
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 0.25 mAdc, I_C = 0)	2N3632		4.0	-	
(I_E = 0.1 mAdc, I_C = 0)	2N3375, 2N3553		4.0	-	
(I_E = 1.0 mAdc, I_C = 0)	2N3961		4.0	-	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N3375, 2N3553		-	0.1	
	2N3632		-	0.25	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 200°C)	2N3375, 2N3553		-	5.0	
	2N3632		-	10	
(V_{CE} = 65 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3375, 2N3553		-	1.0	
	2N3632		-	5.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 28 Vdc, I_E = 0, T_A = 150°C)	2N3961		-	5.0	
(V_{CB} = 65 Vdc, I_E = 0)	2N3632		-	0.5	
	2N3961		-	1.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 4.0 Vdc, I_C = 0)	2N3375, 2N3553		-	0.1	
	2N3632		-	0.25	

* Pulsed thru 25 mH inductor (See Figures 5 and 6).

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain						-
(I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	2N3375, 2N3553, 2N3632	h_{FE}	10	-	-	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	2N3632		5.0	-	-	
Collector-Emitter Saturation Voltage						Vdc
(I_C = 250 mAdc, I_B = 50 mAdc)	2N3553	$V_{CE(sat)}$	-	-	1.0	
(I_C = 500 mAdc, I_B = 100 mAdc)	2N3375, 2N3632		-	-	1.0	
Base-Emitter Saturation Voltage						Vdc
(I_C = 1.0 Adc, I_B = 5.0 Adc)	2N3632	$V_{BE(sat)}$	-	-	1.5	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product						MHz
(I_C = 100 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	2N3553	f_T	-	500	-	
(I_C = 125 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	2N3961		350		-	
(I_C = 150 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	2N3375		-	500	-	
	2N3632		-	400	-	
Output Capacitance						pF
(V_{CB} = 28 Vdc, I_E = 0, f = 100 kHz)	2N3961	C_{ob}	-	8.0	10	
(V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	2N3375, 2N3553		-	8.0	10	
	2N3632		-	.16	20	

FUNCTIONAL TESTS

2N3375

Power Input	Test Circuit Figure 7 (V_{CE} = 28 Vdc, P_{out} = 7.5 Watts, f = 100 MHz)	P_{in}	-	-	1.0	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	8.75	-	-	dB
Collector Efficiency		η	65	-	-	%
Power Input	Test Circuit Figure 8 (V_{CE} = 28 Vdc, P_{out} = 3.0 Watts, f = 400 MHz)	P_{in}	-	-	1.0	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	4.77	-	-	dB
Collector Efficiency		η	40	-	-	%

2N3553

Power Input	Test Circuit Figure 9 (V_{CE} = 28 Vdc, P_{out} = 2.5 Watts, f = 175 MHz)	P_{in}	-	-	0.25	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	10	-	-	dB
Collector Efficiency		η	50	-	-	%

2N3632

Power Input	Test Circuit Figure 10 (V_{CE} = 28 Vdc, P_{out} = 13.5 Watts, f = 175 MHz)	P_{in}	-	-	3.5	Watts
Common-Emitter Amplifier Power Gain		G_{pe}	5.86	-	-	dB
Collector Efficiency		η	70	-	-	%

2N3961

Power Input	Test Circuit Figure 11 (V_{CE} = 12.5 Vdc, P_{out} = 2.0 Watts, R_S = 50 ohms, R_L = 50 ohms, f = 135 MHz)	P_{in}	-	-	0.5	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	6.0	-	-	dB
Collector Efficiency		η	60	-	-	%
Power Input	Test Circuit Figure 12 (V_{CE} = 28 Vdc, P_{out} = 4.0 Watts, R_S = 50 ohms, R_L = 50 ohms, f = 175 MHz)	P_{in}	-	-	0.5	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	9.0	-	-	dB
Collector Efficiency		η	60	-	-	%

POWER OUTPUT versus FREQUENCY

COMMON EMITTER — V_{CE} = 28 Vdc, T_C = 25°C

FIGURE 1 – 2N3375

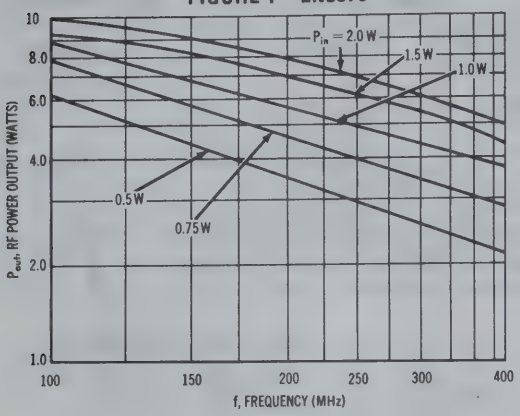


FIGURE 2 – 2N3553

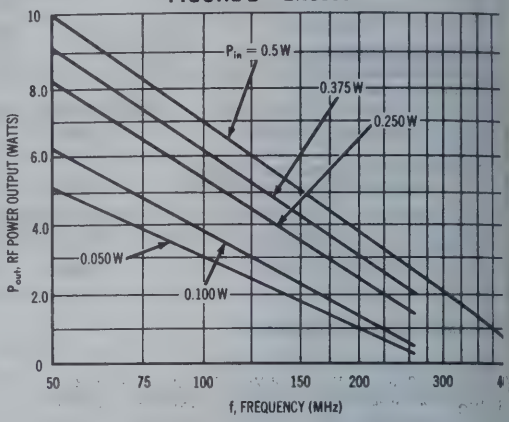


FIGURE 3 – 2N3632

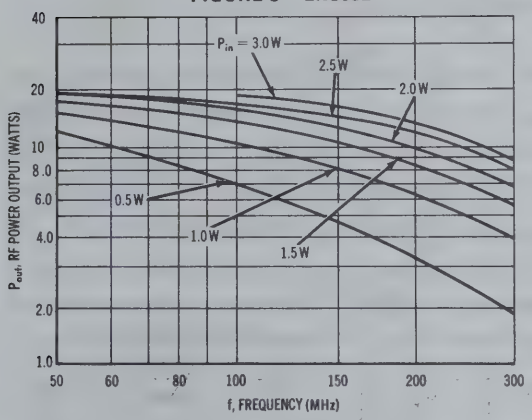
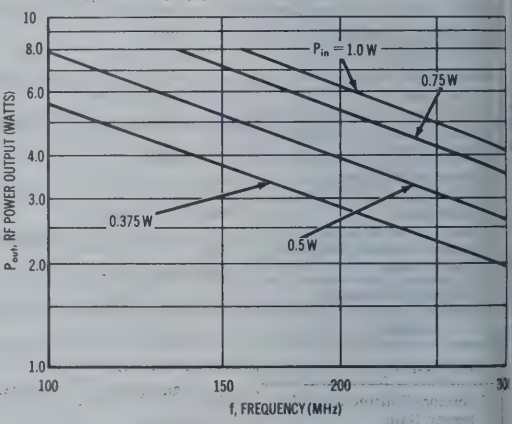


FIGURE 4 – 2N3961



$BV_{CEO(sus)}$ PULSE TEST CIRCUITS

FIGURE 5 – 2N3375, 2N3553, 2N3632

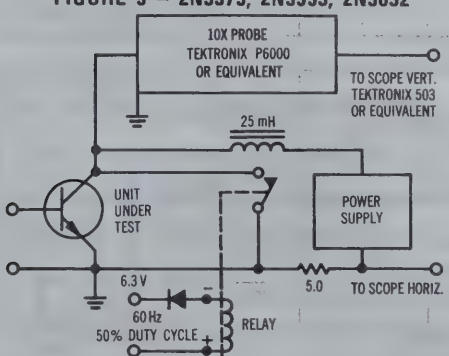
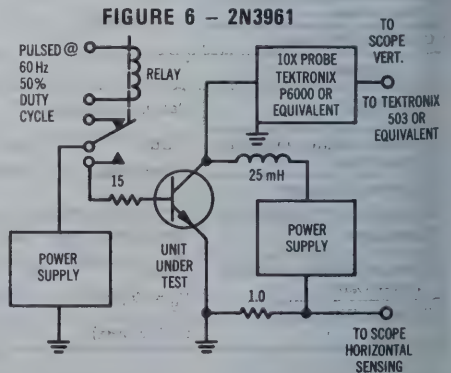


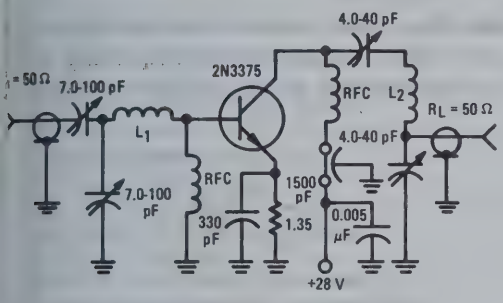
FIGURE 6 – 2N3961



TEST CIRCUITS

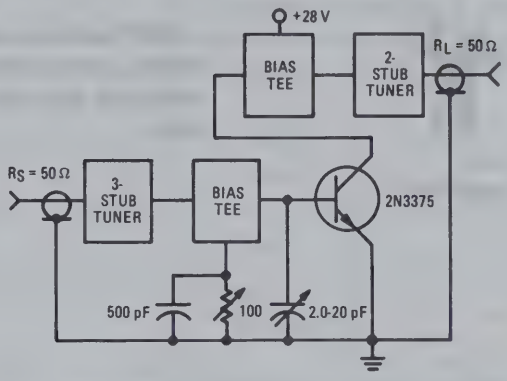
2N3375

FIGURE 7 – 100 MHz



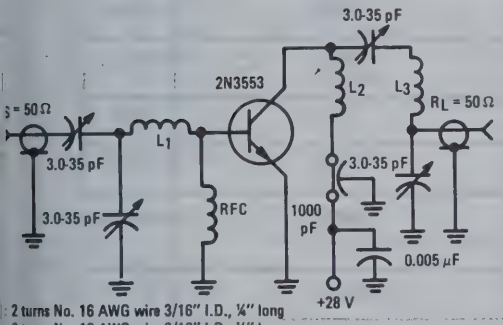
L1: 3 turns No. 16 AWG wire ¼" I.D., 5/16" long
L2: 5 turns No. 16 AWG wire 5/16" I.D., 7/16" long

FIGURE 8 – 400 MHz



2N3553

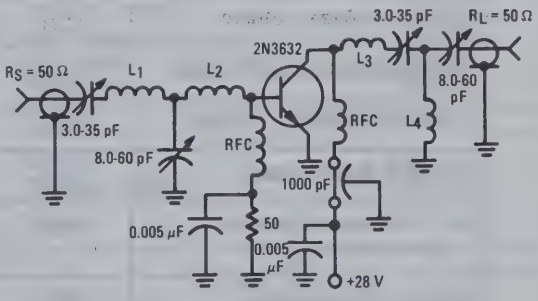
FIGURE 9 – 175 MHz



2 turns No. 16 AWG wire 3/16" I.D., ¼" long
2 turns No. 16 AWG wire 3/16" I.D., ¼" long
3 turns No. 16 AWG wire 3/8" I.D., 3/8" long

2N3632

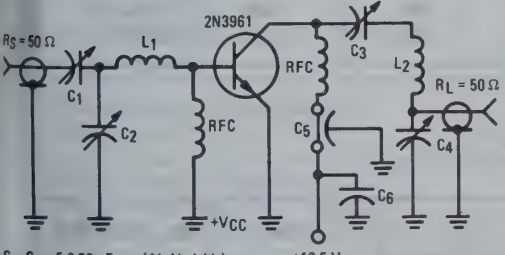
FIGURE 10 – 175 MHz



L1, L3: 4 turns No. 18 AWG wire ¼" I.D. 3/16" long
L2: 1 turn No. 16 AWG wire ¼" I.D., 3/16" long
L4: 2½ turns No. 16 AWG wire ¼" I.D., ¼" long

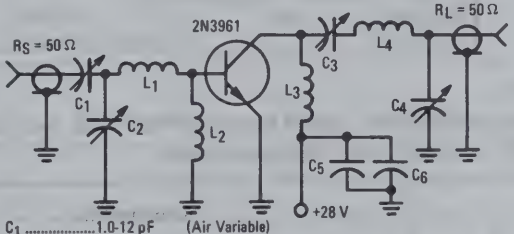
2N3961

FIGURE 11 – 135 MHz



C1, C3 = 5.0-50 pF (Air Variable)
C2 = 7.0-100 pF (Air Variable)
C4 = 1.0-30 pF (Air Variable)
C5 = 1000 pF (Disc Ceramic)
C6 = 0.02 μF (Disc Ceramic)
L1 = 3 turns No. 16 AWG wire, 5/16" I.D., 5/16" long
L2 = 5 turns No. 16 AWG wire, 7/16" I.D., 5/8" long

FIGURE 12 – 175 MHz



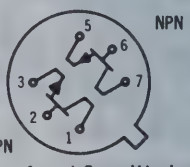
C1	1.0-12 pF	(Air Variable)
C2	1.0-30 pF	(Air Variable)
C3	5.0-50 pF	(Air Variable)
C4	7.0-75 pF	(Air Variable)
C5	470 pF	(Disc Ceramic)
C6	0.001 μF	(Disc Ceramic)
L1, L3, L4		2 turns No. 18 AWG enameled wire ¼" I.D., air wound 3/16" long
L2		RFC, $Q_U < 1$

2N3409 thru 2N3411 (SILICON)



CASE 32C

NPN silicon annular Star dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.



Pins 4 and 8 omitted
Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Collector Voltage	V_{CCO}	100		Vdc
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
D.C. Collector Current (Limited by P_D)	I_C	500		mAdc
Junction Temperature	T_J	+200		^oC
Storage Temperature Range	T_{stg}	-65 to +200		^oC
		One Side	Both Sides	
Total Device Dissipation (25^oC Ambient Temperature) Derate above 25^oC	P_D	500 2.9	600 3.4	mW $mW/^oC$

ELECTRICAL CHARACTERISTICS (each side)

(T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc)	BV_{CEO}*	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)	BV_{EBO}	5	—	Vdc

*Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2%

ELECTRICAL CHARACTERISTICS (each side) (continued)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 50 Vdc) (V_{CB} = 50 Vdc, T_A = 150°C)		I_{CBO}	— —	.010 10	μAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc)		I_{EBO}	—	10	nAdc
Collector to Collector Current (V_{CC} = 100 Vdc)		I_{CCO}	—	100	nAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	—	0.15	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	—	0.85	Vdc
DC Forward Current Transfer Ratio (I_C = 10 μAdc, V_{CE} = 10 Vdc) (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	 2N3410, 2N3411 All Types All Types All Types	h_{FE}	 20 30 40 50	 100 120 160 200	—
DC Current Gain Ratio ** (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1 mAdc, V_{CE} = 10 Vdc)	 2N3409 2N3410, 2N3411 2N3411	h_{FE1}/h_{FE2} **	 0.8 0.9 0.9	 1.0 1.0 1.0	—
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1 mAdc, V_{CE} = 10 Vdc)	 2N3409, 2N3410 2N3411 2N3411	$\lvert V_{BE1}-V_{BE2} \rvert$	 — — —	 10 5 5	mVdc
Base Voltage Differential Change (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = -55 to +25°C) (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = 25 to 125°C)	 2N3409 2N3410, 2N3411 2N3409 2N3410, 2N3411	$\Delta(V_{BE1}-V_{BE2})$	 — — — —	 1.6 0.8 2.0 1.0	mVdc
Collector Output Capacitance (V_{CB} = 10 Vdc, f = 1 MHz)		C_{ob}	—	8	pF
Collector Input Capacitance (V_{BE} = 0.5 Vdc, f = 1 MHz)		C_{ib}	—	25	pF
Small-Signal Forward Current Transfer Ratio (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		h_{fe}	2.5	—	—
Noise Figure (I_C = 100 μA, V_{CE} = 5 V, f = 1 kHz BW = 1 Hz, R_S = 1 kΩ)		NF	—	4	dB

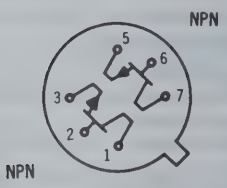
**The lowest h_{FE} reading is taken as h_{FE1} for this ratio

2N3423 (SILICON)
2N3424

Dual NPN silicon transistors designed for use as sense and high-frequency differential amplifiers.



CASE 32 C



PINS 4 AND 8 OMITTED
Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current	I_C	50		mAdc
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	0.3	0.45	Watt
Derate above 25°C		1.72	2.57	mW/°C
Total Device Dissipation @ T_C = 100°C	P_D	0.344	0.685	Watt
T_C = 25°C		0.6	1.2	Watt
Derate above 25°C		3.44	6.85	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 3.0 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	0.01 1.0	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 3.0 mAdc, V_{CE} = 3.0 Vdc)	h_{FE}	20 20	- 200	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	1200	MHz
Output Capacitance (V_{CB} = 0, I_E = 0, f = 140 kHz) (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	- -	3.0 1.7	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	2.0	pF
Real Part of Input Impedance (I_C = 3.0 mAdc, V_{CE} = 3.0 Vdc, f = 350 MHz)	$Re(h_{ie})$	-	45	Ohm
MATCHING CHARACTERISTICS				
DC Current Gain Ratio** (I_C = 3.0 mAdc, V_{CE} = 3.0 Vdc) 2N3423 2N3424	h_{FE1}/h_{FE2}**	0.8 0.9	1.0 1.0	--
Base Voltage Differential (I_C = 3.0 mAdc, V_{CE} = 3.0 Vdc) 2N3423 2N3424	$\lvert V_{BE1}-V_{BE2}\rvert$	- -	10 5.0	mVdc
Base Voltage Differential Gradient (I_C = 3.0 mAdc, V_{CE} = 3.0 Vdc, T_{A1} = +25°C, T_{A2} = -55°C) 2N3423 2N3424 (I_C = 3.0 mAdc, V_{CE} = 3.0 Vdc, T_{A1} = +25°C, T_{A2} = +125°C) 2N3423 2N3424	$\Delta(V_{BE1}-V_{BE2})$	- - - -	3.2 1.6 4.0 2.0	mVdc

*Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%

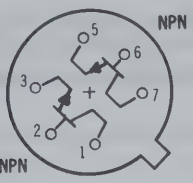
** Lowest of the two h_{FE} readings is taken as h_{FE1} for purposes of this ratio.

2N3425 (SILICON)

Dual NPN silicon transistor designed for use as a high-frequency sense amplifier.



CASE 32C

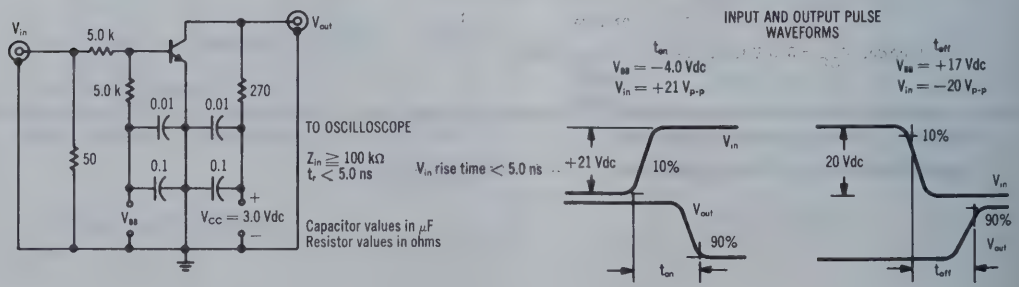


PINS 4 AND 8 OMITTED
Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ ohms)	V_{CER}	20		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	0.3	0.4	Watt
Derate above 25°C		1.72	2.28	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	0.75	1.5	Watt
T_C = 100°C		0.43	0.86	Watt
Derate above 25°C		4.3	8.55	mW/°C

FIGURE 1 — SWITCHING-TIME TEST CIRCUIT



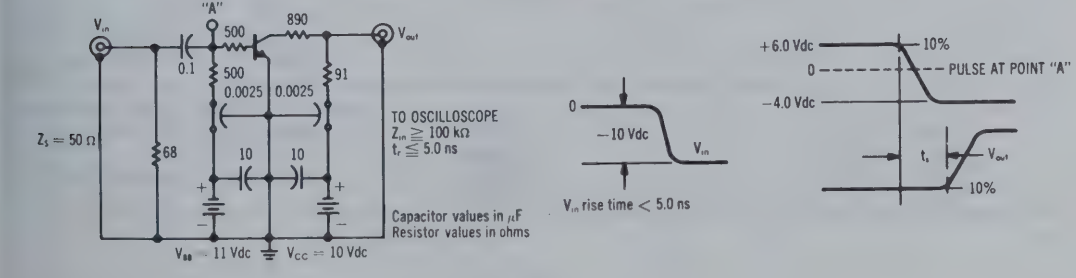
2N3425 (continued)

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	15	-	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, R_{BE} ≤ 10 ohms)	$BV_{CER(sus)}$*	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 125°C)	I_{CEX}	-	15	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	0.025	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		-	15	
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	0.2	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	12	-	-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		30	120	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		12	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
(I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = -55°C to +125°C)		-	0.5	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	0.85	Vdc
(I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = -55°C)		-	0.9	
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	9.0	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 kHz)	h_{fe}	20	-	-
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 300 MHz)	$Re(h_{ie})$	-	50	Ohms
Turn-On Time (Figure 1) (V_{CC} = 3.0 Vdc, $V_{EB(off)}$ = 2.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	-	50	ns
Turn-Off Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{off}	-	90	ns
Storage Time (Figure 2) (I_C = 10 mAdc, I_{B1} = 10 mAdc, I_{B2} = 10 mAdc)	t_s	-	40	ns

* **Pulse Test: Pulse width ≤ 300 μs, duty cycle ≤ 1%**

FIGURE 2 — STORAGE TIME TEST CIRCUIT



2N3427, 2N3428 (GERMANIUM)



CASE 31(1)
(TO-5)
All leads isolated from case

PNP germanium transistors for audio amplifier and medium-speed switching applications.

MAXIMUM RATINGS

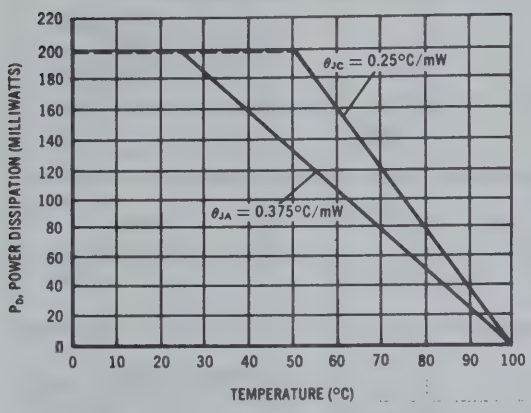
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CER}	30	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current (Continuous)	I_C	500*	mAdc
Base Current (Continuous)	I_B	50*	mAdc
Storage and Operating Temperature Range	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation, Ambient Derate Above 25°C	P_D	200 2.67	mW mW/°C

*Limited by power dissipation

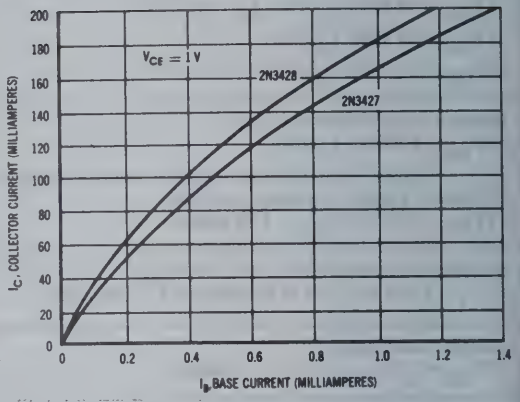
ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 1.5 Vdc, I_E = 0)			–	3.0	5.0	
(V_{CB} = 10 Vdc, I_E = 0, T_A = +71°C)			–	–	100	
(V_{CB} = 30 Vdc, I_E = 0)			–	–	10	
(V_{CB} = 45 Vdc, I_E = 0)			–	–	50	
Emitter-Base Cutoff Current (V_{EB} = 30 Vdc, I_C = 0)		I_{EBO}	–	3.0	10	μAdc
Collector-Emitter Leakage Current (V_{CE} = 30 Vdc, R_{BE} = 10K ohms)		I_{CER}	–	–	600	μAdc
Collector-Emitter Punch-Thru Voltage (V_{fl} = 1.0 Vdc, VTVM impedance ≥ 1 megohm)		V_{pt}	30	–	–	Vdc
Output Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	–	10	20	pF
Noise Figure (V_{CE} = 4.5 Vdc, I_E = 0.5 mAdc, R_S = 1 K ohms, f = 1 kHz, Δf = 1 Hz)		NF	–	5.0	10	dB
Small-Signal Current-Gain Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc)	2N3427	$f_{\alpha b}$	4.0	6.0	–	MHz
	2N3428		5.0	8.0	–	
Input Impedance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)		h_{ib}	25	–	35	Ohms
Output Admittance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)		h_{ob}	0.05	–	0.50	μmho
Small-Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N3427	h_{fe}	200	325	500	–
	2N3428		350	475	800	
Small-Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 2 MHz)	2N3427	$\lvert h_{fe} \rvert$	2.0	–	7.0	–
	2N3428		2.5	–	8.0	
DC Current Gain		h_{FE}				–
(I_C = 20 mAdc, V_{CE} = 1 Vdc)	2N3427		150	275	–	
	2N3428		250	375	–	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N3427		100	210	350	
	2N3428		150	260	400	
(I_C = 200 mAdc, V_{CE} = 1 Vdc)	2N3427		75	–	–	
	2N3428		125	–	–	
Base-Emitter Input Voltage (V_{CE} = 1 Vdc, I_C = 100 mAdc)		V_{BE}	–	–	0.5	Vdc
Collector-Emitter Saturation Voltage		V_{CE} (sat)				Vdc
(I_C = 100 mAdc, I_B = 2 mAdc)	2N3427		–	0.155	0.200	
	2N3428		–	0.150	0.190	
(I_C = 200 mAdc, I_B = 4 mAdc)	2N3427		–	0.220	0.300	
	2N3428		–	0.200	0.280	

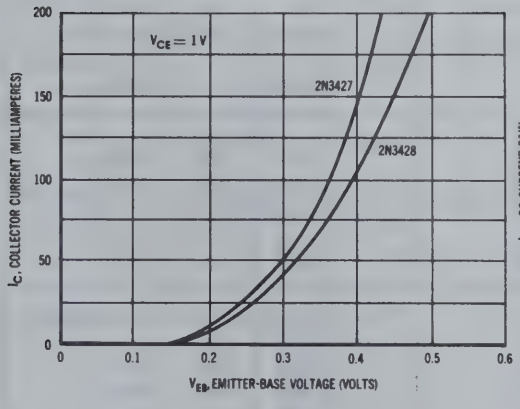
POWER-TEMPERATURE DERATING CURVE



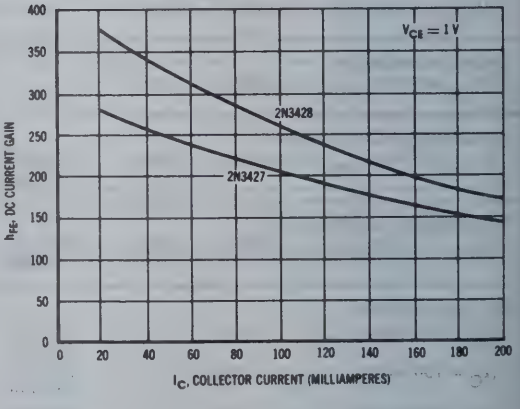
COLLECTOR CURRENT versus BASE CURRENT



OUTPUT CURRENT versus BASE DRIVE VOLTAGE



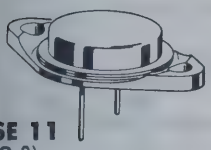
DC CURRENT GAIN versus COLLECTOR CURRENT



2N3444 (SILICON)

For Specifications, See 2N3252 Data.

2N3445 thru 2N3448 (SILICON)



CASE 11
(TO-3)
Collector connected to case

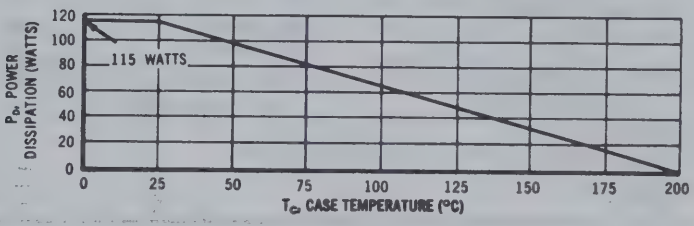
NPN silicon power transistors for switching and amplifier applications requiring fast response, wide band and good Beta linearity.

MAXIMUM RATINGS

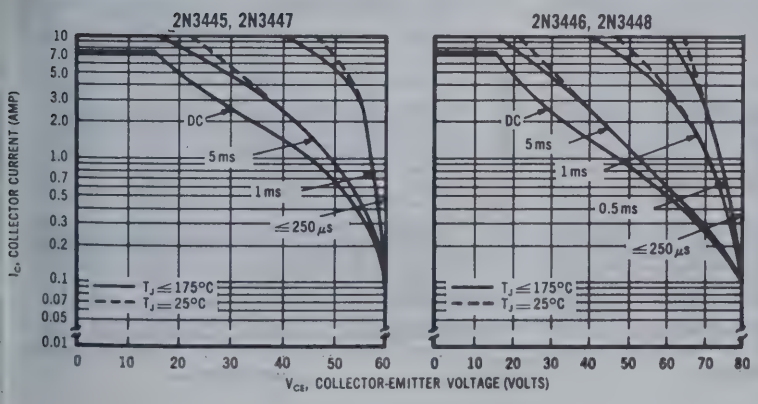
Rating	Symbol	2N3445 2N3447	2N3446 2N3448	Unit
Collector-Base Voltage	V_{CB}	80	100	Volts
Collector-Emitter Voltage	V_{CEO}	60	80	Volts
Emitter-Base Voltage	V_{EB}	6.0	10	Volts
Collector Current	I_C	7.5		Amp
Base Current	I_B	4.0		Amp
Power Dissipation	P_D	115		Watts
Junction Operating Temperature Range	T_J	-65 to +200		°C

POWER-TEMPERATURE DERATING CURVE

These transistors are also subject to safe area curves. Both limits are applicable and must be observed.



SAFE OPERATING AREAS

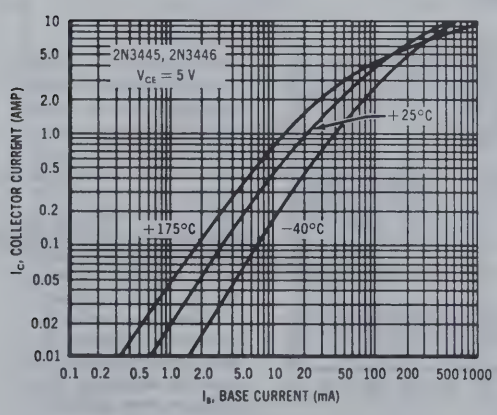


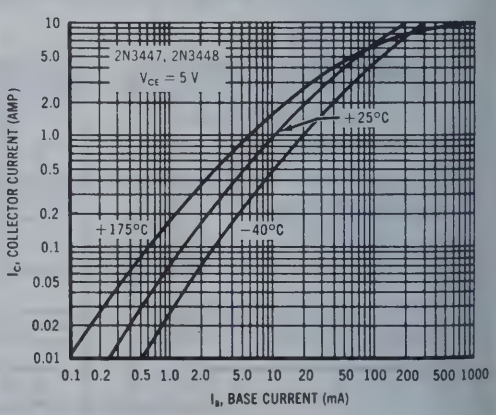
The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Emitter-Base Cutoff Current		I_{EBO}				mAdc
(V_{EB} = 6 Vdc)	2N3445, 2N3447		—	—	0.25	
(V_{EB} = 10 Vdc)	2N3446, 2N3448		—	—	0.25	
Collector-Emitter Cutoff Current		I_{CEX}				mAdc
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc)	2N3445, 2N3447		—	—	0.1	
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3445, 2N3447		—	—	1.0	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc)	2N3446, 2N3448		—	—	0.1	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3446, 2N3448		—	—	1.0	
Collector-Emitter Cutoff Current		I_{CEO}				mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N3445, 2N3447		—	—	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N3446, 2N3448		—	—	1.0	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 1 mAdc, I_E = 0)	2N3445, 2N3447		80	—	—	
	2N3446, 2N3448		100	—	—	
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$				Vdc
(I_C = 100 mAdc, I_B = 0)	2N3445, 2N3447		60	—	—	
	2N3446, 2N3448		80	—	—	
DC Current Gain		h_{FE}				—
(I_C = 0.5 Adc, V_{CE} = 5 Vdc)	2N3445, 2N3446		20	45	—	
	2N3447, 2N3448		40	85	—	
(I_C = 3 Adc, V_{CE} = 5 Vdc)	2N3445, 2N3446		20	40	60	
(I_C = 5 Adc, V_{CE} = 5 Vdc)	2N3447, 2N3448		40	75	120	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3445, 2N3446		—	0.6	1.5	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3447, 2N3448		—	0.8	1.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3445, 2N3446		—	1.0	1.5	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3447, 2N3448		—	1.0	1.5	
Base-Emitter Voltage		V_{BE}				Vdc
(I_C = 3 Adc, V_{CE} = 5 Vdc)	2N3445, 2N3446		—	1.0	1.5	
(I_C = 5 Adc, V_{CE} = 5 Vdc)	2N3447, 2N3448		—	1.0	1.4	
Small Signal Current Gain		h_{fe}				—
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 1 kHz)	2N3445, 2N3446		20	—	100	
	2N3447, 2N3448		40	—	200	
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 10 MHz)			1.0	1.6	—	
Common Base Output Capacitance		C_{ob}				pF
(V_{CB = 10 Vdc, f = 0.1 MHz)			—	260	400	
Switching Times						μs
(V_{CC} ≈ 25 Vdc, R_L = 5 ohms, I_{C} = 5 A, I_{B1} = I_{B2} = 0.5 A)						
Delay Time plus Rise Time		$t_d + t_r$	—	0.15	0.35	
Storage Time		t_s	—	0.9	2.0	
Fall Time		t_f	—	0.15	0.35	

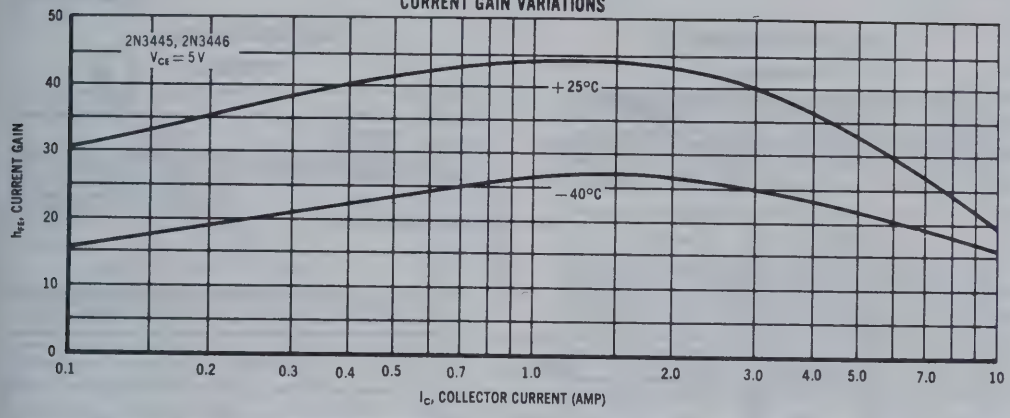
COLLECTOR CURRENT versus BASE CURRENT

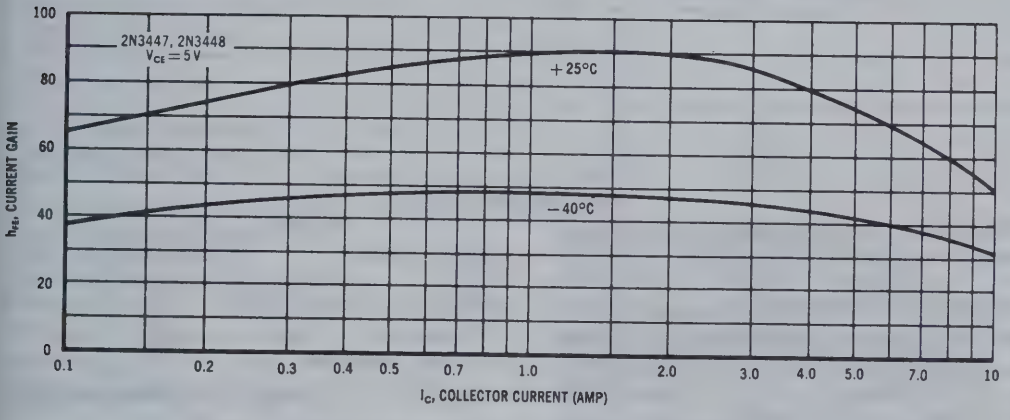




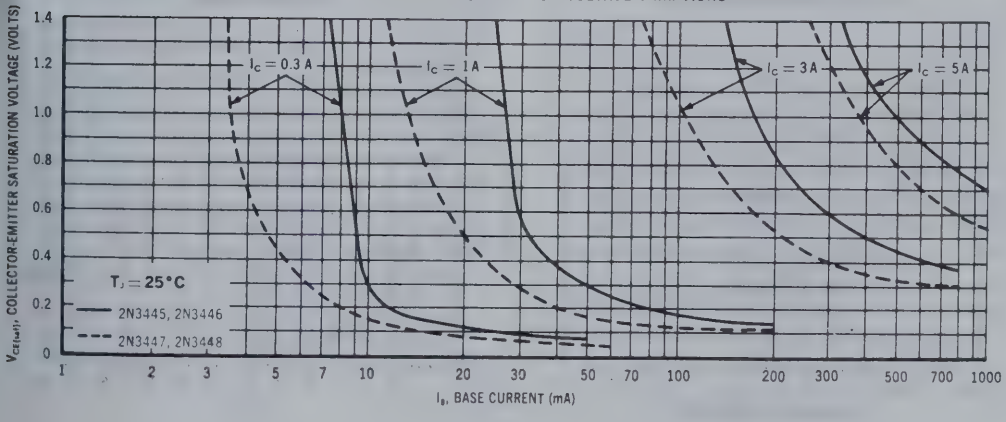
2N3445 thru 2N3448 (continued)

CURRENT GAIN VARIATIONS

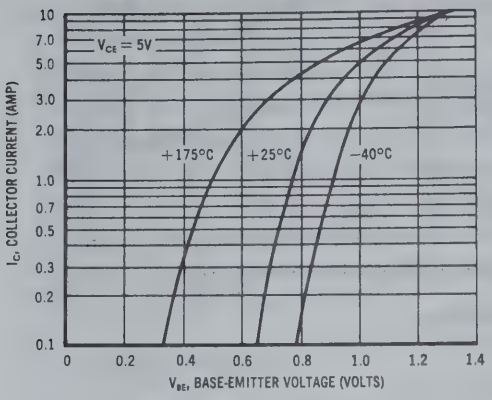




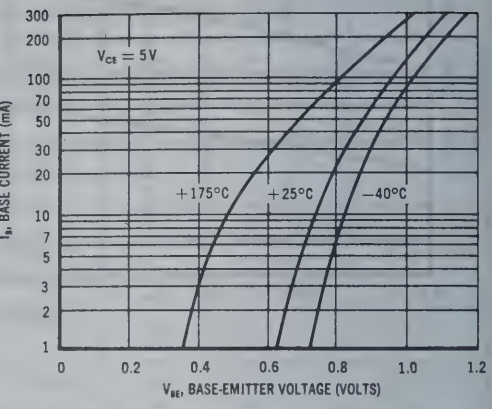
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS



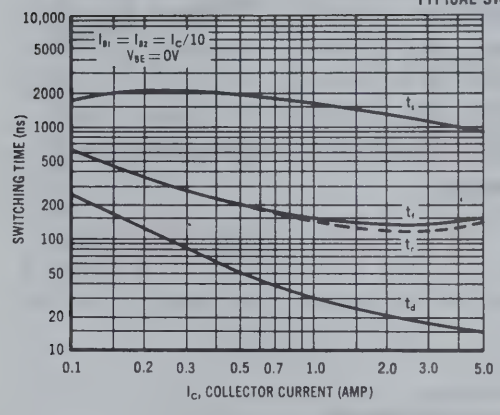
COLLECTOR CURRENT-VOLTAGE VARIATIONS



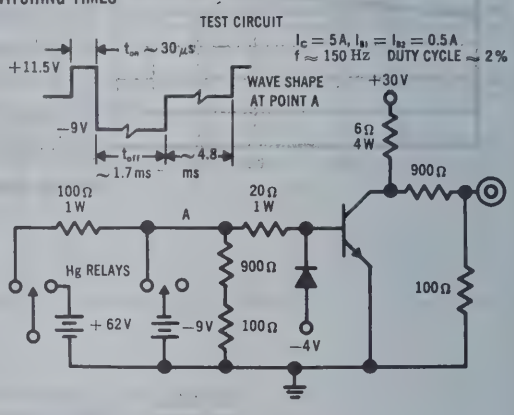
BASE CURRENT-VOLTAGE VARIATIONS



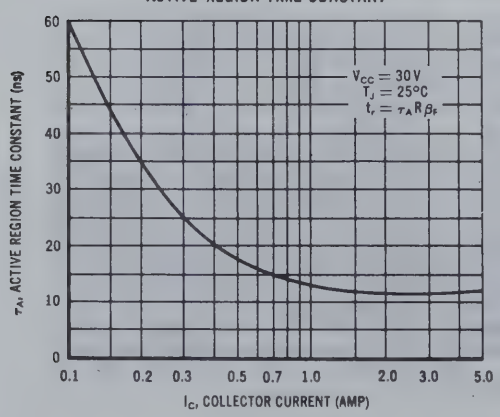
TYPICAL SWITCHING TIMES



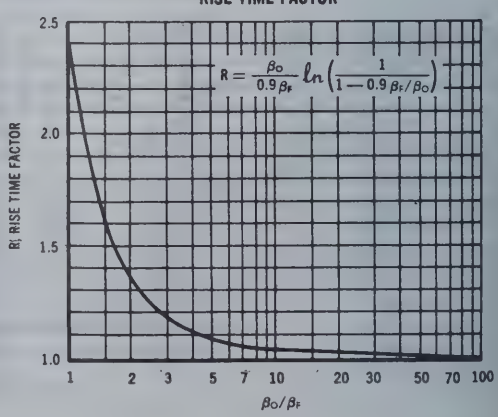
TEST CIRCUIT



ACTIVE REGION TIME CONSTANT



RISE TIME FACTOR



2N3467 (SILICON)
2N3468



CASE 31
(TO-5)

PNP silicon annular transistors for high-speed switching and driver applications.

Collector connected to case

MAXIMUM RATINGS

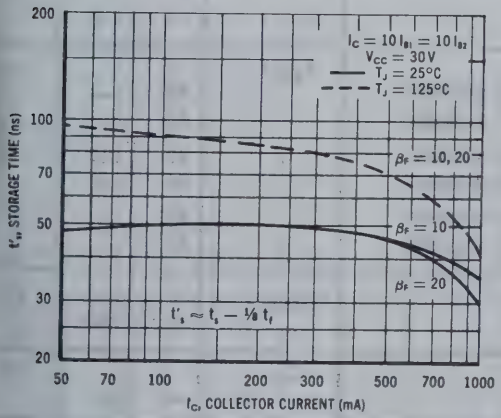
Rating	Symbol	2N3467	2N3468	Unit
Collector-Base Voltage	V_{CB}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	1		Adc
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	5 28.6		Watts mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL RESISTANCE

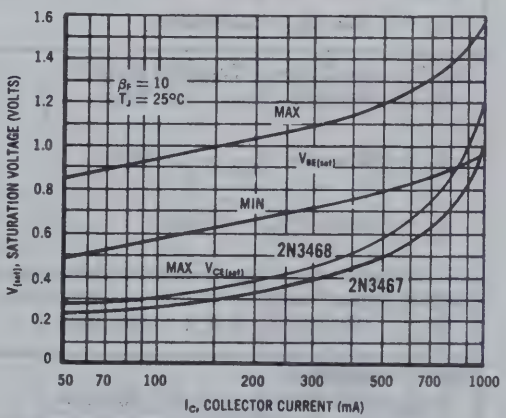
θ_{JA} (air) = 0.175°C/mW

θ_{JC} (case) = 35°C/W

STORAGE TIME VARIATION WITH TEMPERATURE



LIMITS OF SATURATION VOLTAGE



ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

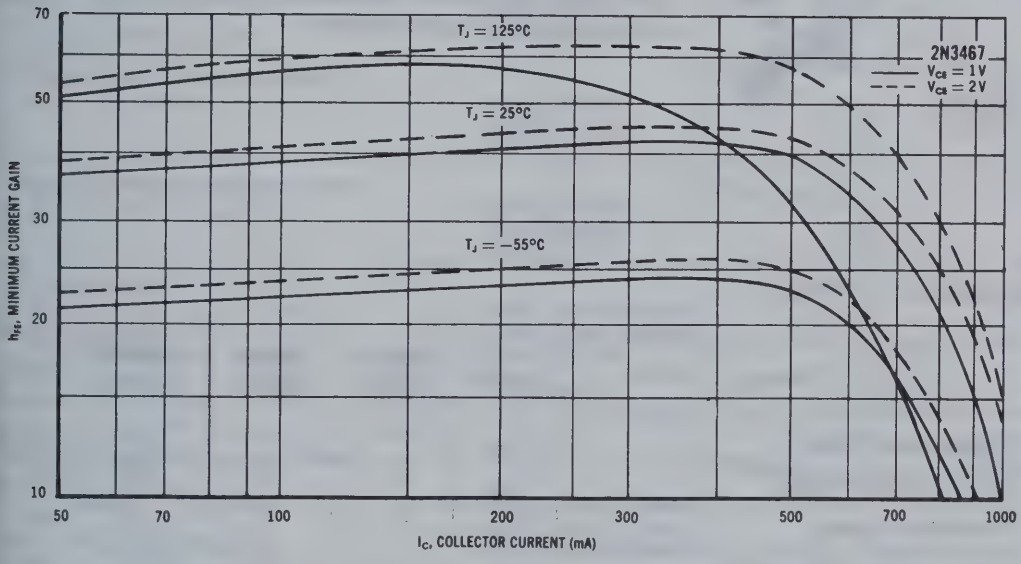
Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)		I_{CBO}	— —	0.10 15	μAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{CEX}	—	100	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{BL}	—	120	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3467 2N3468	BV_{CBO}	40 50	— —	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3467 2N3468	BV_{CEO}*	40 50	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	Vdc
Collector Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)	2N3467 2N3468 2N3467 2N3468 2N3467 2N3468	$V_{CE(sat)}$*	— — — — — —	0.3 0.35 0.5 0.6 1.0 1.2	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$*	— 0.8 —	1.0 1.2 1.6	Vdc
DC Forward Current Transfer Ratio* (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1 Adc, V_{CE} = 5 Vdc)	2N3467 2N3468 2N3467 2N3468 2N3467 2N3468	h_{FE}*	40 25 40 25 40 25	— — 120 75 — —	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	25	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	100	pF
Current-Gain - Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3467 2N3468	f_T	175 150	— —	MHz

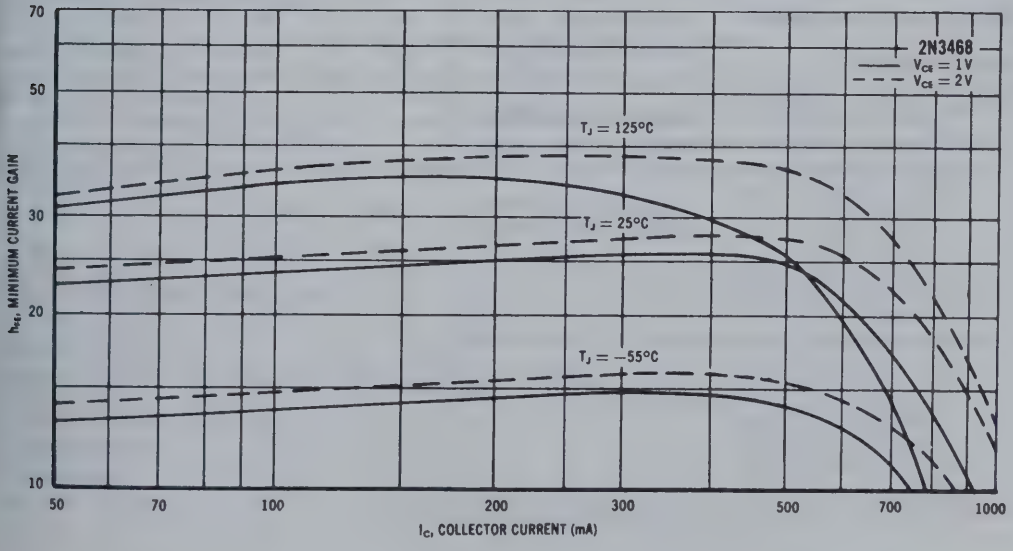
*Pulse Test: PW ≤300 μs, Duty Cycle ≤2%

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
Delay Time	(I_C = 500 mA, I_{B1} = 50 mA, V_{BE} = 2 V, V_{CC} = 30 V)	t_d	—	10	ns
Rise Time		t_r	—	30	ns
Storage Time	(I_C = 500 mA, I_{B1} = I_{B2} = 50 mA, V_{CC} = 30 V)	t_s	—	60	ns
Fall Time		t_f	—	30	ns
Total Control Charge (I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)		Q_T	—	6	nC

MINIMUM CURRENT GAIN CHARACTERISTICS

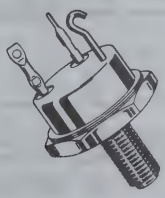




2N3485, A (SILICON)
2N3486, A

For Specifications, See 2N2904 Data.

2N3487 thru 2N3492 (SILICON)



NPN silicon power transistors designed for switching and amplifier applications.

CASE 9
(TO-61)

MAXIMUM RATINGS

Rating	Symbol	2N3487 2N3490	2N3488 2N3491	2N3489 2N3492	Unit
Collector-Base Voltage	V_{CB}	80	100	120	Vdc
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	10	10	10	Vdc
Collector Current (Continuous)	I_C	7.5	7.5	7.5	Adc
Base Current (Continuous)	I_B	4.0	4.0	4.0	Adc
Power Dissipation	P_D	117	117	117	Watts
Thermal Resistance, Junction to Case	θ_{JC}	1.5	1.5	1.5	$^oC/W$
Junction Operating Temperature Range	T_J	-65^oC to $+200^oC$			^oC

2N3487 thru 2N3492 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Emitter-Base Cutoff Current (V_{EB} = 10 Vdc)		I_{EBO}	-	0.10	mAdc
Collector-Emitter Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc)	2N3487, 2N3490		-	25	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc)	2N3488, 2N3491		-	25	
(V_{CE} = 100 Vdc, V_{BE} = -1 Vdc)	2N3489, 2N3492		-	25	
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3487, 2N3490		-	250	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3488, 2N3491		-	250	
(V_{CE} = 100 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3489, 2N3492		-	250	
Collector-Emitter Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N3487, 2N3490		-	250	
(V_{CE} = 60 Vdc, I_B = 0)	2N3488, 2N3491		-	250	
(V_{CE} = 80 Vdc, I_B = 0)	2N3489, 2N3492		-	250	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	2N3487, 2N3490		80	-	
	2N3488, 2N3491		100	-	
	2N3489, 2N3492		120	-	
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N3487, 2N3490		60	-	
	2N3488, 2N3491		80	-	
	2N3489, 2N3490		100	-	
DC Current Gain		h_{FE}			-
(I_C = 0.5 Adc, V_{CE} = 5 Vdc)	2N3487, 2N3488, 2N3489		20	-	
	2N3490, 2N3491, 2N3492		40	-	
(I_C = 3.0 Adc, V_{CE} = 5 Vdc)	2N3487, 2N3488		20	60	
	2N3489		15	45	
(I_C = 5.0 Adc, V_{CE} = 5 Vdc)	2N3490, 2N3491		40	120	
	2N3492		30	90	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 1 Adc, I_B = 0.1 Adc)			-	0.3	
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3487, 2N3488, 2N3489		-	1.2	
	2N3490, 2N3491, 2N3492		-	1.0	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3490, 2N3491, 2N3492		-	1.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3487, 2N3488, 2N3489		-	1.5	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3490, 2N3491, 2N3492		-	1.5	
Base-Emitter Voltage		V_{BE}			Vdc
(I_C = 3 Adc, V_{CE} = 5 Vdc)	2N3487, 2N3488, 2N3489		-	1.5	
(I_C = 5 Adc, V_{CE} = 5 Vdc)	2N3490, 2N3491, 2N3492		-	1.4	
Small Signal Current Gain		h_{fe}			-
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 1 kHz)	2N3487, 2N3488, 2N3489		20	100	
	2N3490, 2N3491, 2N3492		40	200	
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 10 MHz)	All Types		1.0	-	
Common Base Output Capacitance (V_{CB} = 10 Vdc, f = 0.1 MHz)		C_{ob}	-	550	pF
Switching Times (V_{CC} ≈ 25 Vdc, R_L = 5Ω, I_C = 5 Adc, I_{B_1} = -I_{B_2} = 0.5 Adc)			-	-	μs
Delay Time plus Rise Time		t_d+t_r	-	0.35	μs
Storage Time		t_s	-	2.0	
Fall Time		t_f	-	0.35	

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE

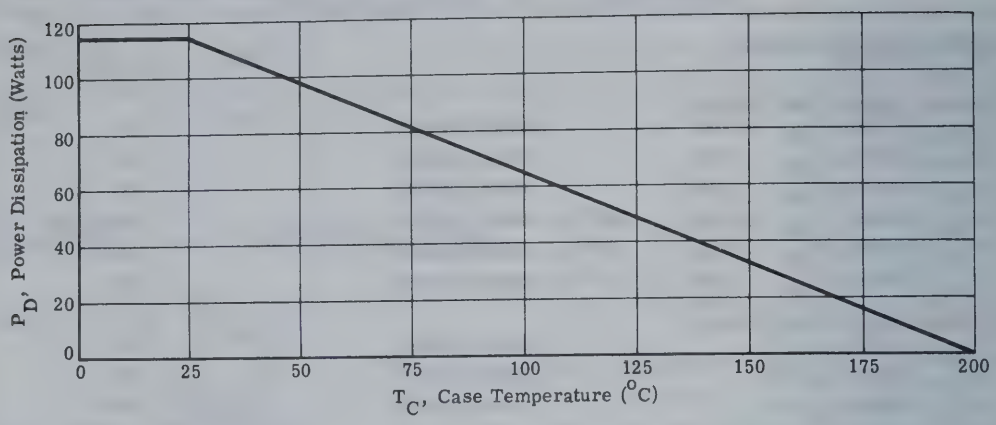
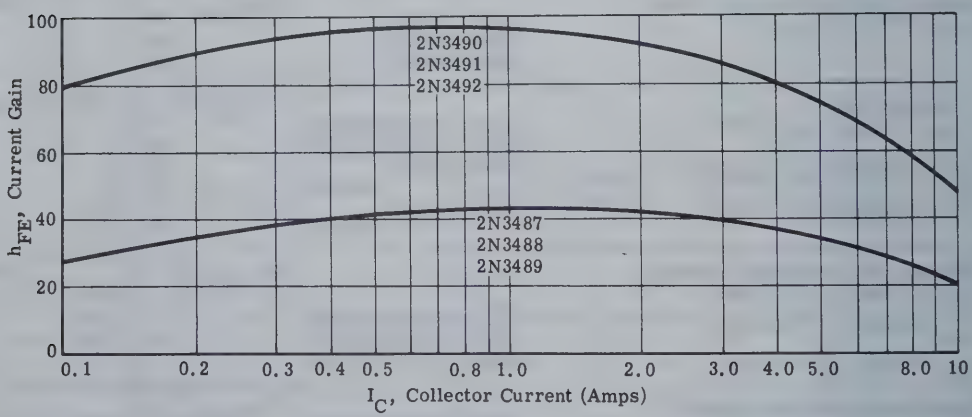


FIGURE 2 — DC CURRENT GAIN versus COLLECTOR CURRENT

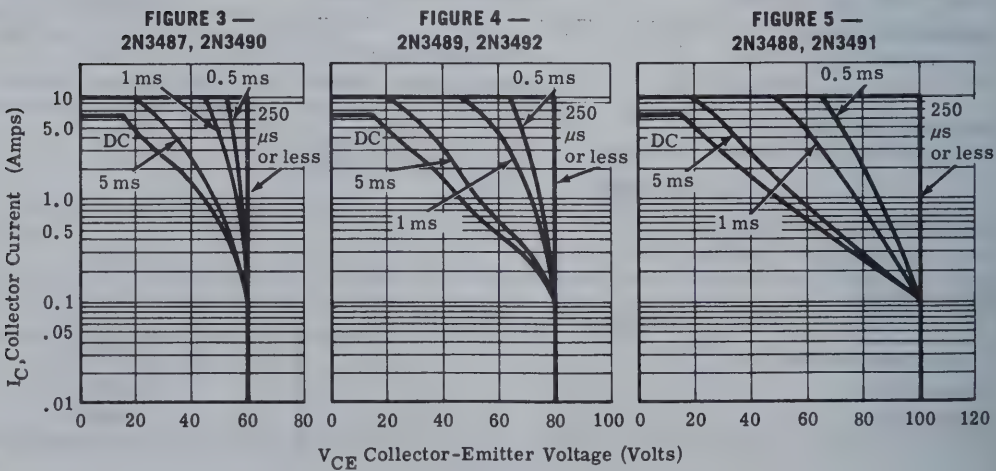


ACTIVE - REGION SAFE OPERATING AREAS

FIGURE 3 — 2N3487, 2N3490

FIGURE 4 — 2N3489, 2N3492

FIGURE 5 — 2N3488, 2N3491



2N3494 thru 2N3497 (SILICON)



CASE 31 (TO-5) CASE 22 (TO-18)

2N3494 2N3496
2N3495 2N3497

Collector connected to case

PNP silicon annular Star transistors for high voltage switching and DC to VHF amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	2N 3494 (TO-5)	2N 3495 (TO-5)	2N 3496 (TO-18)	2N 3497 (TO-18)	Unit
Collector-Base Voltage	V_{CB}	80	120	80	120	Vdc
Collector-Emitter Voltage	V_{CEO}	80	120	80	120	Vdc
Emitter-Base Voltage	V_{EB}	4.5		4.5		Vdc
Collector Current	I_C	100		100		mA
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	3 17.2		1.8 10.3		Watts mW/°C
Total Device Dissipation @ T_A = 25°C Derate Above 25°C	P_D	600 3.43		400 2.28		mW mW/°C
Junction Temperature	T_J	-65 to +200				°C
Storage Temperature	T_{stg}	-65 to +200				°C

SWITCHING CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristic	Symbol	Min	Max	Unit
Turn-On Time (V_{CC} = 30 V, I_C = 10 mA, I_{B1} = 1 mA, V_{BE} = 0)	t_{on}	—	300	ns
Turn-Off Time (V_{CC} = 30 V, I_C = 10 mA, I_{B1} = I_{B2} = 1 mA)	t_{off}	—	450	ns

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3494, 2N3496	BV_{CBO}	80	—	Vdc
	2N3495, 2N3497		120	—	
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3494, 2N3496	BV_{CEO}*	80	—	Vdc
	2N3495, 2N3497		120	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.5	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	2N3494, 2N3496	I_{CBO}	—	100	nAdc
(V_{CB} = 90 Vdc, I_E = 0)	2N3495, 2N3497		—	100	
Emitter-Base Leakage Current (V_{CB} = 3 Vdc)		I_{EBO}	—	25	nAdc
DC Forward Current Transfer Ratio (I_C = 100 μAdc, V_{CE} = 10 Vdc)	All Types	h_{FE}	35	—	—
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	All Types		40	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	All Types		40	—	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	All Types		40	—	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	2N3494, 2N3496		35	—	
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	2N3494, 2N3496	$V_{CE(sat)}$	—	0.3	Vdc
	2N3495, 2N3497		—	0.35	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	0.6	0.9	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	2N3494, 2N3496	C_{ob}	—	7	pF
	2N3495, 2N3497		—	6	
Input Capacitance (V_{BE} = 2 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	30	pF
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3494, 2N3496	f_T	200	—	MHz
	2N3495, 2N3497		150	—	
Small Signal Current Gain (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)		h_{fe}	40	300	—
Input Impedance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)		h_{ie}	0.1	1.2	kohms
Voltage Feedback Ratio (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)		h_{re}	—	2.0	$X10^{-4}$
Output Admittance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)		h_{oe}	—	300	μ mhos
Extrinsic Base Resistance (V_{CE} = 10 V, I_C = 20 mA, f = 300 MHz)		r_b	—	30	ohms

* Pulse width ≤ 300 μs, Duty Cycle = 2%

2N3498 thru 2N3501 (SILICON)



CASE 31
(TO-5)

NPN silicon annular transistors for high-voltage switching and low-power amplifier applications.

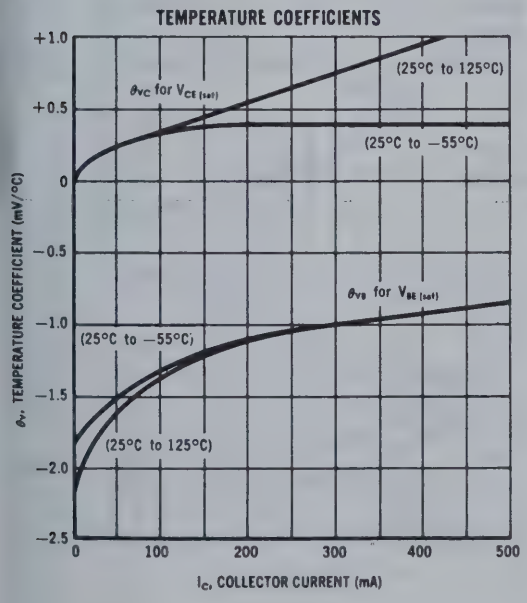
Collector connected to case

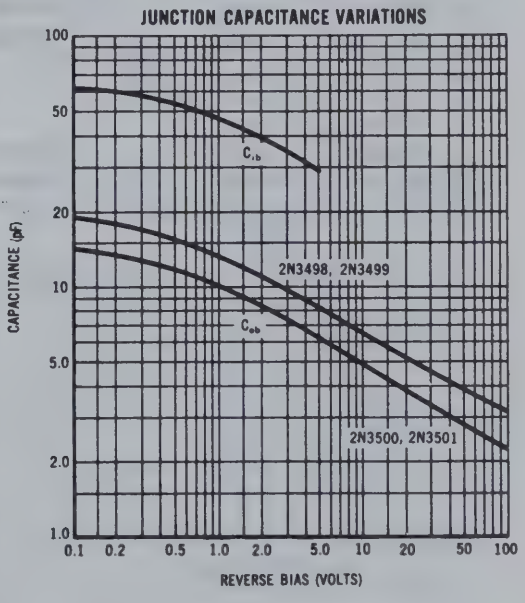
MAXIMUM RATINGS

Rating	Symbol	2N3498 2N3499	2N3500 2N3501	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	Vdc
Collector-Base Voltage	V_{CB}	100	150	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current	I_C	500	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N3498 2N3499	2N3500 2N3501	Unit
Thermal Resistance, Junction to Case	θ_{JC}	35		°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	0.175		°C/mW





ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

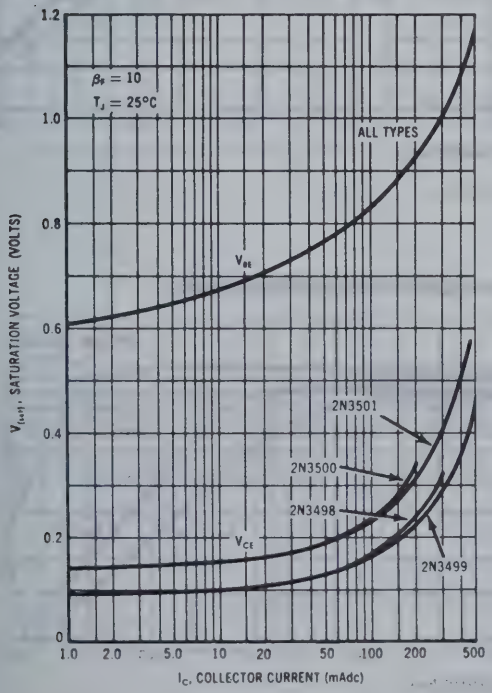
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3498, 2N3499	BV_{CEO}*	100	-	Vdc
	2N3500, 2N3501		150	-	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3498, 2N3499	BV_{CBO}	100	-	Vdc
	2N3500, 2N3501		150	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	2N3498, 2N3499	I_{CBO}	-	0.050	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	2N3498, 2N3499		-	50	
(V_{CB} = 75 Vdc, I_E = 0)	2N3500, 2N3501		-	0.050	
(V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)	2N3500, 2N3501		-	50	
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	-	25	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500	h_{FE}*	20	-	-
	2N3499, 2N3501		35	-	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500		25	-	
	2N3499, 2N3501		50	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500		35	-	
	2N3499, 2N3501		75	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500		40	120	
	2N3499, 2N3501		100	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	2N3500		15	-	
	2N3501		20	-	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N3498		15	-	
	2N3499		20	-	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$*	-	0.2	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)			-	0.25	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3500, 2N3501		-	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3498, 2N3499		-	0.6	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$*	-	0.8	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)				0.9	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3500, 2N3501		-	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3498, 2N3499		-	1.4	

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

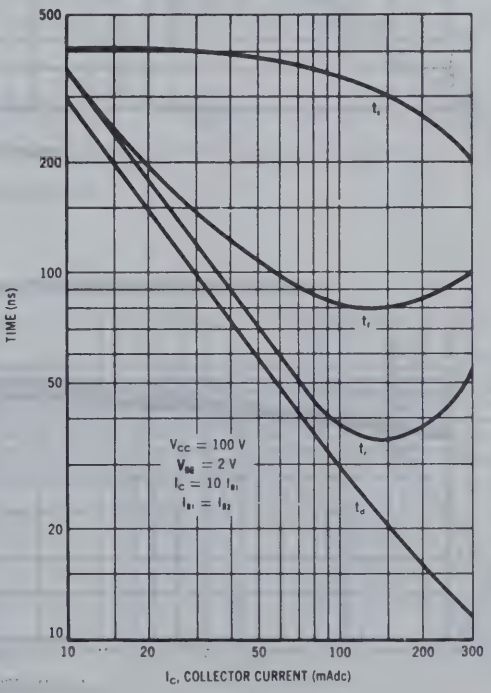
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	150	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	2N3498, 2N3499 2N3500, 2N3501	C_{ob}	- -	10 8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	80	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{ie}	0.2 0.25	1.0 1.25	k ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{re}	- -	2.5 4.0	X 10^{-4}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{fe}	50 75	300 375	-
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{oe}	10 20	100 200	μmhos
SWITCHING CHARACTERISTICS			Typ		
Delay Time	(V_{CC} = 100 Vdc, $V_{BE(off)}$ = 2.0 Vdc,	t_d	20		ns
Rise Time	I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_r	35		ns
Storage Time	(V_{CC} = 100 Vdc, I_C = 150 mAdc,	t_s	300		ns
Fall Time	I_{B1} = I_{B2} = 15 mAdc)	t_f	80		ns

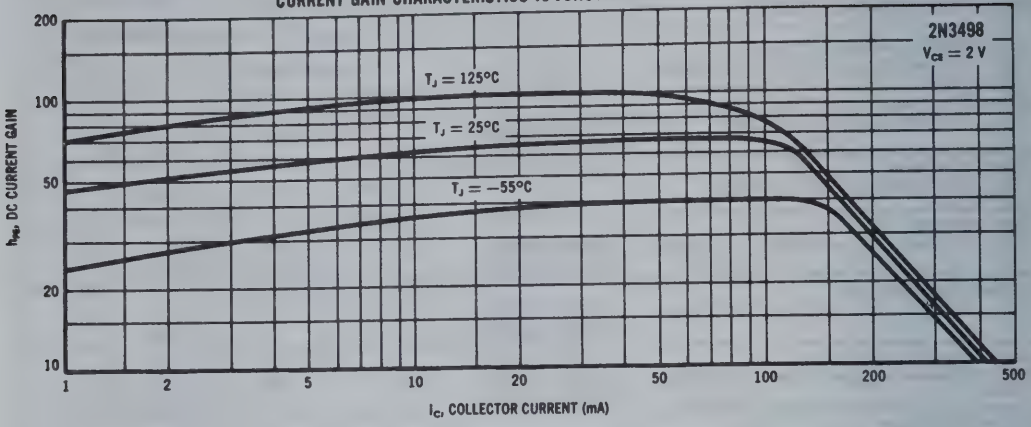
SATURATION VOLTAGES

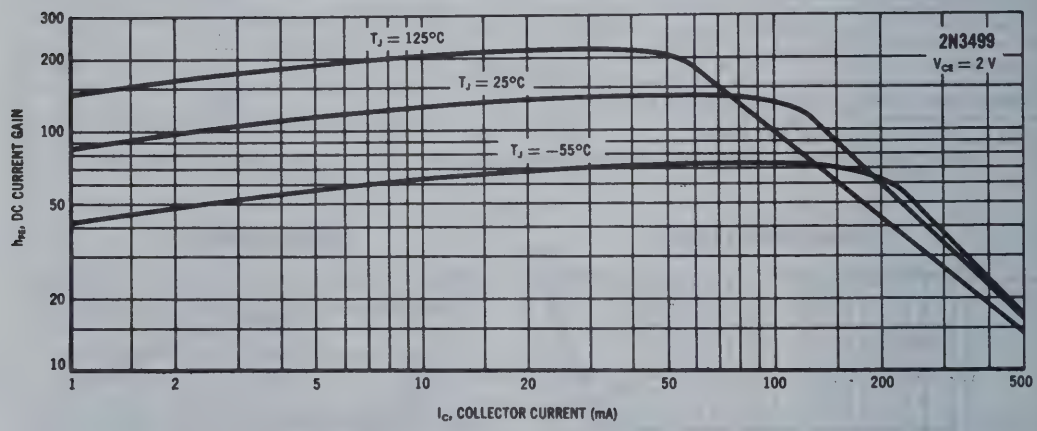


SWITCHING TIMES

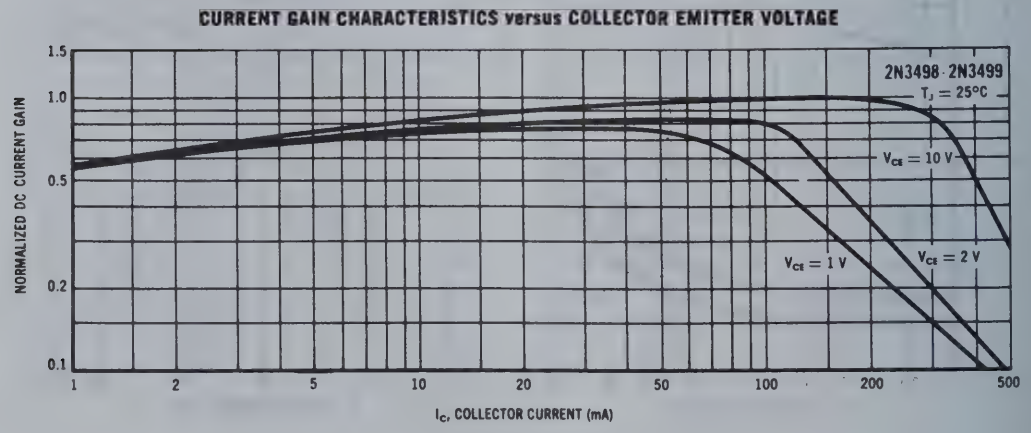


CURRENT GAIN CHARACTERISTICS vs JUNCTION TEMPERATURE

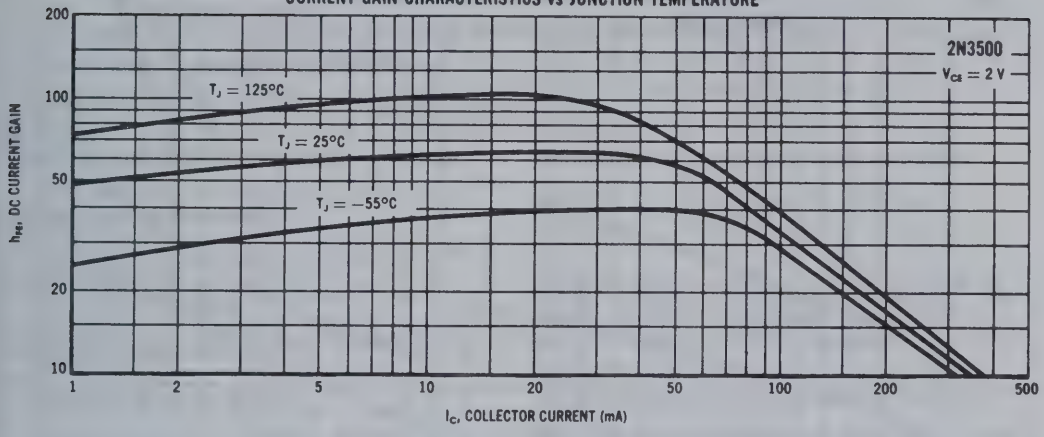


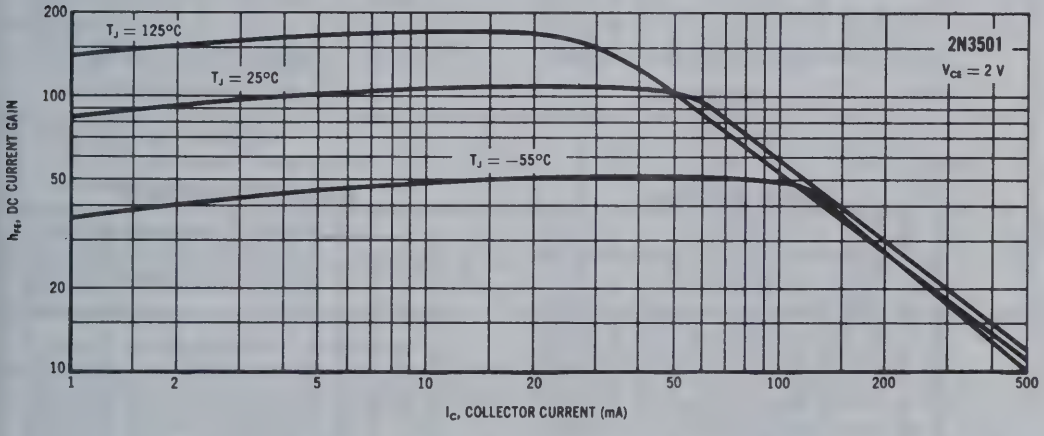


CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

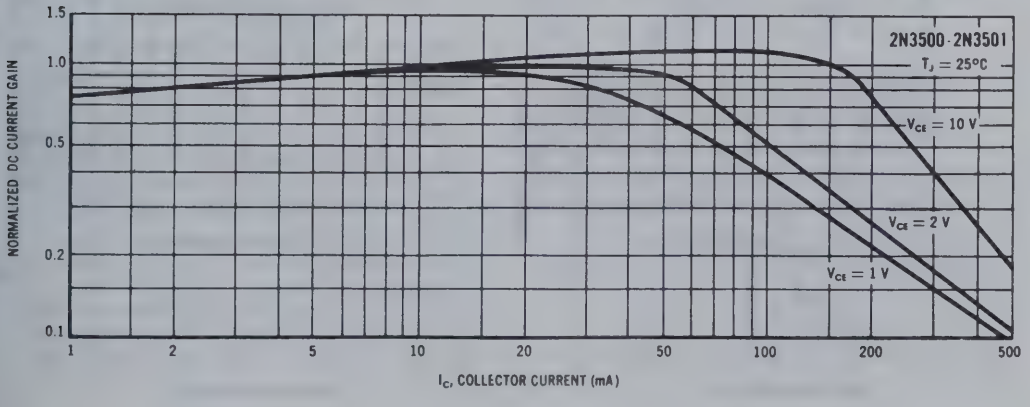


CURRENT GAIN CHARACTERISTICS vs JUNCTION TEMPERATURE



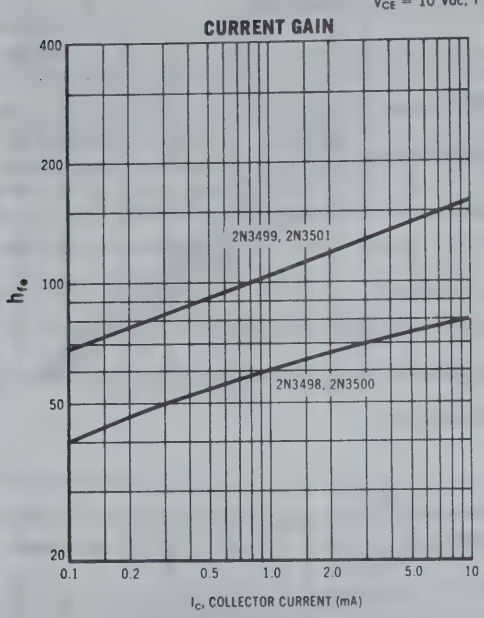


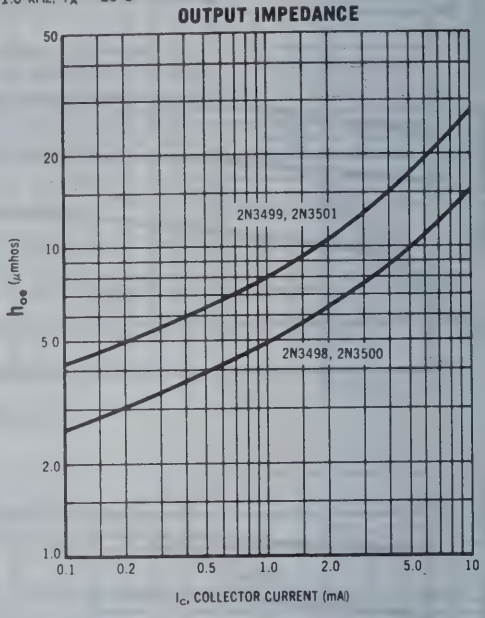
CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

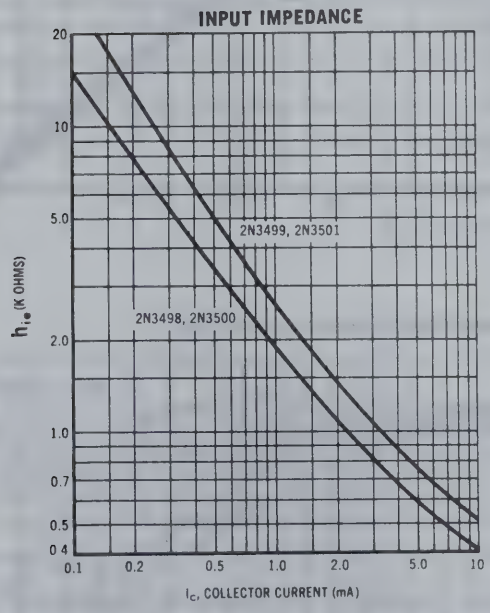


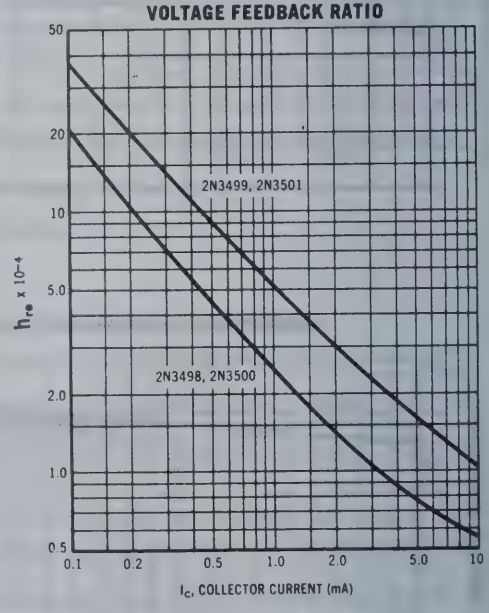
SMALL SIGNAL h PARAMETER CHARACTERISTICS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C









2N3506, 2N3507 (SILICON)



CASE 31
(TO-5)

NPN silicon annular transistors for high-current, high-speed, saturated switching and core driver applications.

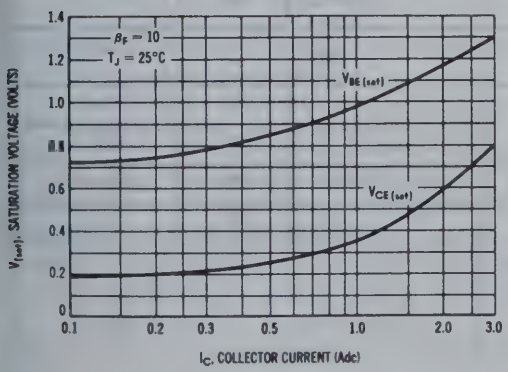
Collector connected to case

MAXIMUM RATINGS

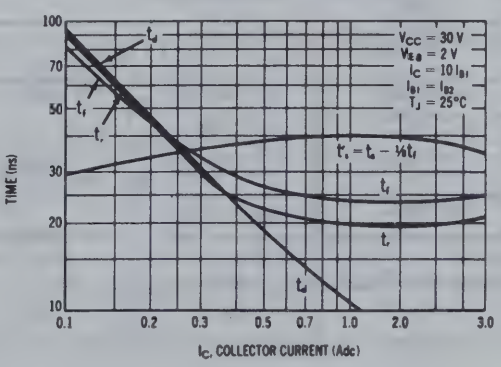
Rating	Symbol	2N3506	2N3507	Unit
Collector-Base Voltage	V_{CB}	60	80	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	3		Adc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	5 28.6		Watts mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	1.0 5.71		Watts mW/°C
Junction Operating Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL RESISTANCE $\theta_{JA} = 0.175°C/mW$
$\theta_{JC} = 35°C/W$

SATURATION VOLTAGES



SWITCHING TIMES

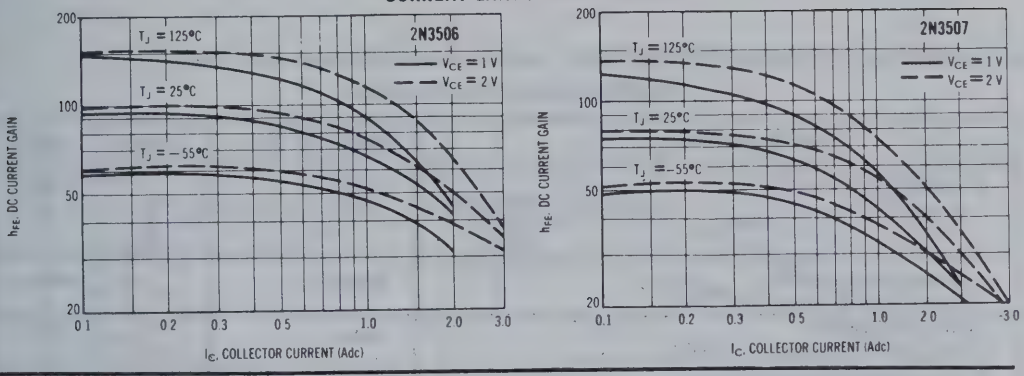


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3506		--	1.0	
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4 Vdc, T_A = 100°C)			--	150	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3507		--	1.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4 Vdc, T_A = 100°C)			--	150	
Base Cutoff Current		I_{BL}			μAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3506		--	1.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3507		--	1.0	
Collector-Base Breakdown Voltage	2N3506	BV_{CBO}	60	--	Vdc
(I_C = 100 μAdc, I_E = 0)	2N3507		80	--	
Collector-Emitter Breakdown Voltage*	2N3506	BV_{CEO}*	40	--	Vdc
(I_C = 10 mAdc, pulsed, I_B = 0)	2N3507		50	--	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0)			5	--	
Collector Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			--	0.5	
(I_C = 1.5 Adc, I_B = 150 mAdc)			--	1.0	
(I_C = 2.5 Adc, I_B = 250 mAdc)			--	1.5	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			--	1.0	
(I_C = 1.5 Adc, I_B = 150 mAdc)			0.9	1.4	
(I_C = 2.5 Adc, I_B = 250 mAdc)			--	2.0	
DC Current Gain*		h_{FE}*			--
(I_C = 500 mAdc, V_{CE} = 1 Vdc)	2N3506		50	--	
	2N3507		35	--	
(I_C = 1.5 Adc, V_{CE} = 2 Vdc)	2N3506		40	200	
	2N3507		30	150	
(I_C = 2.5 Adc, V_{CE} = 3 Vdc)	2N3506		30	--	
	2N3507		25	--	
(I_C = 3.0 Adc, V_{CE} = 5 Vdc)	2N3506		25	--	
	2N3507		20	--	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			--	40	
Input Capacitance		C_{ib}			pF
(V_{BE} = 3 Vdc, I_C = 0, f = 100 kHz)			--	300	
Current Gain-Bandwidth Product		f_T			MHz
(I_C = 100 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)			60	--	
Delay Time	I_C = 1.5 Adc, I_{B1} = 150 mAdc	t_d	--	15	ns
Rise Time	V_{CC} = 30 V, V_{EB} = 0 V	t_r	--	30	ns
Storage Time	I_C = 1.5 Adc, I_{B1} = I_{B2} = 150 mAdc	t_s	--	55	ns
Fall Time	V_{CC} = 30 V	t_f	--	35	ns

*Pulse Test: Pulse width = 300 μs, duty cycle = 2%

CURRENT GAIN CHARACTERISTICS



2N3508 (SILICON)
2N3509



NPN silicon annular transistor for high-speed, low-current switching applications.

CASE 26
(TO-46)

Collector connected to case

MAXIMUM RATINGS

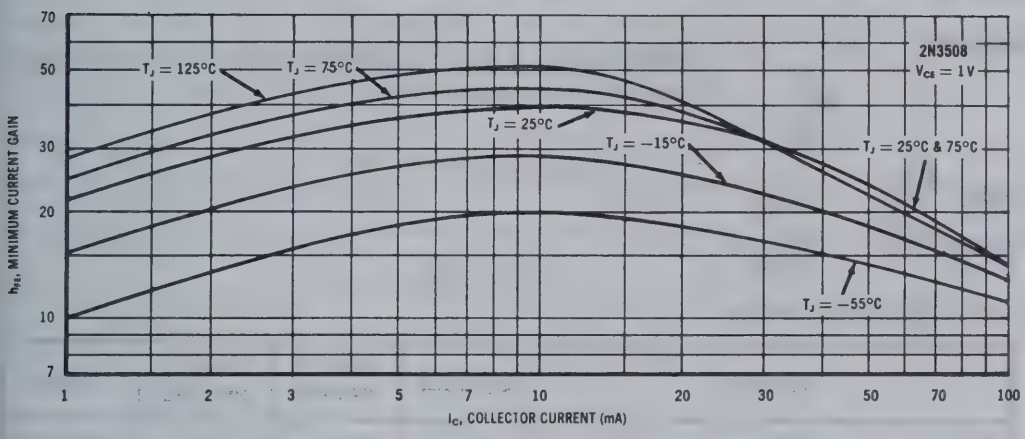
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current (10 μs pulse)	$I_{C(Peak)}$	500	mA
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.40 2.29	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	2.0 11.43	Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Thermal Resistance, Junction to Case Thermal Resistance, Junction to Ambient	θ_{JC} θ_{JA}	0.438 0.0875	°C/mW °C/mW

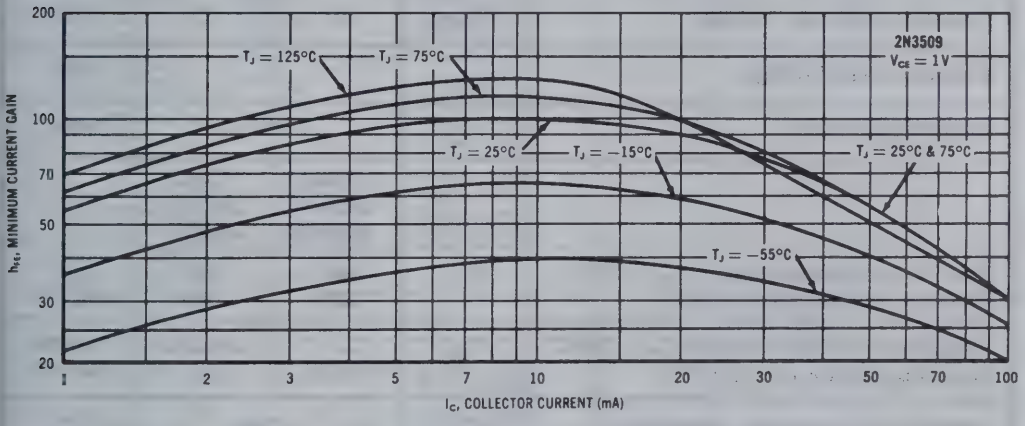
ELECTRICAL CHARACTERISTICS (at 25°C unless otherwise specified)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 20 Vdc)	Both Types	I_{CBO}	—	0.2	μAdc
(V_{CB} = 20 Vdc, T_A = 150°C)	2N3508		—	30	
	2N3509		—	50	
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3 Vdc)		I_{CEX}	—	0.2	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3 Vdc)		I_{BL}	—	0.5	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_B = 0)		BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc)		BV_{CEO}*	20	—	Vdc
Collector-Emitter Voltage (I_C = 10 μAdc, I_B = 0)		BV_{CES}	40	—	Vdc
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$*	—	0.25	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			—	0.45	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$*	0.70	0.85	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			0.8	1.4	
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3508	h_{FE}*	40	120	—
	2N3509		100	300	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)	2N3508		20	—	
	2N3509		40	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3508		20	—	
	2N3509		30	—	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		h_{fe}	5	—	—
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	—	4	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	—	4	pF
Storage Time (I_C = I_{B1} = I_{B2} = 10 mA)		$t_s(T_s)$	—	13	ns
Turn-On Time (I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 3 V, V_{OB} = 1.5 V)		t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mA, I_{B1} = 3 mA, I_{B2} = 1.5 mA, V_{CC} = 3 V)		t_{off}	—	18	ns
Total Control Charge (I_C = 10 mA, I_B = 1 mA, V_{CC} = 3 V)		Q_T	—	50	pC
Delay Time	V_{CC} = 10 V, V_{EB} = 2 V, I_C = 100 mA, I_{B1} = 10 mA	t_d	—	5	ns
Rise Time		t_r	—	18	ns
Storage Time	V_{CC} = 10 V, I_C = 100 mA, I_{B1} = I_{B2} = 10 mA	t_s	—	13	ns
Fall Time		t_f	—	15	ns

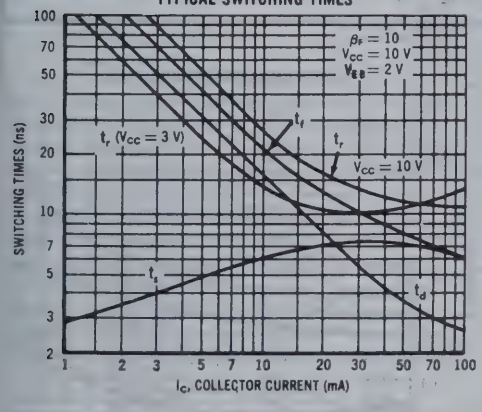
*Pulse Test: PW = 300μs, Duty Cycle ≤ 2%

MINIMUM CURRENT GAIN CHARACTERISTICS

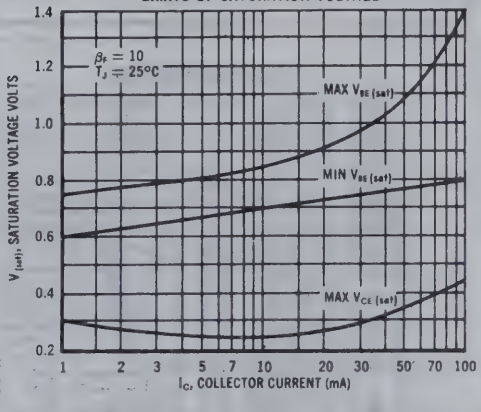




TYPICAL SWITCHING TIMES

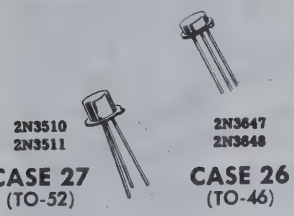


LIMITS OF SATURATION VOLTAGE



2N3510 (SILICON)
2N3511
2N3647
2N3648

NPN silicon annular transistors for high-speed saturated switching applications to 500 mA.



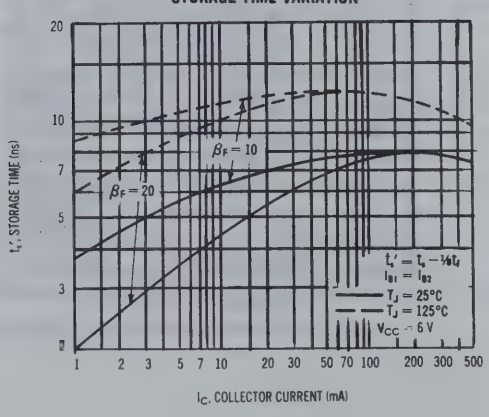
CASE 27 (TO-52)

CASE 26 (TO-46)

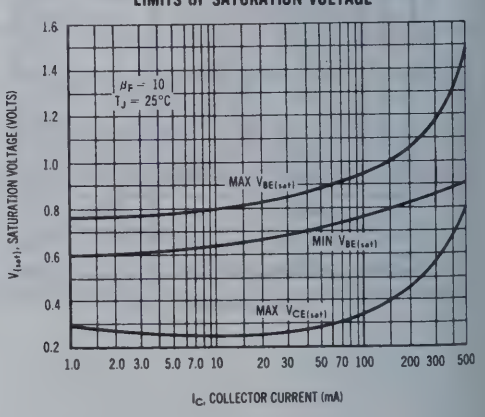
MAXIMUM RATINGS

Rating	Symbol	2N3510 2N3647	2N3511 2N3648	Unit
Collector-Base Voltage	V_{CB}	40	40	Vdc
Collector-Emitter Voltage	V_{CEO}	10	15	Vdc
Emitter-Base Voltage	V_{EB}	6		Vdc
Collector Current	I_C	500		mAdc
		TO-46 2N3647 2N3648	TO-52 2N3510 2N3511	
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	400 2.28	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	2.0 11.43	1.2 6.9	Watts mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

STORAGE TIME VARIATION



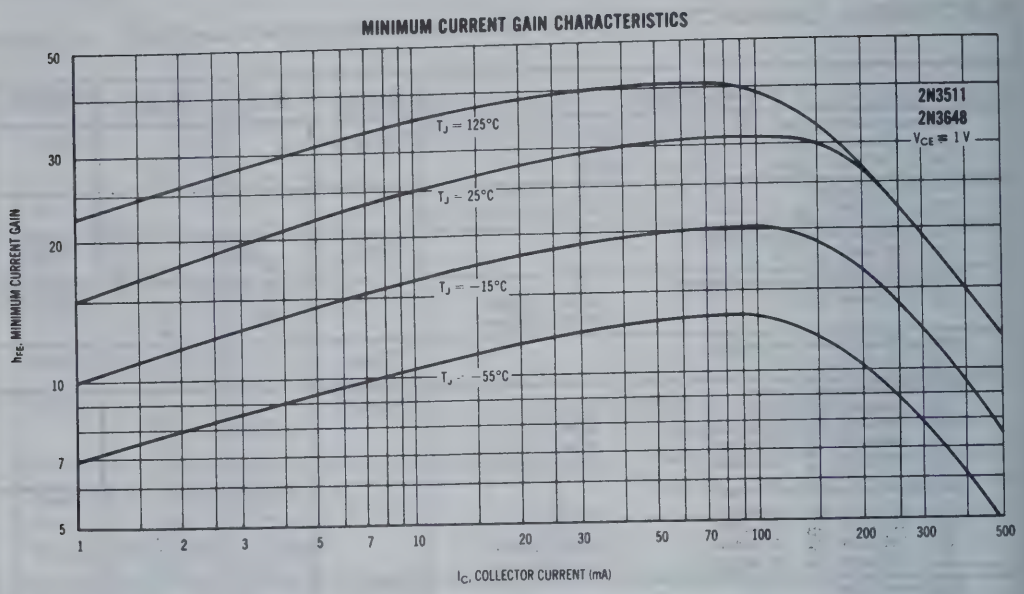
LIMITS OF SATURATION VOLTAGE

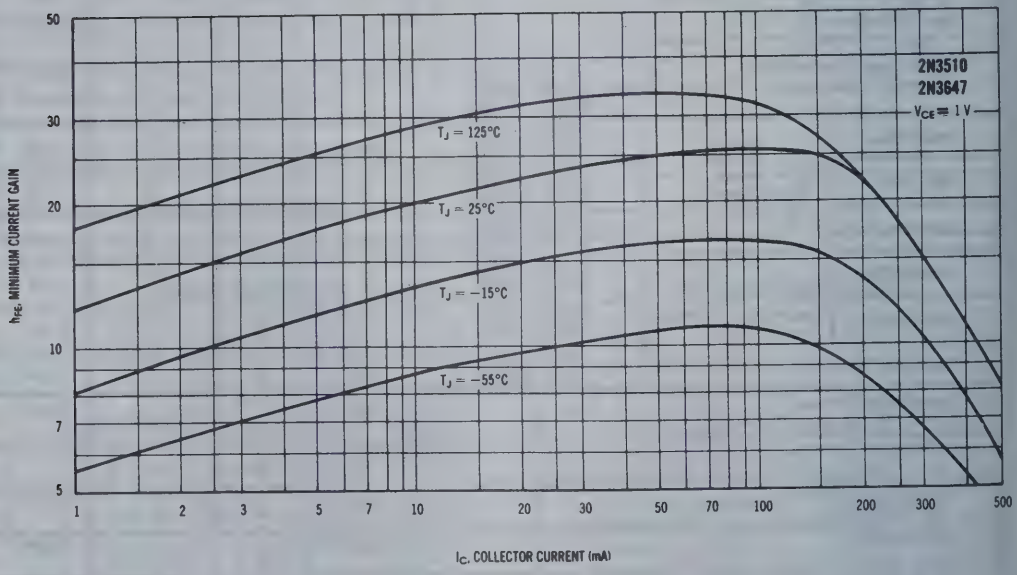


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristic			Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CE} = 10 Vdc, $V_{EB(off)}$ = 1 Vdc) (V_{CE} = 10 Vdc, $V_{EB(off)}$ = 1 Vdc, T_A = 150°C)			I_{CEX}	— —	.025 50	μAdc
Base Cutoff Current (V_{CE} = 10 Vdc, V_{OB} = 1 Vdc)			I_{BL}	—	.025	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		2N3510, 2N3647 2N3511, 2N3648	BV_{CEO}*	10 15	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	6	—	Vdc
Collector Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		All Types All Types 2N3510, 2N3647 2N3511, 2N3648	$V_{CE(sat)}$*	— — — —	0.25 0.4 0.6 0.8	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		All Types All Types 2N3510, 2N3647 2N3511, 2N3648	$V_{BE(sat)}$*	— 0.8 — —	0.8 1.0 1.15 1.5	Vdc
DC Current Gain* (I_C = 1.0 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 150 mAdc, V_{CE} = 1 Vdc) (I_C = 150 mAdc, V_{CE} = 1 Vdc, TA = -55°C) (I_C = 300 mAdc, V_{CE} = 1 Vdc) (I_C = 500 mAdc, V_{CE} = 1 Vdc)		2N3510, 2N3647 2N3511, 2N3648 2N3510, 2N3647 2N3511, 2N3648 2N3510, 2N3647 2N3511, 2N3648 2N3510, 2N3647 2N3511, 2N3648 2N3510, 2N3647 2N3511, 2N3648	h_{FE}*	12 15 20 25 25 30 12 15 12	— — — — 150 120 — — —	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			C_{ob}	—	4	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)			C_{ib}	—	8	pF
Small Signal Current Gain (I_C = 15 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		2N3510, 2N3647 2N3511. 2N3648	h_{fe}	3.5 4.5	— —	—
Delay Time	(I_C = 150 mA, I_{B1} = 15 mA, V_{EB} = 0.5 V, V_{CC} = 6 V)	2N3510, 2N3647 2N3511, 2N3648	t_d	— —	10 8	ns
Rise Time		2N3510, 2N3647 2N3511, 2N3648	t_r	— —	12 10	ns
Turn-On Time		2N3510, 2N3647 2N3511, 2N3648	t_{on}	— —	20 16	ns
Storage Time	(I_C = 150 mA, I_{B1} = $-I_{B2}$ = 15 mA, V_{CC} = 6 V)	2N3510, 2N3647 2N3511, 2N3648	t_s	— —	16 12	ns
Fall Time		2N3510, 2N3647 2N3511, 2N3648	t_f	— —	12 8	ns
Turn-Off Time		2N3510, 2N3647 2N3511. 2N3648	t_{off}	— —	25 18	ns
Total Control Charge (I_C = 150 mA, I_B = 15 mA, V_{CC} = 6 V)			Q_T	—	300	pC
Small Signal Current Gain (I_C = 1 mA, V_{CE} = 10 V, f = 1 kHz)			h_{fe}	20	150	—
Voltage Feedback Ratio (I_C = 1 mA, V_{CE} = 10 V, f = 1 kHz)			h_{re}	—	25	$X10^{-4}$
Input Impedance (I_C = 1 mA, V_{CE} = 10 V, f = 1 kHz)			h_{ie}	0.6	4.5	kohms
Output Admittance (I_C = 1 mA, V_{CE} = 10 V, f = 1 kHz)			h_{oe}	10	100	μmhos

* Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%


MINIMUM CURRENT GAIN CHARACTERISTICS
2N3511
2N3648
V_{CE} = 1 V
T_J = 125°C
T_J = 25°C
T_J = −15°C
T_J = −55°C
h_{FE}, MINIMUM CURRENT GAIN
I_C, COLLECTOR CURRENT (mA)
50
30
20
10
7
5
1
2
3
5
7
10
20
30
50
70
100
200
300
500

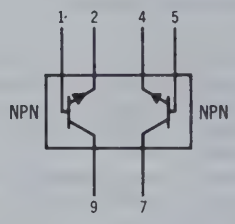

2N3510
2N3647
V_{CE} = 1 V
T_J = 125°C
T_J = 25°C
T_J = −15°C
T_J = −55°C
h_{FE}, MINIMUM CURRENT GAIN
I_C, COLLECTOR CURRENT (mA)
50
30
20
10
7
5
1
2
3
5
7
10
20
30
50
70
100
200
300
500

2N3515 (SILICON)
2N3518



CASE 33
(TO-89)

Dual NPN silicon transistor for use as a differential amplifier.



Pin Connections,
Bottom View

MAXIMUM RATINGS (each side) (T_A = 25°C)

Rating	Symbol	2N3515	2N3518	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0	7.0	Vdc
Collector Current	I_C	500		mAdc
Operating Junction Temperature Range	T_J	-65 to +175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	250	350	mW
Derate above 25°C		1.67	2.33	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	700	1,400	mW
Derate above 25°C		4.67	9.33	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 20 mAdc, I_B = 0)	2N3515	BV_{CEO}*	40	-	Vdc
	2N3518		60	-	
Collector-Base Breakdown Voltage (I_C = 50 nAdc, I_E = 0)	2N3515	BV_{CBO}	80	-	Vdc
(I_C = 100 μAdc, I_E = 0)	2N3518		100	-	
Emitter-Base Breakdown Voltage (I_E = 50 nAdc, I_C = 0)	2N3515	BV_{EBO}	5.0	-	Vdc
(I_E = 100 μAdc, I_C = 0)	2N3518		7.0	-	
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	2N3515	I_{CBO}	-	0.02	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N3515		-	15	
(V_{CB} = 50 Vdc, I_E = 0)	2N3518			0.002	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	2N3518		-	10	
Emitter-Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	2N3515	I_{EBO}	-	20	nAdc
	2N3518		-	2.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		h_{FE}	35	-	-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)			50	200	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	2N3518		15	-	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	-	1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	-	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N3515	f_T	50	-	MHz
	2N3518		60	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N3515	C_{ob}	-	18	pF
	2N3518		-	15	
Input Capacitance (V_{BE} = 0, 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	-	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	20	35	ohms
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N3515	h_{ie}	1.0	5.0	k ohms
	2N3518		1.0	10.5	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{fe}	50	300	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N3515	h_{oe}	4.0	16	μmhos
	2N3518		4.0	50	
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_G = 510 ohms, B. W. = 1.0 Hz, f = 1.0 kHz)		NF	-	8.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3515	h_{FE1}/h_{FE2}**	0.8	1.0	-
	2N3518		0.9	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N3515		0.8	1.0	
	2N3518		0.9	1.0	
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3515	$\lvert V_{BE1}-V_{BE2}\rvert$	-	5.0	mVdc
	2N3518		-	3.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N3515		-	5.0	
	2N3518		-	3.0	
Base Voltage Differential Gradient (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +125°C)	2N3515	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	-	15	μV/°C
	2N3518		-	10	

* Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

** The lowest of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N3544 (SILICON)



CASE 22
(TO-18)

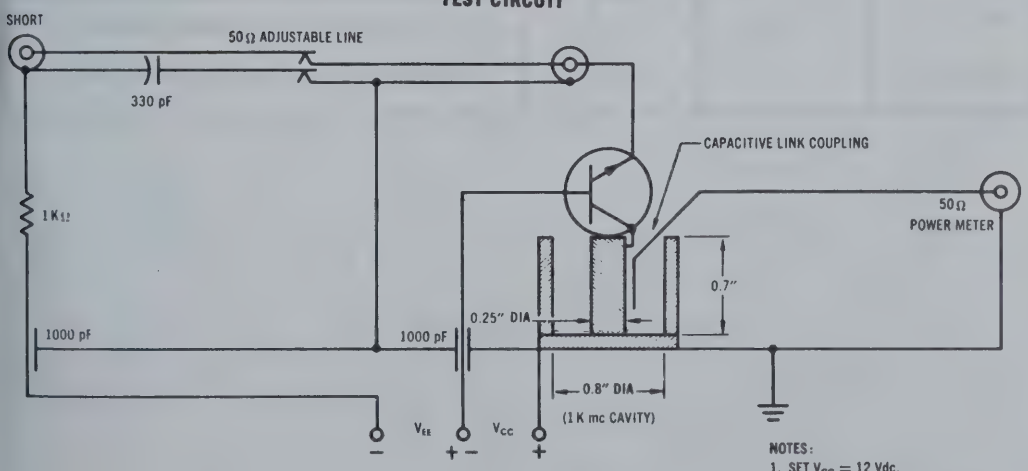
NPN silicon annular transistor for VHF and UHF oscillator applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Volts
Collector-Emitter Voltage	V_{CES}	25	Volts
Emitter-Base Voltage	V_{EB}	3.0	Volts
Collector Current	I_C	100	mA
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

TEST CIRCUIT



NOTES:
1. SET V_{CC} = 12 Vdc.
2. ADJUST V_{EE} FOR I_C = 12 mAdc.
3. SET ADJUSTABLE LINE FOR MAXIMUM POWER OUTPUT.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 10 μAdc, I_E = 0	25	30	--	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 10 μA, V_{BE} = 0	25	30	--	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc, I_E = 0	--	0.01	0.1	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 3 Vdc, I_C = 0	--	0.1	10	μAdc
DC Current Gain	h_{FE}	V_{CE} = 10 Vdc, I_C=10 mAdc	25	50	--	--
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 100 MHz	6	9	15	--
Collector Output Capacitance	C_{ob}	V_{CB} = 15 Vdc, I_E = 0, f = 100 kHz	--	--	2.5	pF
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 10 mAdc, f = 31.8 MHz	--	--	10	ps
Oscillator Power Output	P_{out}	f = 1.0 GHz, V_C = 12 Vdc, I_C=12 mAdc	10	16	--	mW

2N3546 (SILICON)



CASE 22
(TO-18)

PNP silicon annular transistor for low-level, high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Thermal Resistance, Junction to Ambient	θ_{JA}	0.49	°C/mW
Thermal Resistance, Junction to Case	θ_{JC}	0.15	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 10 Vdc) (V_{CB} = 10 Vdc, T_A = 150°C)		I_{CBO}	-- --	0.010 10	μAdc
Collector Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{CEX}	--	0.010	μAdc
Base Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{BL}	--	0.10	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	15	--	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.5	--	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	12	--	Vdc
Collector Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$*	-- -- --	0.15 0.25 0.50	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{BE(sat)}$*	0.7 0.8 --	0.9 1.3 1.6	Vdc
DC Current Gain* (I_C = 1.0 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55°C) (I_C = 50 mAdc, V_{CE} = 1 Vdc) (I_C = 100 mAdc, V_{CE} = 1Vdc)		h_{FE}*	20 30 15 25 15	-- 120 -- -- --	--
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	--	6	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1 MHz)		C_{ib}	--	5	pF
Current-Gain - Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	700	--	MHz
Total Control Charge (I_C = 50 mA, I_B = 5 mA, V_{CC} = 3 V)		Q_T	--	400	pC
Delay Time	I_C = 50 mA, I_{B1} = 5mA,	t_d	--	10	ns
Rise Time	V_{BE} = 2 V, V_{CC} = 3 V	t_r	--	15	ns
Storage Time	I_C = 50 mA, I_{B1} = I_{B2} = 5 mA,	t_s	--	20	ns
Fall Time	V_{CC} = 3 V	t_f	--	15	ns
Turn-On Time	(See Figure 3,4,5)	t_{on}	--	40	ns
Turn-Off Time		t_{off}	--	30	ns

*Pulse Test: PW = 300 μs, Duty Cycle ≤ 2%

FIGURE 1

LIMITS OF SATURATION VOLTAGES

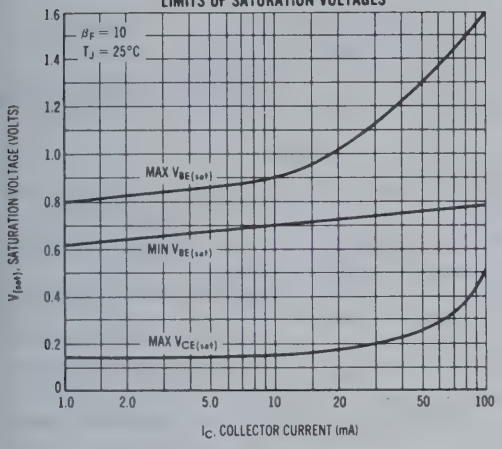


FIGURE 2

STORAGE TIME BEHAVIOR

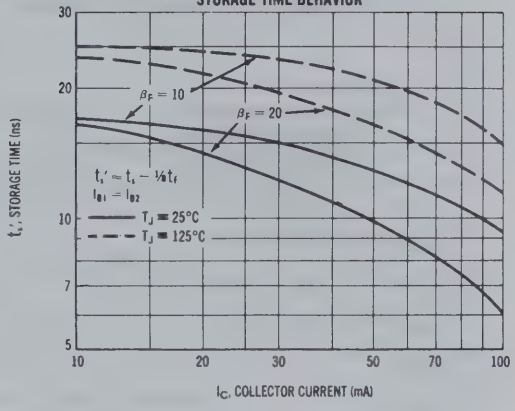
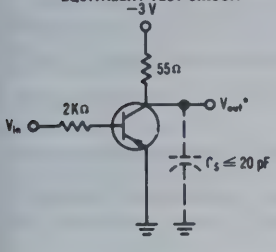
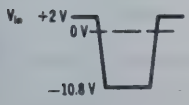


FIGURE 3

DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT



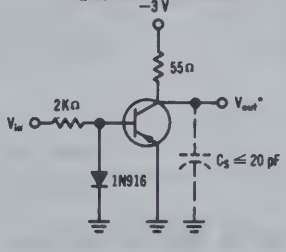


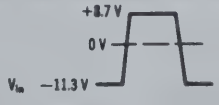
PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE ≤ 10%

*OSCILLOSCOPE RISE TIME ≤ 1 ns

FIGURE 4

STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT

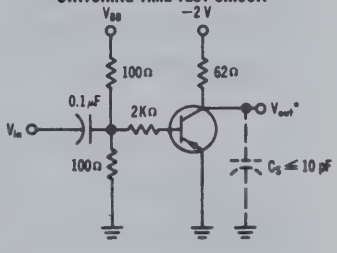




PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE ≤ 10%

FIGURE 5

SWITCHING TIME TEST CIRCUIT

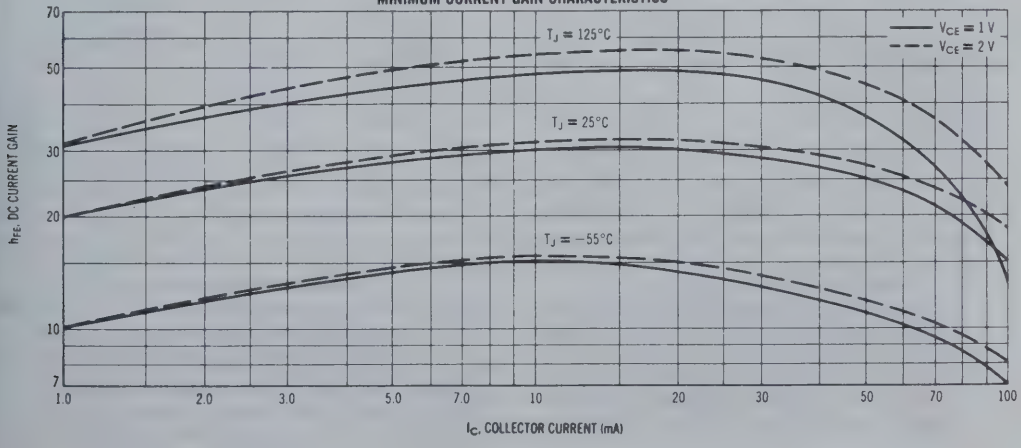


PULSE WIDTH > 200 ns
RISE TIME < 1 ns
$Z_{in} = 50\Omega$

t_{on} : $V_{BB} = +3$ V, $V_{in} = -7$ V
t_{off} : $V_{BB} = -4$ V, $V_{in} = +6$ V

FIGURE 6

MINIMUM CURRENT GAIN CHARACTERISTICS



2N3553 (SILICON)

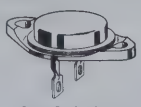
For Specifications, See 2N3375 Data.

2N3611 thru 2N3614 (GERMANIUM)

PNP germanium power transistors for switching and amplifier applications.



CASE 11
(TO-3)



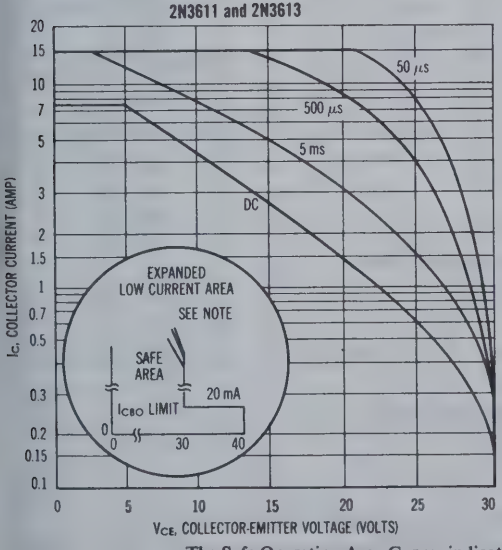
CASE 4-04
(TO-41)

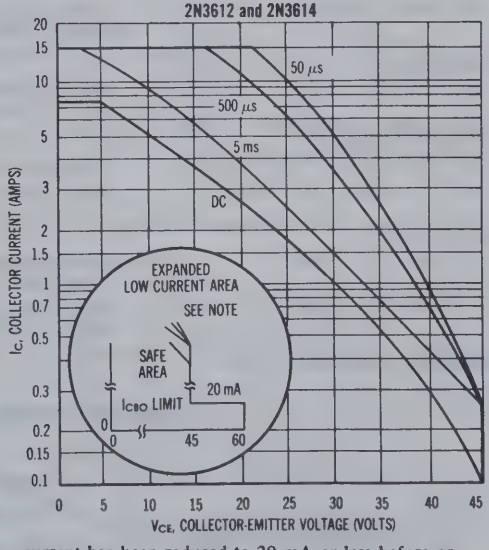
For units with solder lugs attached, specify device MP3611 etc. (TO-41 package)

MAXIMUM RATINGS

Rating	Symbol	2N3611 2N3613	2N3612 2N3614	Unit
Collector-Emitter Voltage	V_{CES}	30	45	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	25	35	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	20	30	Vdc
Collector Current (Continuous)	I_C	7		Adc
Peak Collector Current (PW ≦ 5 msec)	I_C	15		Adc
Base Current (Continuous)	I_B	2		Adc
Storage Temperature Range	T_{stg}	-65 to +110		°C
Operating Case Temperature Range	T_C	-65 to +110		°C
Total Device Dissipation @ T_C = 25°C Derate above T_C = 25°C	P_D	77 1		Watts W/°C
Thermal Resistance, Junction to Case	θJC	1.1		°C/W
Thermal Resistance, Case to Ambient	θCA	32.7		°C/W

SAFE OPERATING AREAS





The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

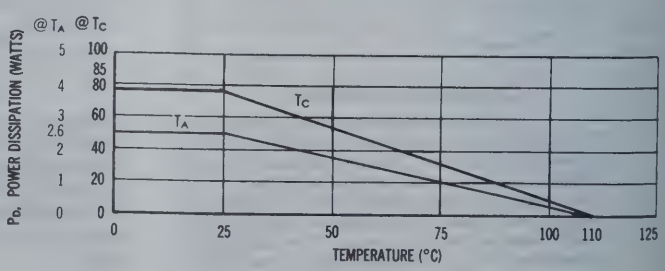
ELECTRICAL CHARACTERISTICS

Characteristics		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc)	2N3611, 2N3613	BV_{CES}*	30	–	Vdc
	2N3612, 2N3614		45	–	
Collector-Emitter Breakdown Voltage* (I_C = 500 mAdc)	2N3611, 2N3613	BV_{CEO}*	25	–	Vdc
	2N3612, 2N3614		35	–	
Floating Potential (V_{CB} = V_{CB} max)		V_{EBF}	–	1.0	Vdc
Collector-Emitter Leakage Current (V_{CE} = 1/2 V_{CEO} max)		I_{CEO}	–	30	mAdc
Collector-Emitter Leakage Current (V_{CE} = V_{CE} max, V_{BE} = 1.0 Vdc, T_C = +100°C)		I_{CEX}	–	10	mAdc
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 2 Vdc)			–	.040	
(V_{CB} = 25 Vdc)	2N3611, 2N3613		–	0.5	
(V_{CB} = 40 Vdc)	2N3612, 2N3614		–	0.5	
(V_{CB} = V_{CB} max)			–	5.0	
Emitter-Base Cutoff Current (V_{EB} = V_{EB} max)		I_{EBO}	–	500	μAdc
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 3 Adc, I_B = 300 mAdc)			–	0.25	
(I_C = 7 Adc, I_B = 700 mAdc)			–	0.35	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 3 Adc, I_B = 300 mAdc)	2N3611, 2N3612		–	0.7	
	2N3613, 2N3614		–	0.6	
(I_C = 7 Adc, I_B = 700 mAdc)	2N3611, 2N3612		–	1.1	
	2N3613, 2N3614		–	0.9	
Transconductance		g_{FE}			mhos
(I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3611, 2N3612		3.0	–	
	2N3613, 2N3614		3.5	–	
Small Signal Current Gain		h_{fe}			–
(I_C = 0.5 A, V_{CE} = 12 V, f = 20 kHz)			15	–	
(I_C = 0.5 A, V_{CE} = 2 V, f = 1 kHz)	2N3611, 2N3612		40	100	
	2N3613, 2N3614		60	150	
DC Current Gain		h_{FE}			–
(I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3611, 2N3612		35	70	
	2N3613, 2N3614		60	120	
(I_C = 7 Adc, V_{CE} = 2 Vdc)	2N3611, 2N3612		20	–	
	2N3613, 2N3614		30	–	

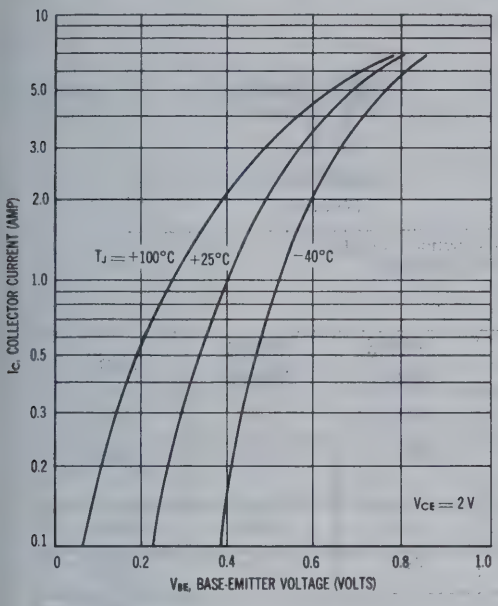
*Sweep Test: 1/2 sine wave, 60 Hz

These transistors are also subject to safe area curves. Both limits are applicable and must be observed.

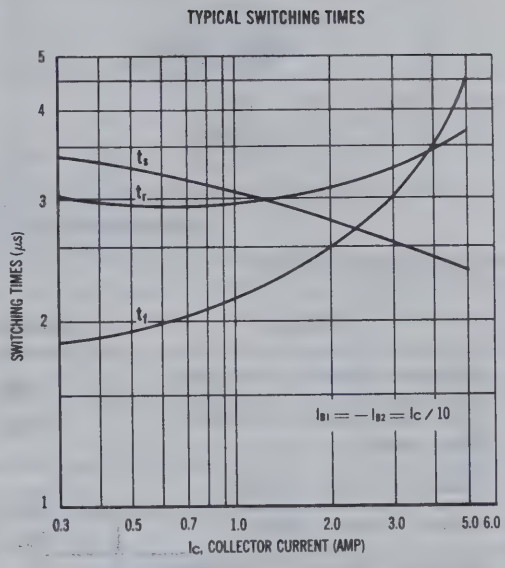
POWER-TEMPERATURE DERATING CURVE



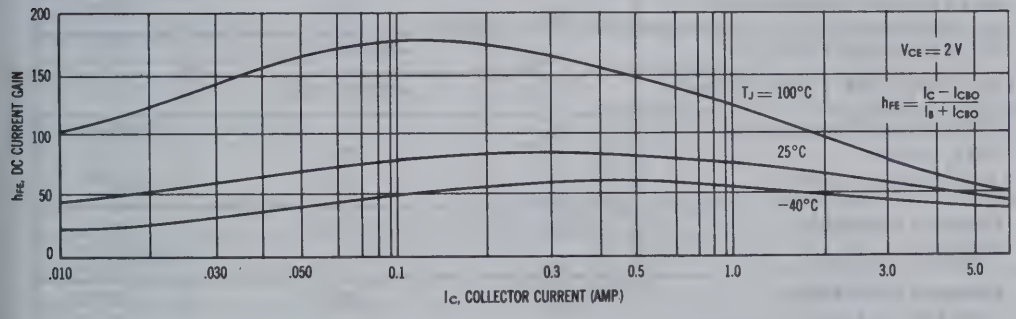
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



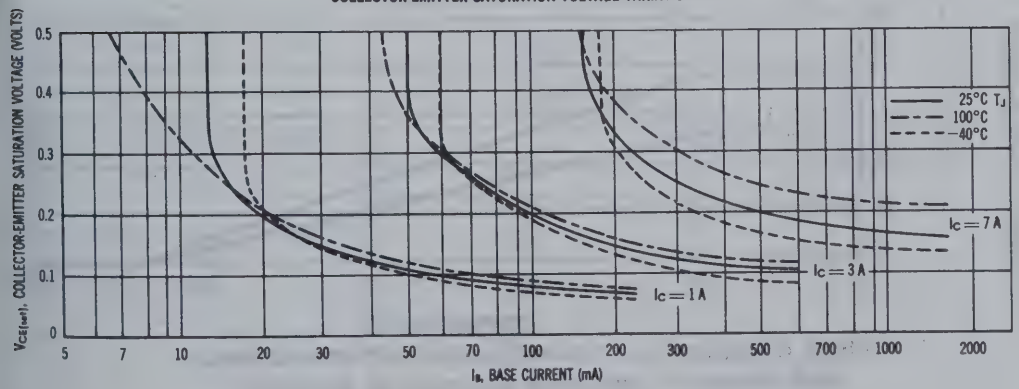
TYPICAL SWITCHING TIMES



DC CURRENT GAIN versus COLLECTOR CURRENT

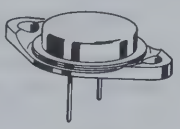


COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS

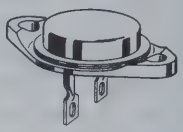


2N3615 thru 2N3618 (GERMANIUM)

PNP germanium power transistors for switching and amplifier applications.



CASE 11
(TO-3)

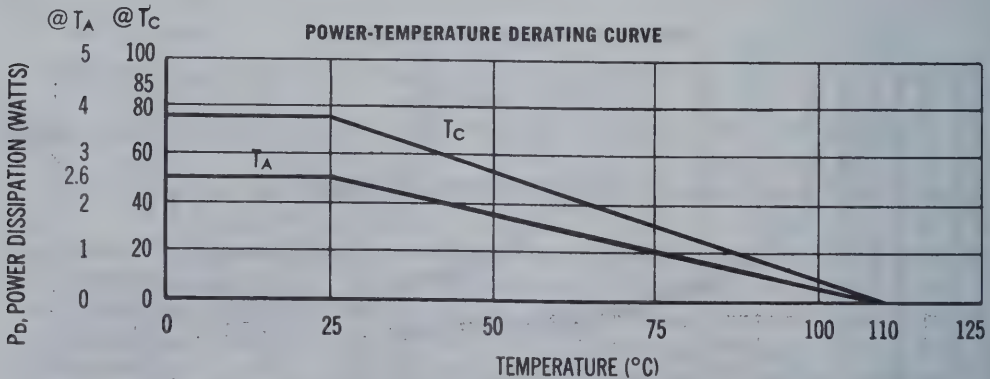


CASE 4-04
(TO-41)

For units with solder lugs attached, specify devices MP3615 etc. (TO-41 package)

MAXIMUM RATINGS

Rating	Symbol	2N3615 2N3617	2N3616 2N3618	Unit
Collector-Emitter Voltage	V_{CES}	60	75	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	50	60	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	40	50	Vdc
Collector Current (Continuous)	I_C	7		Adc
Peak Collector Current (PW ≤ 5 msec)	I_C	15		Adc
Base Current (Continuous)	I_B	2		Adc
Storage Temperature	T_{stg}	-65 to +110		°C
Operating Case Temperature	T_C	-65 to +110		°C
Total Device Dissipation @T_C = 25°C Derate above 25°C	P_D	77 1		Watts W/°C
Thermal Resistance, Junction to Case	θ_{JC}	1.0		°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	32.7		°C/W



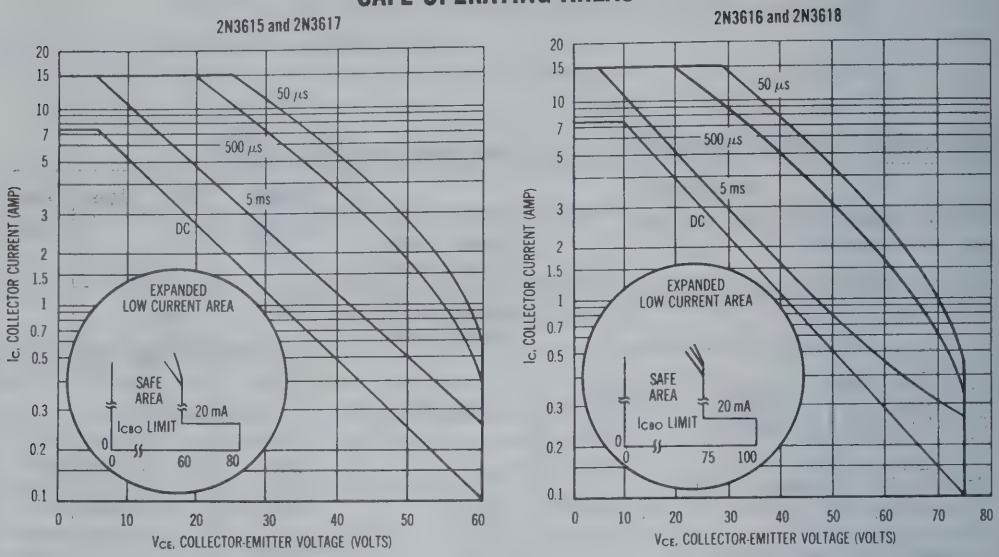
These transistors are also subject to safe area curves. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc)	2N3615, 2N3617	BV_{CES}*	60	-	Vdc
	2N3616, 2N3618		75	-	
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc)	2N3615, 2N3617	BV_{CEO}*	50	-	Vdc
	2N3616, 2N3618		60		
Floating Potential (V_{CB} = V_{CB} max)		V_{EBF}	-	1.0	Vdc
Collector-Emitter Leakage Current (V_{CE} = 1/2 V_{CEO} max)		I_{CEO}	-	30	mAdc
Collector-Emitter Leakage Current (V_{CE} = V_{CE} max, V_{BE} = 1.0 Vdc, T_C = +100°C)		I_{CEX}	-	10	mAdc
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 2.0 Vdc)			-	0.060	
(V_{CB} = 55 Vdc)	2N3615, 2N3617		-	1.0	
(V_{CB} = 65 Vdc)	2N3616, 2N3618		-	1.0	
(V_{CB} = V_{CB} max)			-	5.0	
Emitter-Base Cutoff Current		I_{EBO}			μAdc
(V_{EB} = V_{EB} max)				500	
(V_{EB} = 12 Vdc)			-		
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 3.0 Adc, I_B = 300 mAdc)			-	0.25	
(I_C = 7.0 Adc, I_B = 700 mAdc)			-	0.35	
Base Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 3.0 Adc, I_B = 300 mAdc)	2N3615, 2N3616		-	0.7	
	2N3617, 2N3618		-	0.6	
(I_C = 7.0 Adc, I_B = 700 mAdc)	2N3615, 2N3616		-	1.1	
	2N3617, 2N3618		-	0.9	
Transconductance		g_{FE}			mhos
(I_C = 3.0 A, V_{CE} = 2.0 V)	2N3615, 2N3616		3.0	-	
	2N3617, 2N3618		3.5	-	
Small Signal Current Gain		h_{fe}			-
(I_C = 0.5 A, V_{CE} = 12 V, f = 20 kHz)			15	-	
(I_C = 0.5 A, V_{CE} = 2.0 V, f = 1.0 kHz)	2N3615, 2N3616		40	100	
	2N3617, 2N3618		60	150	
DC Current Gain		h_{FE}			-
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N3615, 2N3616		30	60	
	2N3617, 2N3618		45	90	
(I_C = 7.0 Adc, V_{CE} = 2.0 Vdc)	2N3615, 2N3616		20	-	
	2N3617, 2N3618		30	-	
Current-Gain-Bandwidth Product		f_T	Typ		kHz
(I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)			600		

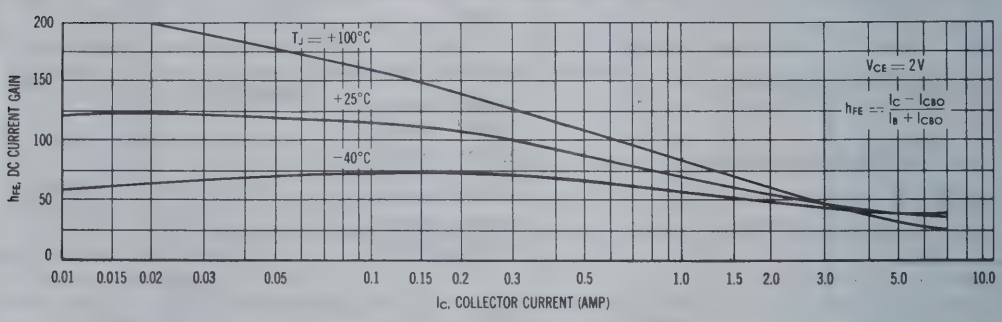
*Sweep Test: 1/2 sine wave, 60 Hz

SAFE OPERATING AREAS

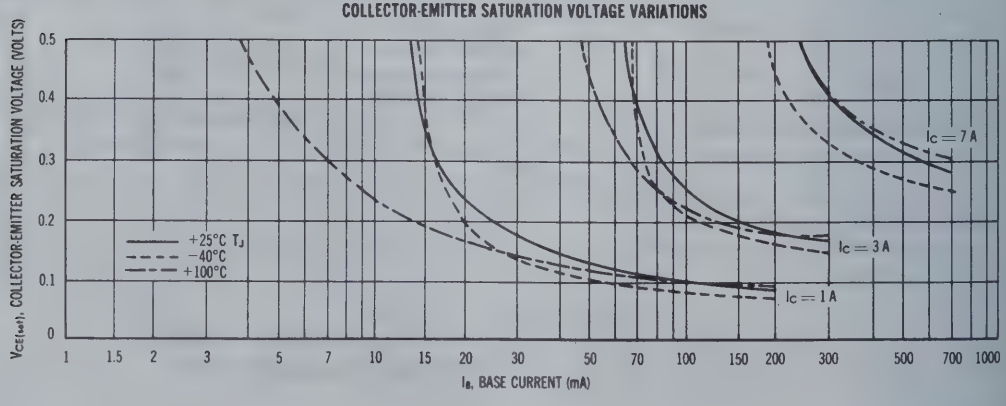


NOTE The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

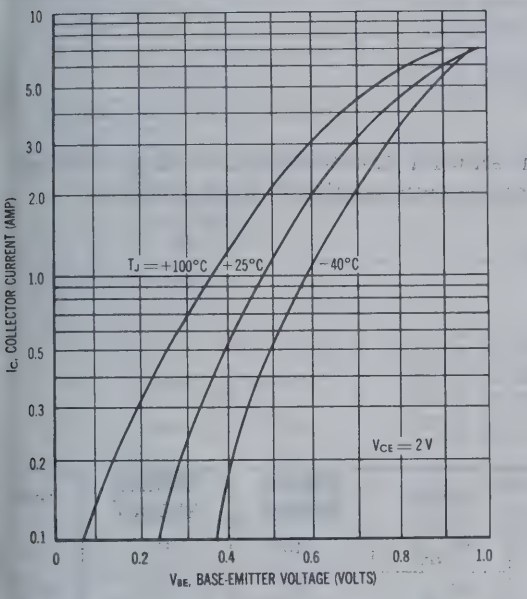
DC CURRENT GAIN versus COLLECTOR CURRENT



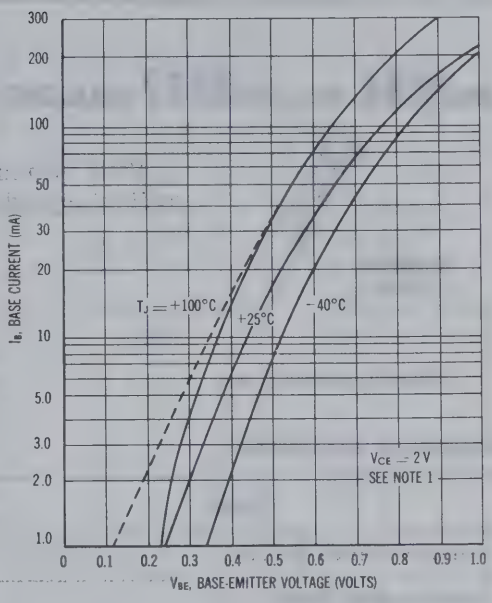
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS



COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

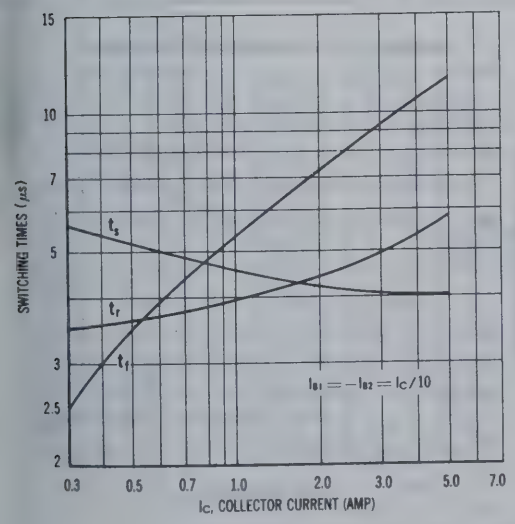


BASE CURRENT versus BASE-EMITTER VOLTAGE

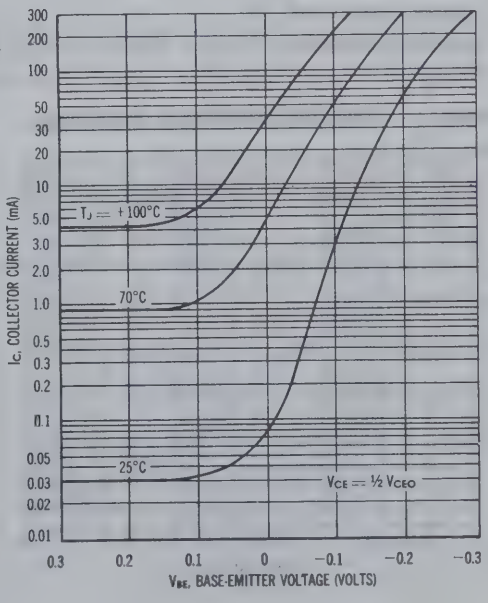


NOTE 1 — Dotted line indicates Metered Base Current plus the I_{CBO} of the transistor at 100°C.

TYPICAL SWITCHING TIMES



COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



2N3632

For Specifications, See 2N3375 Data.

2N3634 thru 2N3637 (SILICON)



CASE 31
(TO-5)

Collector connected to case

PNP silicon annular transistors for high-voltage switching and low-power amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	2N3634 2N3635	2N3636 2N3637	Unit
Collector-Emitter Voltage	V_{CEO}	140	175	Vdc
Collector-Base Voltage	V_{CB}	140	175	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

FIGURE 1 — JUNCTION CAPACITANCE VARIATIONS

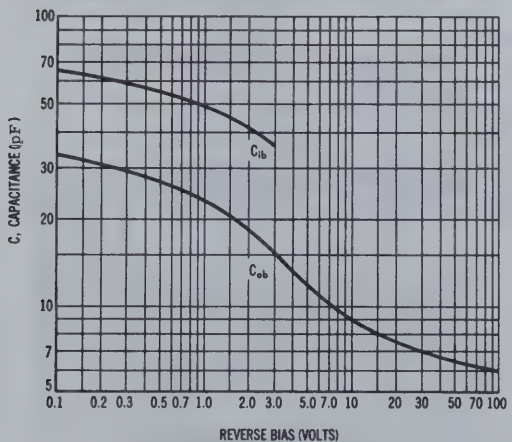
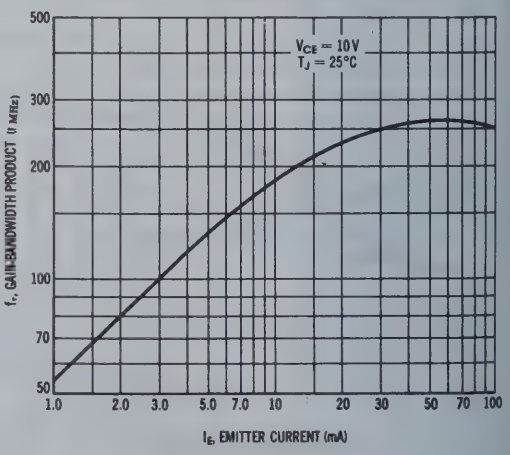


FIGURE 2 — GAIN-BANDWIDTH PRODUCT

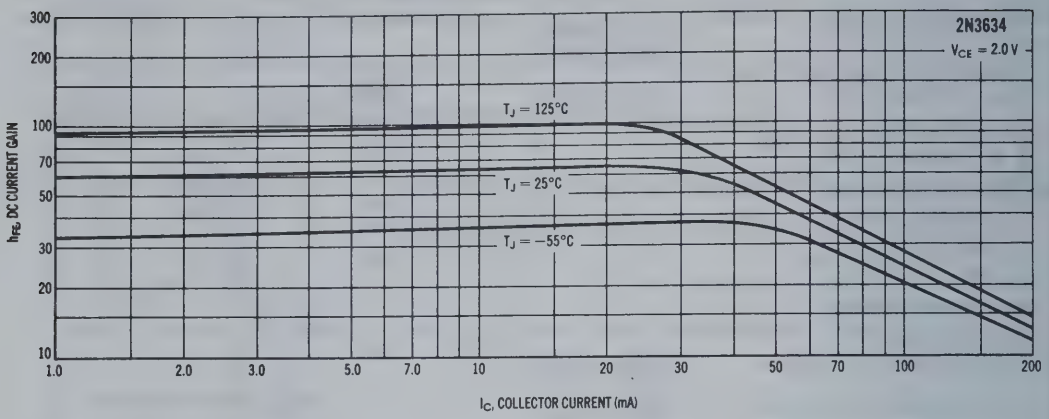


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0) 2N3634, 2N3635	-	BV_{CEO}*	140	-	Vdc
2N3636, 2N3637			175	-	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) 2N3634, 2N3635	-	BV_{CBO}	140	-	Vdc
2N3636, 2N3637			175	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	-	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)	-	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	-	I_{EBO}	-	50	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) 2N3634, 2N3636	3, 4, 5, 6	h_{FE}*	40	-	-
2N3635, 2N3637			80	-	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc) 2N3634, 2N3636			45	-	
2N3635, 2N3637			90	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc) 2N3634, 2N3636			50	-	
2N3635, 2N3637			100	-	
(I_C = 50 mAdc, V_{CE} = 10 Vdc) 2N3634, 2N3636			50	150	
2N3635, 2N3637			100	300	
(I_C = 150 mAdc, V_{CE} = 10 Vdc) 2N3634, 2N3636			25	-	
2N3635, 2N3637			50	-	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	11, 12	$V_{CE(sat)}$*	-	0.3	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)			-	0.5	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	11, 12	$V_{BE(sat)}$*	-	0.8	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)			0.65	0.9	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (V_{CE} = 30 Vdc, I_C = 30 mAdc, f = 100 MHz) 2N3634, 2N3636	2	f_T	150	-	MHz
2N3635, 2N3637			200	-	
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	1	C_{ob}	-	10	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)	1	C_{ib}	-	75	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) 2N3634, 2N3636	7	h_{ie}	100	600	ohms
2N3635, 2N3637			200	1200	
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	10	h_{re}	-	3.0	X 10^{-4}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) 2N3634, 2N3636	9	h_{fe}	40	160	-
2N3635, 2N3637			80	320	
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	8	h_{oe}	-	200	μmhos
Noise Figure (I_C = 0.5 mAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)	-	NF	-	3.0	dB
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 100 Vdc, V_{BE} = 4.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	13, 14	t_{on}	-	400	ns
Turn-Off Time	13, 15	t_{off}	-	600	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 3 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



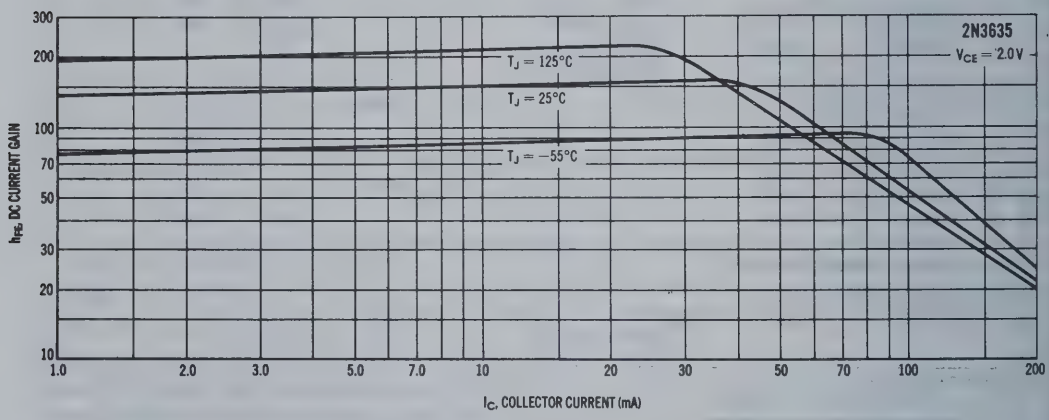


FIGURE 4 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

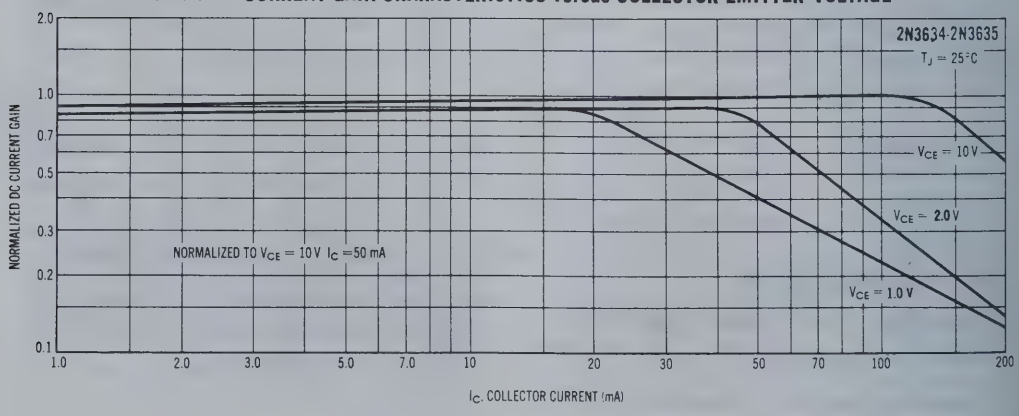
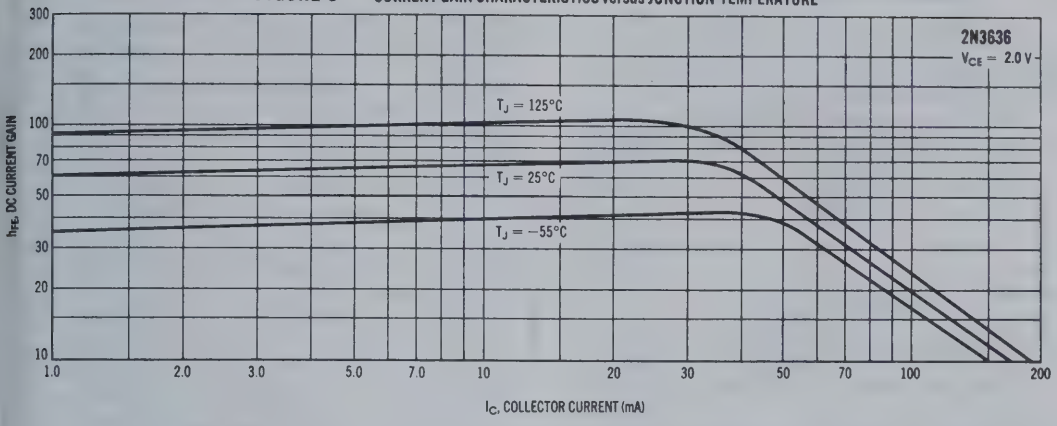


FIGURE 5 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



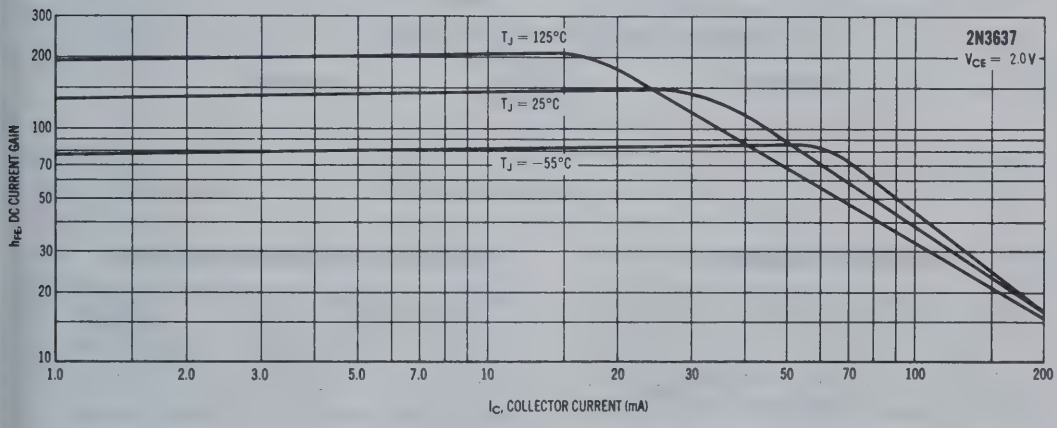


FIGURE 6 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

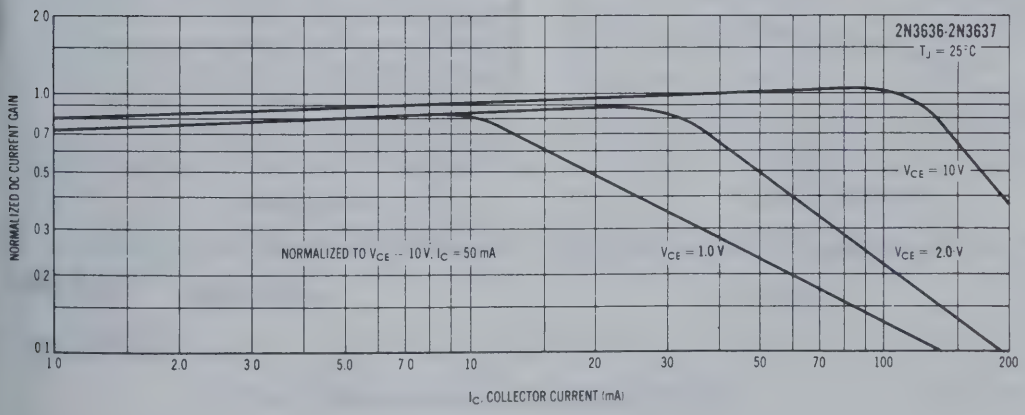


FIGURE 7 — INPUT IMPEDANCE

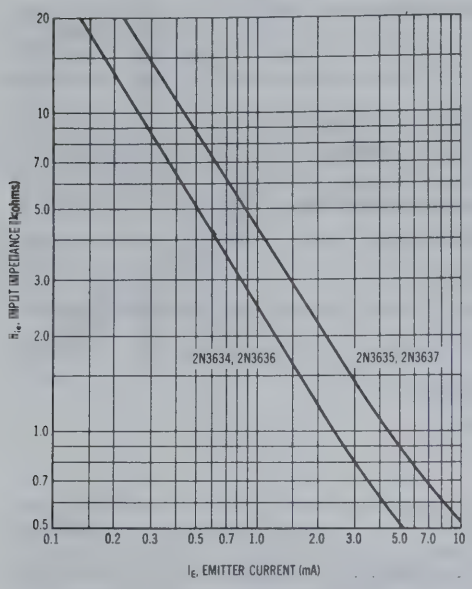


FIGURE 8 — OUTPUT IMPEDANCE

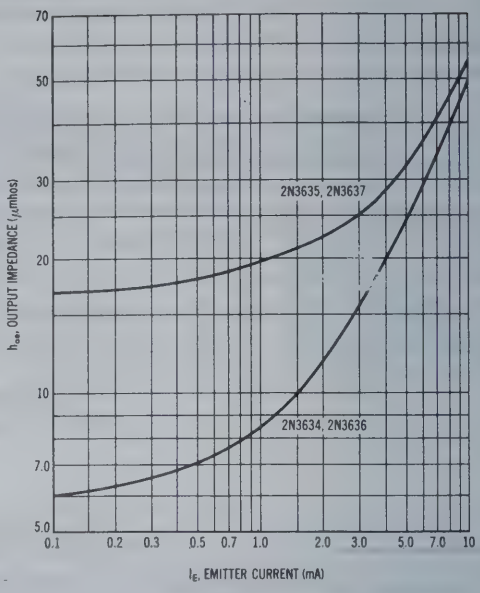


FIGURE 9 — CURRENT GAIN

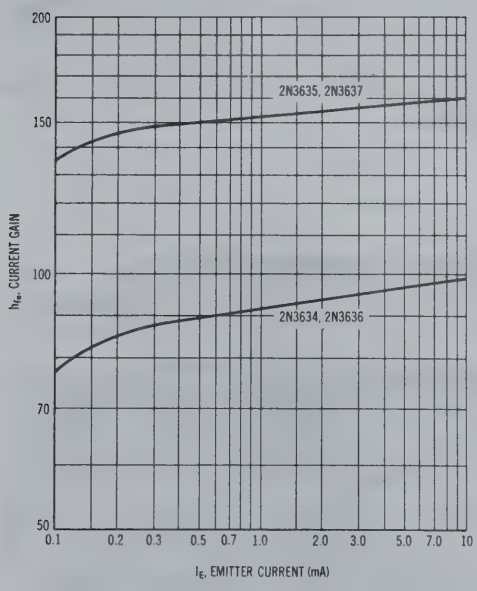


FIGURE 10 — VOLTAGE FEEDBACK RATIO

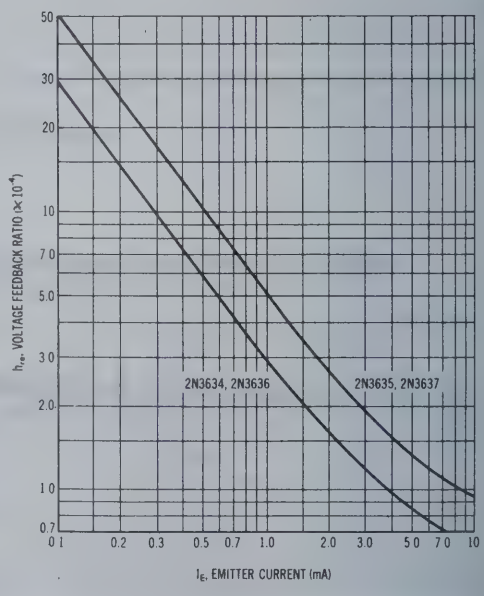


FIGURE 11 — SATURATION VOLTAGES

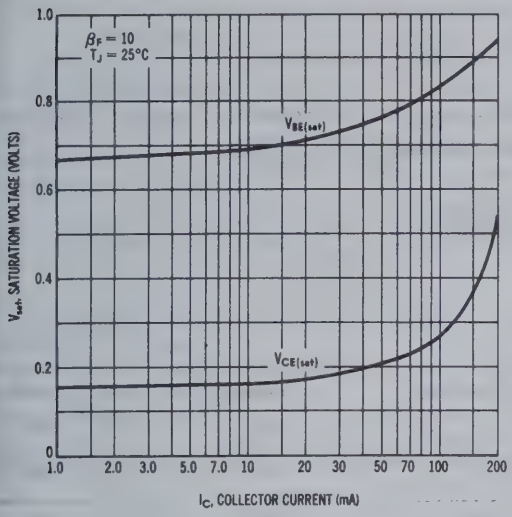


FIGURE 12 — TEMPERATURE COEFFICIENTS

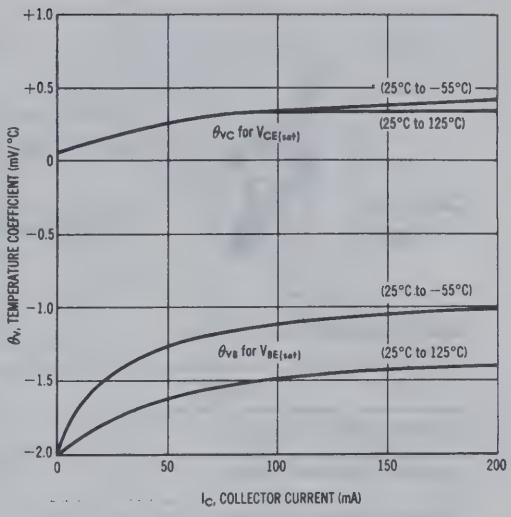
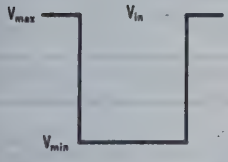


FIGURE 13 — SWITCHING TIME TEST CIRCUIT



P.W. ≅ 20 μs
DUTY CYCLE ≤ 2%
RISE TIME ≤ 20 ns

	V_{max}	V_{min}
TURN-ON	+4.0 V	−5.65 V
TURN-OFF	+4.1 V	−5.9 V

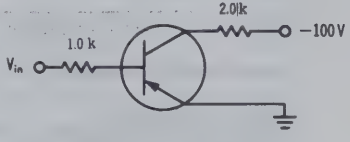


FIGURE 14 — TURN-ON TIME VARIATIONS WITH VOLTAGE

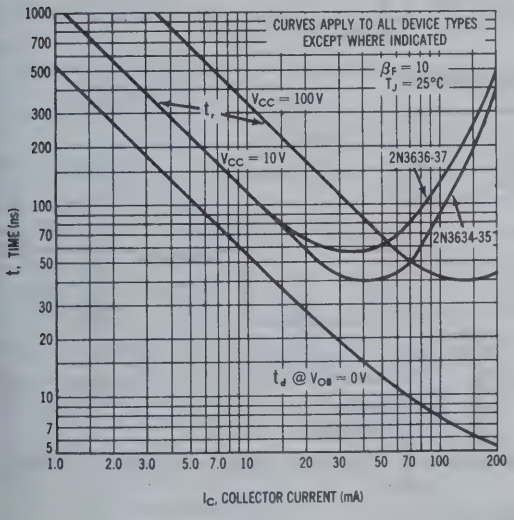
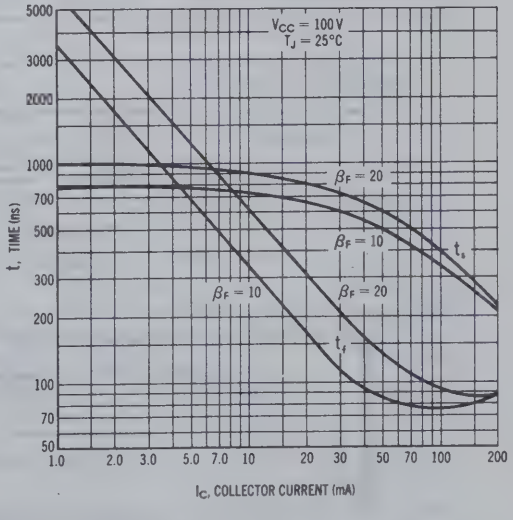


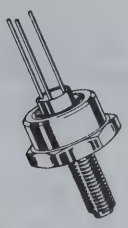
FIGURE 15 — TURN-OFF TIME VARIATIONS WITH CIRCUIT GAIN



2N3647 (SILICON)
2N3648

For Specifications, See 2N3510 Data.

2N3664 (SILICON)



CASE 24
(TO-102)

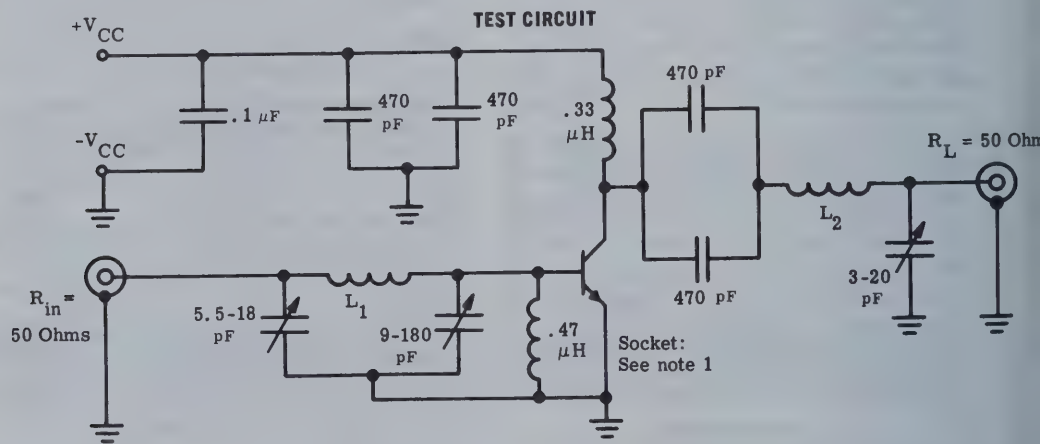
NPN silicon annular transistor for power amplifier and driver applications to 500 MHz.

Collector connected to case; stud isolated from case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector Base Voltage	V_{CB}	60	Vdc
Collector Emitter Voltage	V_{CES}	60	Vdc
Collector Emitter Voltage	V_{CEO}	40	Vdc
Emitter Base Voltage	V_{EB}	4	Vdc
Collector Current (Continuous)	I_C	0.5	Adc
Base Current (Continuous)	I_B	0.1	Adc
Power Dissipation @ 25°C Case Temperature @ 25°C Ambient Temperature	P_D	 5.0 1.0	 Watts Watts
Operating Junction and Storage Temperature Range	$T_{J'}$ T_{stg}	-65 to +200	°C

TEST CIRCUIT



L_1: 2T No. 14 tinned wire 5/16" ID, 1/4" long

L_2: 2T No. 14 tinned wire 3/8" ID, 3/16" long

Note 1: Use a 0.100" pin circle teflon socket with the emitter grounded to the chassis at the top of the socket.

When making RF power test, the device must be provided with an adequate heat sink.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Sustain Voltage* I_C = 30mAdc, R_{BE} = 0 ohms	$V_{CES(sus)}$*	60		Vdc
Collector-Emitter Open Base Sustain Voltage* I_C = 30mAdc, I_B = 0	$V_{CEO(sus)}$*	40		Vdc
Collector-Emitter Cutoff Current V_{CE} = 25Vdc, V_{BE} = 0, T_C = +150°C	I_{CES}		50	μAdc
Collector-Emitter Cutoff Current V_{CE} = 25Vdc, V_{BE} = 0	I_{CES}		0.05	μAdc
Collector-Emitter Cutoff Current V_{CE} = 50Vdc, V_{BE} = 0	I_{CES}		10	μAdc
Emitter Cutoff Current V_{EB} = 4Vdc, I_C = 0	I_{EBO}		100	μAdc
DC Current Gain V_{CE} = 2Vdc, I_C = 250mAdc V_{CE} = 2Vdc, I_C = 50mAdc	h_{FE}	8 8	 80	
Collector-Emitter Saturation Voltage I_C = 250mAdc, I_B = 50mAdc	$V_{CE(sat)}$		0.75	Vdc
Base-Emitter Saturation Voltage I_C = 250mAdc, I_B = 50mAdc	$V_{BE(sat)}$		1.2	Vdc
Small Signal Current Gain V_{CE} = 15Vdc, I_C = 100mAdc, f = 100 MHz	$\lvert h_{fe} \rvert$	3		
Common Base Output Capacitance V_{CB} = 15Vdc, I_E = 0, f = 100kHz	C_{ob}		6.0	pF
Power Output** (P_{in} = 400 mW, f = 250 MHz, V_{CE} = 25 Vdc)	P_{out}**	2.2		Watts
Power Gain	G_{PE}	7.4		dB
Efficiency	η	50		%

* Pulse Test: Pulse Width ≤ 200 μs, Duty Cycle ≤ 2.0%.

**In functional test P_{out} is fixed at 2.2 watts and P_{in} is monitored to be ≤ 400 mW.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance - Junction to Case	θ_{JC}	35	°C/W
Thermal Resistance - Junction to Ambient	θ_{JA}	175	°C/W

2N3712 (SILICON)



NPN silicon annular transistor designed for high-voltage DC to VHF amplifier applications.

Collector connected to case

CASE 31
(TO-5)

MAXIMUM RATINGS

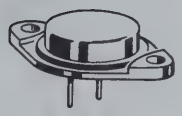
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	150	Vdc
Collector-Base Voltage	V_{CB}	150	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_B = 0)	BV_{CEO}*	150	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	150	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	I_{CBO}	-	0.1	μAdc
(V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)		-	50	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}*	25	-	-
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		30	150	
Collector-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$*	-	2.0	Vdc
Base-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$*	-	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	40	240	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	1.0	9.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	-	80	pF
Small-Signal Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	25	-	-
Collector-Base Time Constant (I_E = 30 mAdc, V_{CB} = 10 Vdc, f = 31.9 MHz)	$r_b'C_c$	-	100	ps

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3713 thru 2N3716 (SILICON)

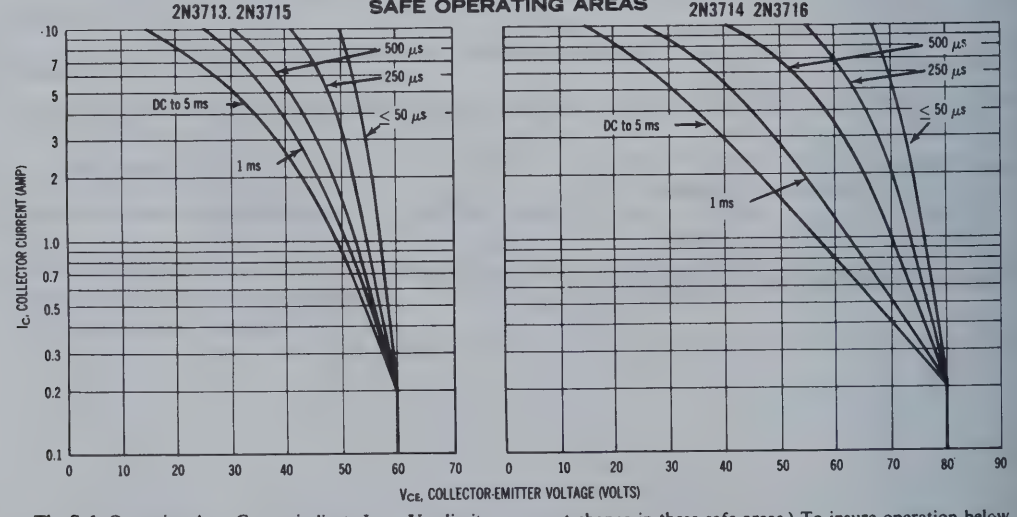


NPN silicon power transistors for medium-speed switching and amplifier applications. Complement to PNP types 2N3789 thru 2N3792.

CASE 11
(TO-3)

MAXIMUM RATINGS

Rating	Symbol	2N3713 2N3715	2N3714 2N3716	Unit
Collector-Base Voltage	V_{CB}	80	100	Volts
Collector-Emitter Voltage	V_{CEO}	60	80	Volts
Emitter-Base Voltage	V_{EB}	7	7	Volts
Collector Current	I_C	10	10	Amp
Base Current	I_B	4.0	4.0	Amp
Power Dissipation	P_D	150	150	Watts
Thermal Resistance	Θ_{JC}	1.17	1.17	°C/W
Operating Junction and Storage Temperature Range	T_J and T_{stg}	-65 to +200		°C



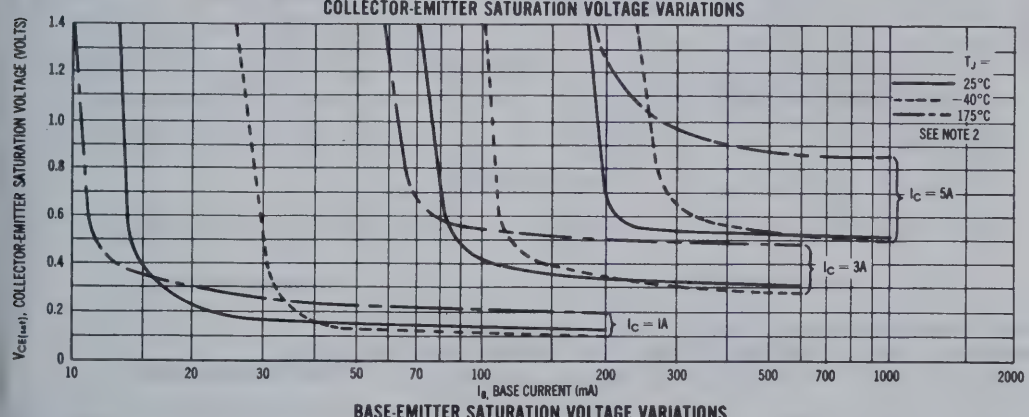
The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

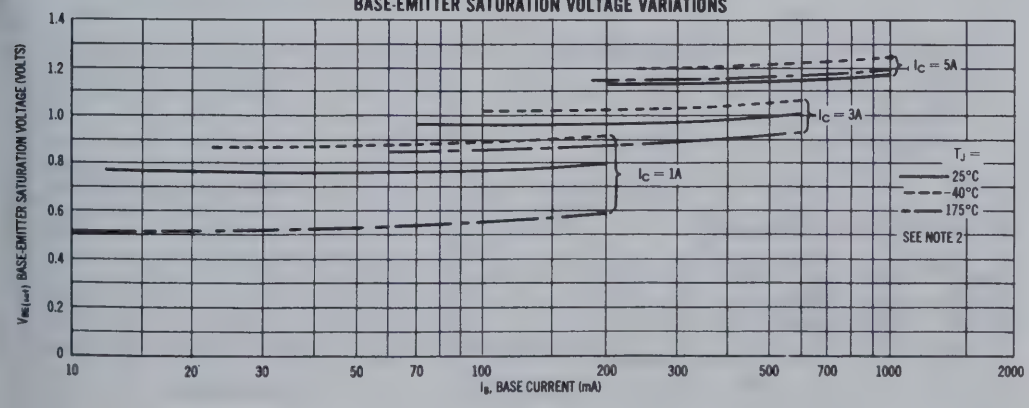
2N3713 thru 2N3716 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Types	Symbol	Min	Max	Unit
Emitter-Base Cutoff Current (V_{EB} = 7 Vdc)		I_{EBO}	—	5	mAdc
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc)	2N3713, 2N3715		—	1	
(V_{CE} = 100 Vdc, V_{BE} = -1.5 Vdc)	2N3714, 2N3716		—	1	
(V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3713, 2N3715		—	10	
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3714, 2N3716		—	10	
Collector-Emitter Sustaining Voltage*		$V_{CEO(sus)}$*			Vdc
(I_C = 200 mAdc, I_B = 0)	2N3713, 2N3715		60	—	
	2N3714, 2N3716		80	—	
DC Current Gain*		h_{FE}*			—
(I_C = 1 Adc, V_{CE} = 2 Vdc)	2N3713, 2N3714		25	90	
	2N3715, 2N3716		50	150	
(I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3713, 2N3714		15	—	
	2N3715, 2N3716		30	—	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3713, 2N3714		—	1.0	
	2N3715, 2N3716		—	0.8	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3713, 2N3714		—	2.0	
	2N3715, 2N3716		—	1.5	
Base-Emitter Voltage*		V_{BE}*			Vdc
(I_C = 3 Adc, V_{CE} = 2 Vdc)			—	1.5	
Small Signal Current Gain		h_{fe}			—
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 1 MHz)			2.5	—	
Switching Times			Typ		μs
(I_C = 5A, I_{B1} = I_{B2} = 0.5 A)					
Rise Time		t_r	0.45		
Storage Time		t_s	0.3		
Fall Time		t_f	0.4		

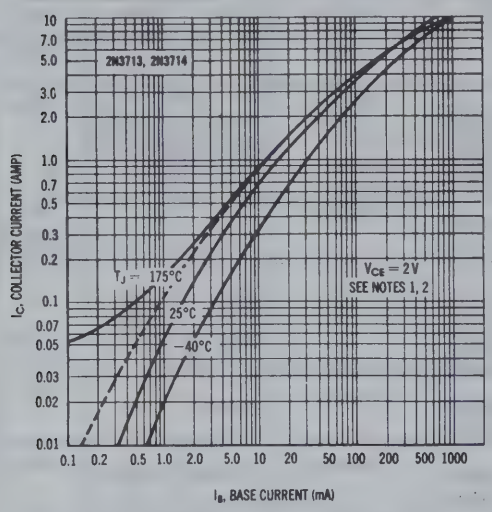
*Use sweep test to prevent overheating

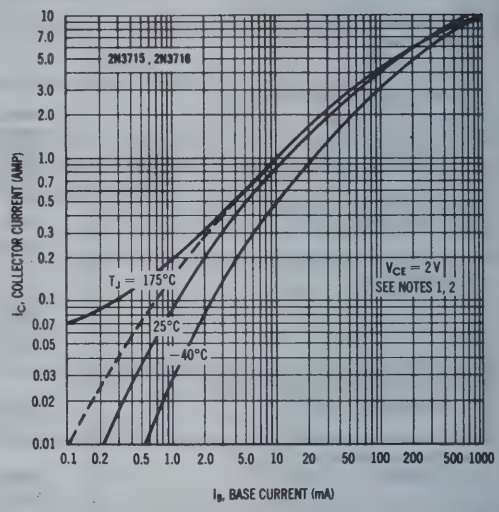




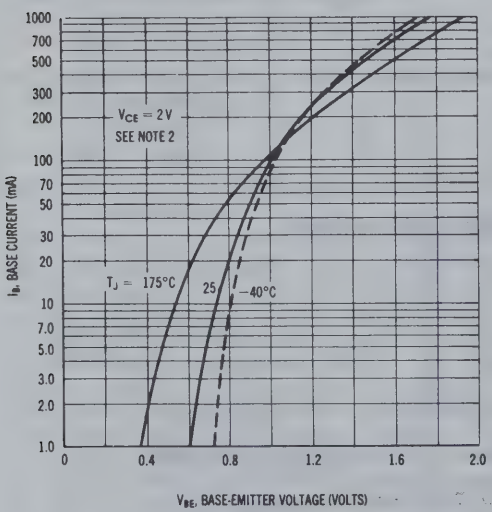
2N3713 thru 2N3716 (continued)

COLLECTOR CURRENT versus BASE CURRENT

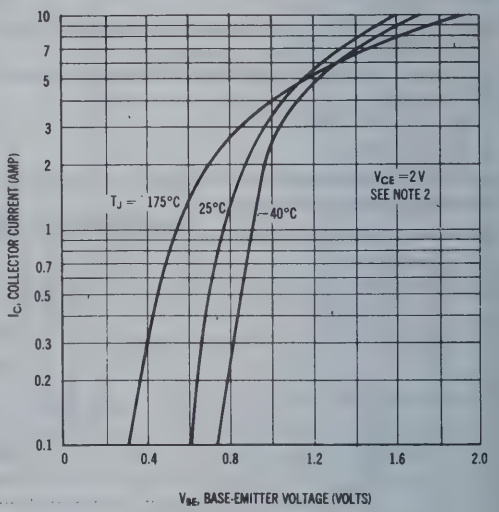




BASE CURRENT-VOLTAGE VARIATIONS



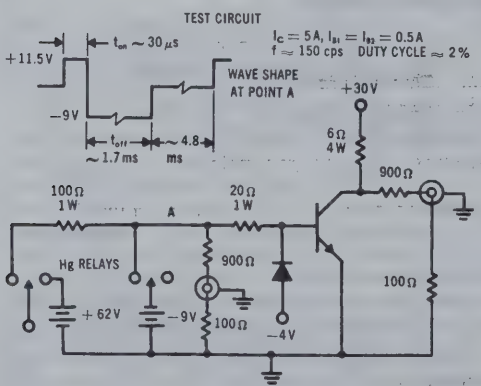
COLLECTOR CURRENT-VOLTAGE VARIATIONS



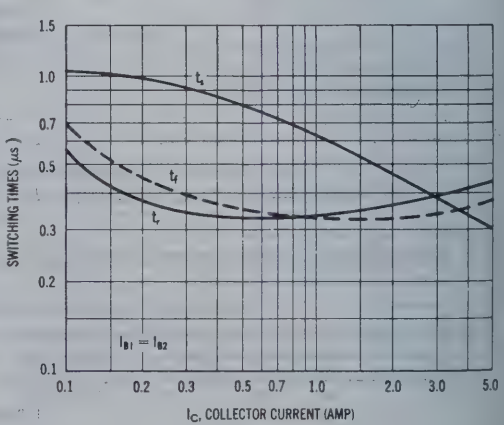
NOTE 1. Dotted line indicates metered base current plus the I_{CBO} of the transistor at 175°C.

NOTE 2. Pulse test: pulse width ≈ 200 μs, duty cycle ≈ 1.5%

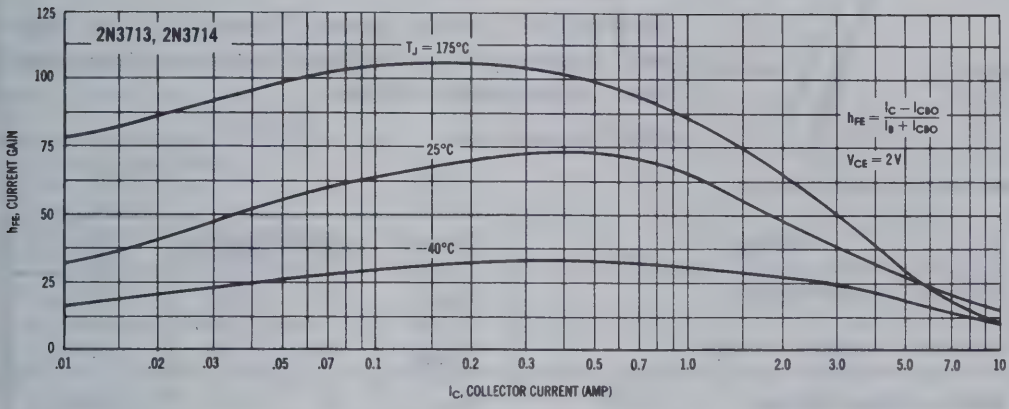
TEST CIRCUIT

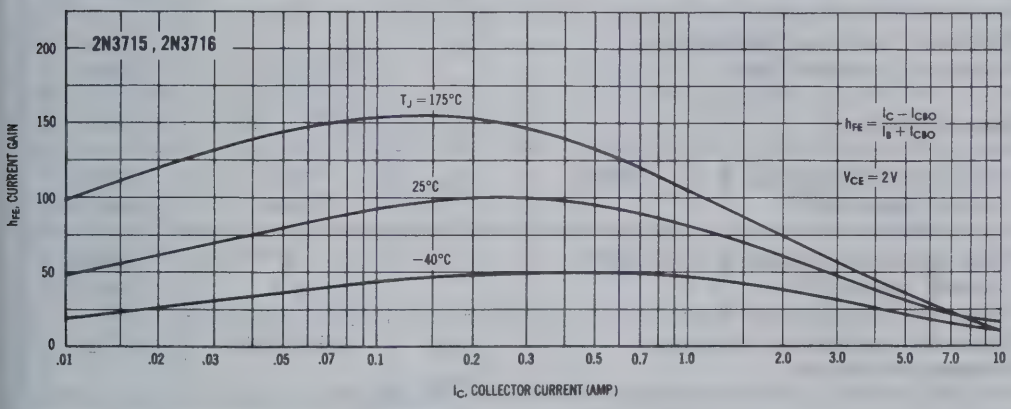


TYPICAL SWITCHING TIMES

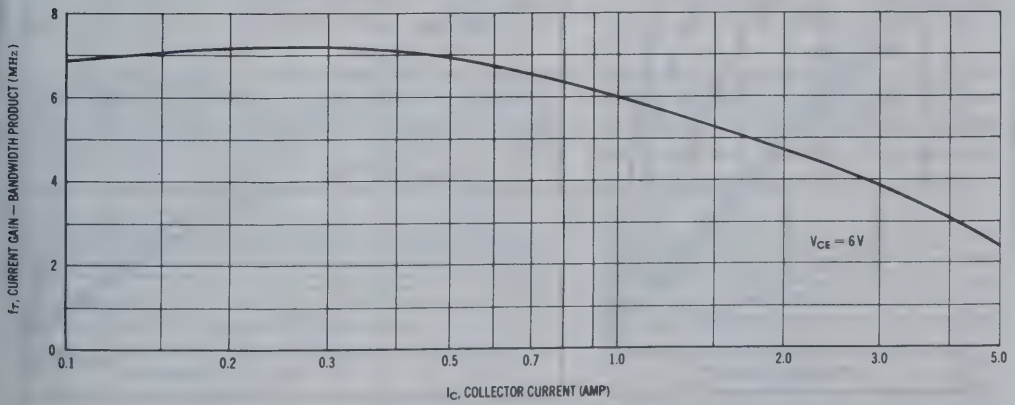


CURRENT GAIN VARIATIONS





CURRENT-GAIN—BANDWIDTH PRODUCT versus COLLECTOR CURRENT



2N3719 (SILICON)
2N3720



CASE 31
(TO-5)

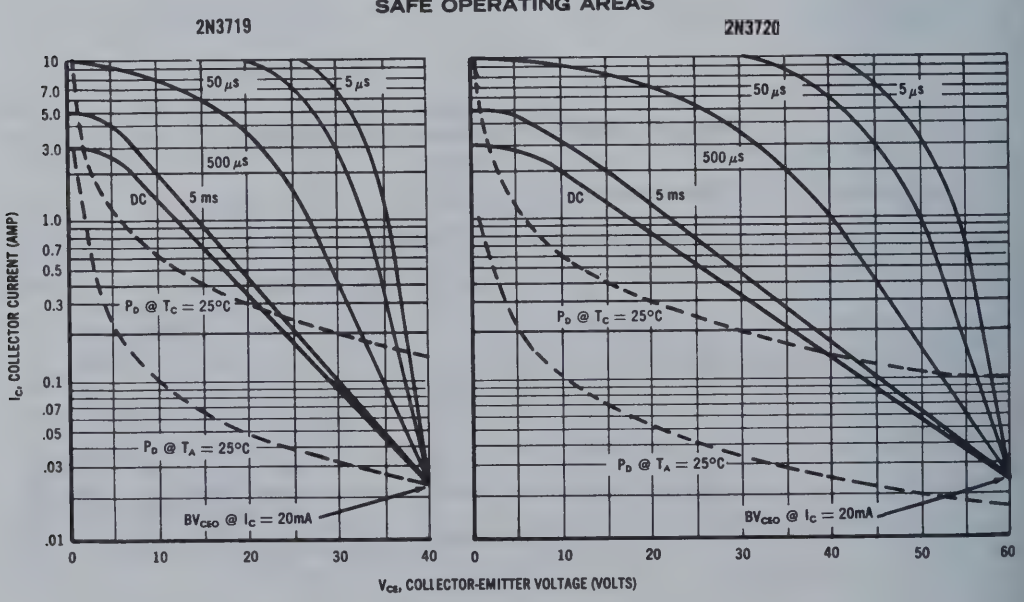
PNP silicon annular power transistors for high-speed, high-current switching in core, driver and Class C power applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N3719	2N3720	Unit
Collector-Base Voltage	V_{CB}	40	60	Volts
Collector-Emitter Voltage	V_{CEO}	40	60	Volts
Emitter-Base Voltage	V_{EB}	4	4	Volts
Collector Current—Continuous Collector Current—Peak	I_C	3 10	3 10	Amp Amp
Base Current	I_B	0.5	0.5	Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.72		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	6 34.3		Watts mW/°C
Operating Junction and Storage Temperature Range	T_J and T_{stg}	-65 to +200		°C

SAFE OPERATING AREAS

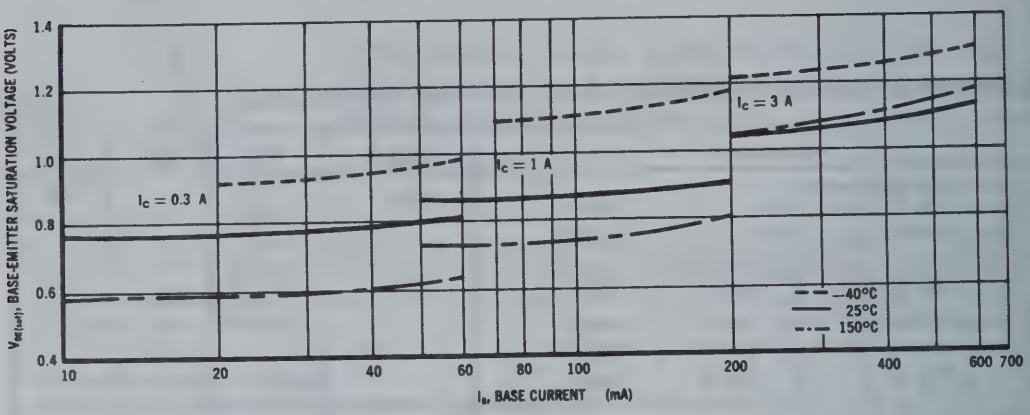


ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

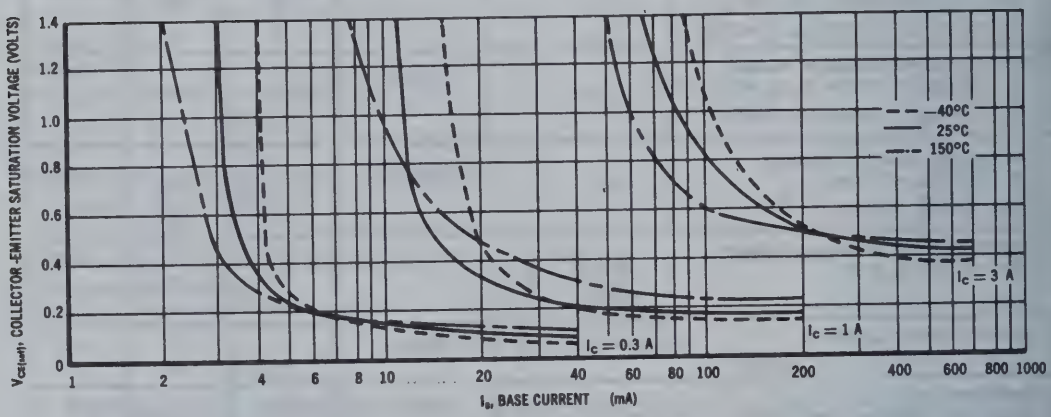
Characteristic		Symbol	Min	Max	Unit
Collector Leakage Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, V_{BE} = 2 Vdc)	2N3719		—	10	
(V_{CE} = 60 Vdc, V_{BE} = 2 Vdc)	2N3720		—	10	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0, T_A = 25°C)	2N3719		—	0.010	
(V_{CB} = 40 Vdc, I_E = 0, T_A = 150°C)	2N3719		—	1	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 25°C)	2N3720		—	0.010	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	2N3720		—	1	
Emitter-Base Cutoff Current (V_{BE} = 4 Vdc, I_C = 0)		I_{EBO}	—	1	mAdc
DC Current Gain*		h_{FE}*			—
(I_C = 500 mA, V_{CE} = 1.5 V, T_A = 25°C)			20	—	
(I_C = 1 A, V_{CE} = 1.5 V, T_A = 25°C)			25	180	
(I_C = 1 A, V_{CE} = 1.5 V, T_A = -40°C)			15	—	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Volts
(I_C = 1 A, I_B = 100 mA, T_A = -40 to +100°C			—	0.75	
(I_C = 3 A, I_B = 300 mA, T_A = 25°C)			—	1.5	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Volts
(I_C = 1 A, I_B = 100 mA)			—	1.5	
(I_C = 3 A, I_B = 300 mA)			—	2.3	
Collector-Emitter Breakdown Voltage*		BV_{CEO}*			Volts
(I_C = 20 mA, I_B = 0)	2N3719		40	—	
	2N3720		60	—	
Collector Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	120	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	1000	pF
Current-Gain — Bandwidth Product (V_{CE} = 10 Vdc, I_C = 500 mAdc, f = 30 MHz)		f_T	60	—	MHz
Delay Plus Rise Time (I_C = 1 Adc, I_{B1} = 100 mA)		t_{on}	—	100	ns
Storage Time and Fall Time (I_C = 1 Adc, I_{B1} = I_{B2} = 100 mA)		t_{off}	—	400	ns
Fall Time		t_f			ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

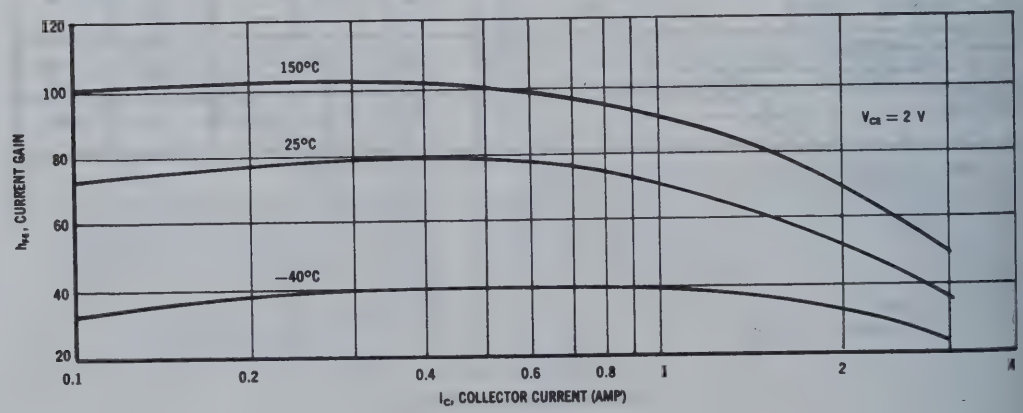
BASE EMITTER SATURATION VOLTAGE VARIATIONS



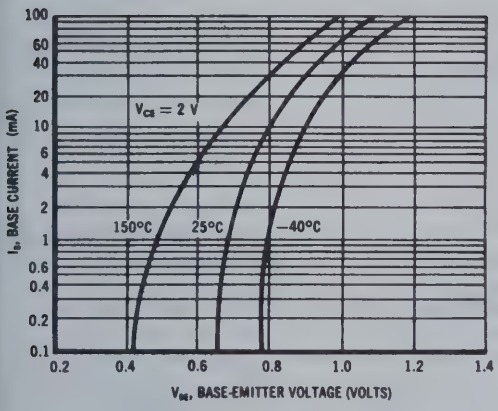
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS



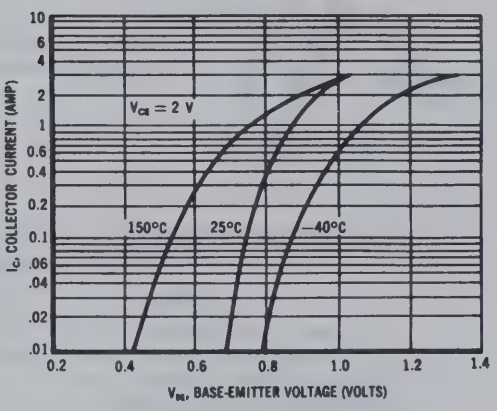
CURRENT GAIN VARIATIONS



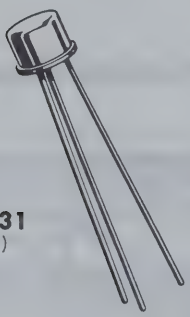
BASE CURRENT — VOLTAGE VARIATIONS



COLLECTOR CURRENT vs BASE-EMITTER VOLTAGE



2N3722 (SILICON)
2N3723



CASE 31
(TO-5)

NPN silicon annular transistors designed for medium-current, high-speed, high-voltage switching and driver applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N3722	2N3723	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.56		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	4.0 22.8		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3722 2N3723	BV_{CEO}*	60 80	- -	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	2N3722 2N3723	BV_{CES}	80 100	- -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N3722 2N3723	BV_{CBO}	80 100	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0) (V_{CE} = 50 Vdc, V_{BE} = 0) (V_{CE} = 40 Vdc, V_{BE} = 0, T_A = +125°C) (V_{CE} = 50 Vdc, V_{BE} = 0, T_A = +125°C)	 2N3722 2N3723 2N3722 2N3723	I_{CES}	 - - - -	 0.5 0.5 70 70	μAdc
Base Current (V_{CE} = 40 Vdc, V_{BE} = 0) (V_{CE} = 50 Vdc, V_{BE} = 0)	 2N3722 2N3723	I_B	 - -	 0.5 0.5	μAdc

* Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

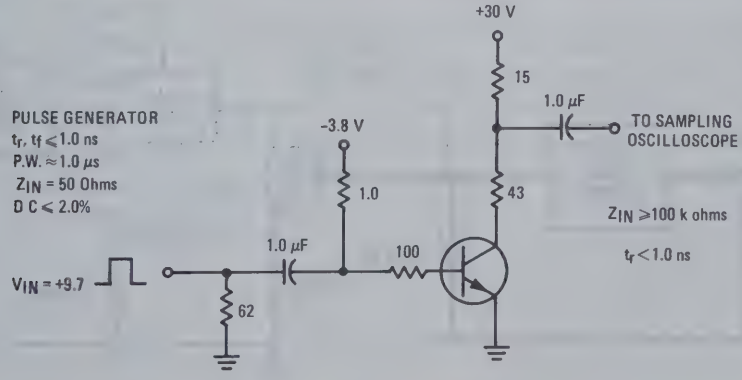
2N3722, 2N3723 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}*			-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3722, 2N3723		25	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3722, 2N3723		40	150	
(I_C = 300 mAdc, V_{CE} = 2.0 Vdc)	2N3722		20	-	
	2N3723		15	-	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N3722		15	-	
(I_C = 500 mAdc, V_{CE} = 3.0 Vdc)	2N3723		15	-	
(I_C = 800 mAdc, V_{CE} = 5.0 Vdc)	2N3722, 2N3723		12	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)	2N3722, 2N3723		15	-	
(I_C = 200 mAdc, V_{CE} = 2.0 Vdc, T_A = -55°C)	2N3722, 2N3723		20	-	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N3722		-	0.22	
	2N3723		-	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3722		-	0.25	
	2N3723		-	0.28	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3722		-	0.37	
	2N3723		-	0.44	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3722		-	0.50	
	2N3723		-	0.75	
(I_C = 800 mAdc, I_B = 80 mAdc)	2N3722		-	2.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N3722, 2N3723		-	0.75	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3722, 2N3723		-	0.85	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3722, 2N3723		-	1.1	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3722, 2N3723		0.86	1.2	
(I_C = 800 mAdc, I_B = 80 mAdc)	2N3722		-	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	2N3722	C_{ob}	-	10	pF
	2N3723		-	9.0	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	65	pF
SWITCHING CHARACTERISTICS					
Turn-On Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (See Figure 1) 2N3722	t_{on}	-	50	ns
	2N3723		-	70	
Delay Time	2N3722	t_d	-	12	ns
	2N3723		-	15	
Rise Time	2N3722	t_r	-	50	ns
	2N3723		-	70	
Turn-Off Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (See Figure 1) 2N3722	t_{off}	-	100	ns
	2N3723		-	130	
Storage Time	2N3722	t_s	-	85	ns
	2N3723		-	110	
Fall Time	2N3722	t_f	-	45	ns
	2N3723		-	50	

* Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



2N3733 (SILICON)



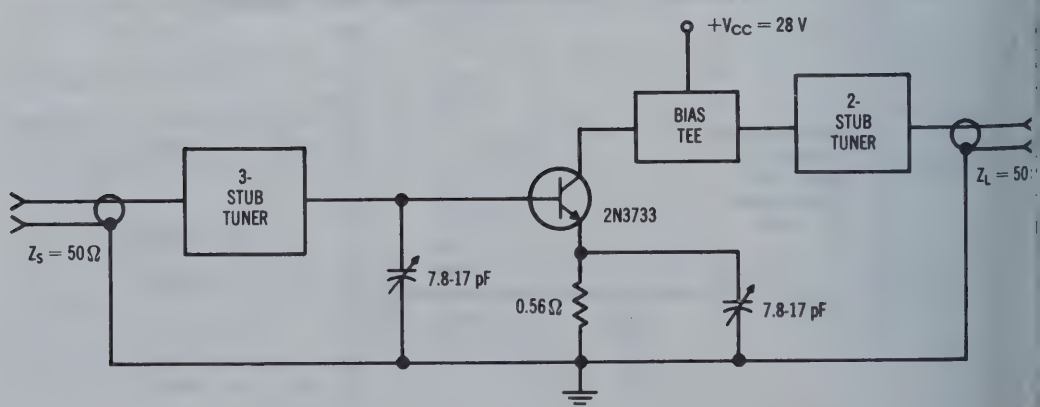
NPN silicon transistor designed for amplifier, frequency multiplier, and oscillator applications.

CASE 36
(TO-60)
stud isolated from case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage ($V_{EB(off)}$ = 1.5 Vdc)	V_{CEV}	65	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current	I_C	3	Amps
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	23 0.13	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

FIGURE 1 — 400-MHz TEST CIRCUIT

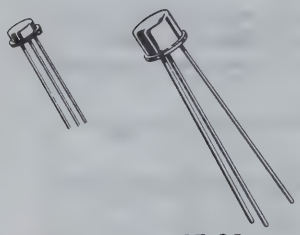


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 0 to 200 mAdc, I_B = 0)	BV_{CEO}*	40	-	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 0 to 200 mAdc, $V_{EB(off)}$ = 1.5 Vdc)	BV_{CEV}*	65	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.5 mAdc, I_E = 0)	BV_{CBO}	65	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.25 mAdc, I_C = 0)	BV_{EBO}	4	-	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	-	-	0.25	mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 100 mAdc)	$V_{CE(sat)}$	-	-	1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 150 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	-	400	-	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0)	C_{ob}	-	-	20	pF
Collector-Case Capacitance	C_s	-	-	6	pF
Base-Spreading Resistance (I_C = 250 mAdc, V_{CE} = 28 Vdc, f = 200 MHz)	$r_{bb'}$	-	6.5	-	Ohms
FUNCTIONAL TEST					
Power Output	V_{CE} = 28 Vdc, P_{in} = 4 W, f = 260 MHz	P_{out}	-	14.5	-	Watts
Efficiency		η	-	60	-	%
Power Output	V_{CE} = 28 Vdc, P_{in} = 4 W, f = 400 MHz (Figure 1)	P_{out}	10	-	-	Watts
Efficiency		η	45	-	-	%

*Pulsed through a 25 mH inductor; duty cycle = 50%

2N3734 (SILICON)
2N3735
2N3736
2N3737



CASE 26 (TO-46)
2N3736
2N3737

CASE 31 (TO-5)
2N3734
2N3735

Medium current NPN silicon annular transistors designed for high-speed switching and driver applications.

Collector connected to case

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	2N3734 2N3736	2N3735 2N3737	Unit
Collector-Base Voltage	V_{CB}	50	75	Vdc
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	1.5		Adc
		TO-5 2N3734 2N3735	TO-46 2N3736 2N3737	
Total Device Dissipation @ $T_A = 25^oC$ Derating Factor Above 25^oC	P_D	1.0 5.71	0.5 2.86	Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derating Factor Above 25^oC	P_D	4.0 22.8	2.0 11.4	Watts $mW/^oC$
Thermal Resistance Junction to Ambient Junction to Case	 θ_{JA} θ_{JC}	 0.175 0.044	 0.35 0.088	$^oC/mW$
Junction Temperature, Operating	T_J	+200		^oC
Storage Temperature Range	T_{stg}	-65 to +200		^oC

2N3734, 2N3735, 2N3736, 2N3737 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

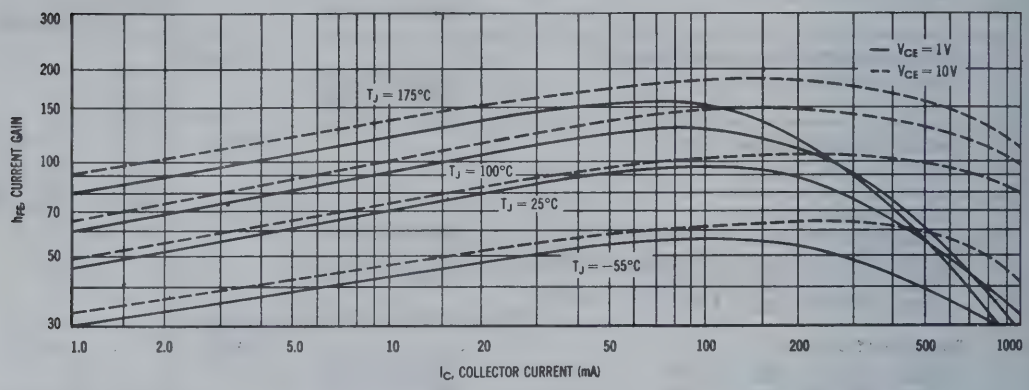
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3734, 2N3736	BV_{CBO}	50	—	Vdc
	2N3735, 2N3737		75	—	
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3734, 2N3736	BV_{CEO}*	30	—	Vdc
	2N3735, 2N3737		50	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	Vdc
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 25 Vdc, V_{EB} = 2 Vdc)	2N3734, 2N3736		—	0.20	
(V_{CE} = 25 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)			—	20	
(V_{CE} = 40 Vdc, V_{EB} = 2 Vdc)	2N3735, 2N3737		—	0.20	
(V_{CE} = 40 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)			—	20	
Base Cutoff Current		I_{BL}			μAdc
(V_{CE} = 25 Vdc, V_{EB} = 2 Vdc)	2N3734, 2N3736		—	0.3	
(V_{CE} = 40 Vdc, V_{EB} = 2 Vdc)	2N3735, 2N3737		—	0.3	
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			—
(I_C = 10 mAdc, V_{CE} = 1 Vdc)			35	—	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)			40	—	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)			35	—	
(I_C = 1 Adc, V_{CE} = 1.5 Vdc)	2N3734, 2N3736		30	120	
	2N3735, 2N3737		20	80	
(I_C = 1.5 Adc, V_{CE} = 5 Vdc)	2N3734, 2N3736		30	—	
	2N3735, 2N3737		20	—	
Collector Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			—	0.2	
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	0.5	
(I_C = 1 Adc, I_B = 100 mAdc)			—	0.9	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			—	0.8	
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.2	
(I_C = 1 Adc, I_B = 100 mAdc)			0.9	1.4	
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	9	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	80	pF
High-Frequency Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		h_{fe}	2.5	—	—
Delay Time	(V_{CC} = 30 V, $V_{BE(off)}$ = 2 V, I_C = 1 Amp, I_{B1} = 100 mA)	t_d	—	8	ns
Rise Time		t_r	—	40	ns
Storage Time	(V_{CC} = 30 V, I_C = 1 Amp, I_{B1} = $-I_{B2}$ = 100 mA)	t_s	—	30	ns
Fall Time		t_f	—	30	ns
Total Control Charge (I_C = 1 Amp, I_B = 100 mA, V_{CC} = 30 V)		Q_T	—	10	nC

*Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

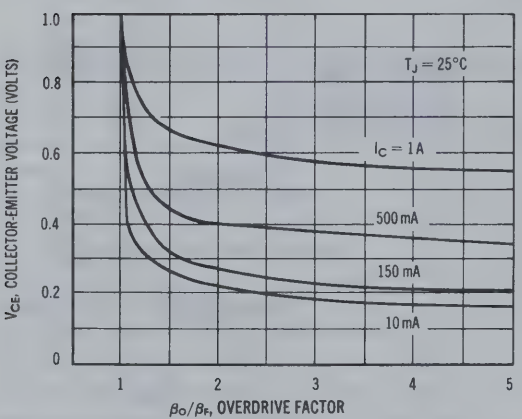
"ON" CONDITION CHARACTERISTICS

FIGURE 1

DC CURRENT GAIN



COLLECTOR SATURATION REGION

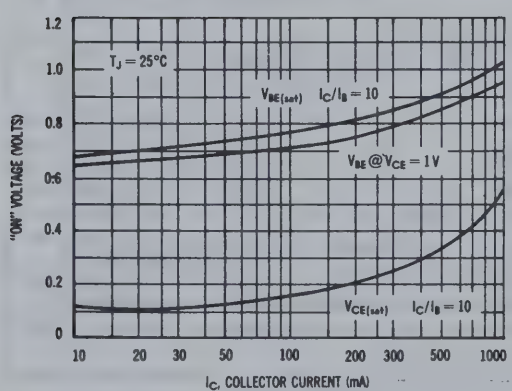


This graph shows the effect of base current on collector current. β_O (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3734, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 500 mA.

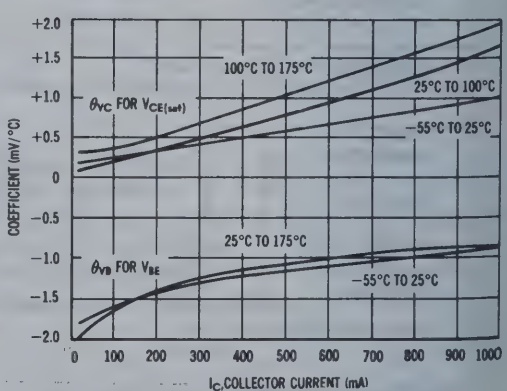
Observe that at $I_C = 500$ mA an overdrive factor of at least 2.0 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 54 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design).

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE}@\,1\text{ Volt}}{I_C/I_{BF}} \qquad 2 = \frac{54}{500\text{ mA}/I_{BF}} \qquad I_{BF} \approx 18.5\text{ mA typ}$$

"ON" VOLTAGES

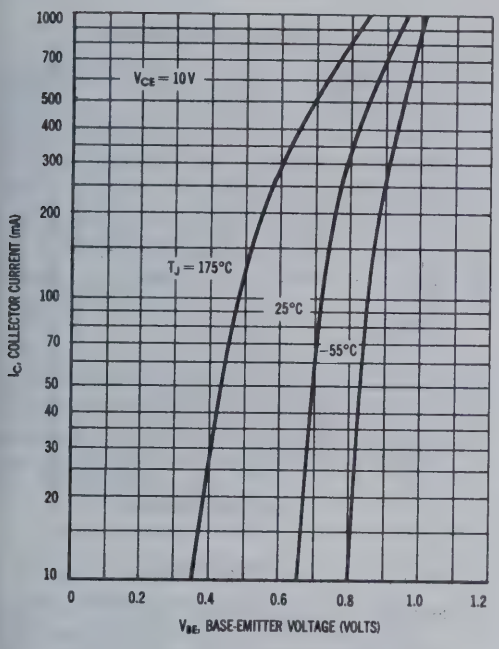


TEMPERATURE COEFFICIENTS

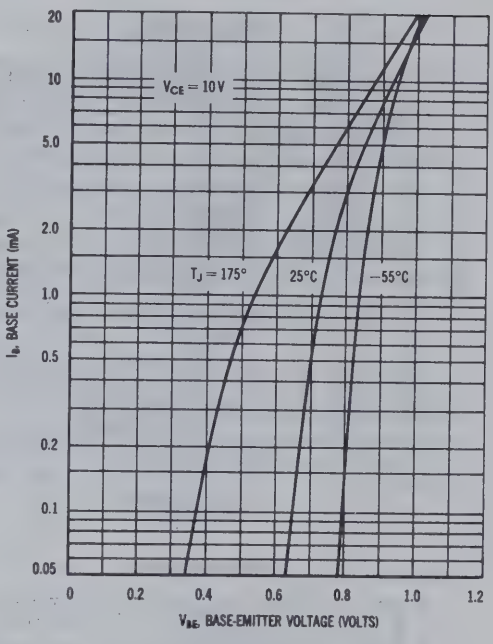


LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

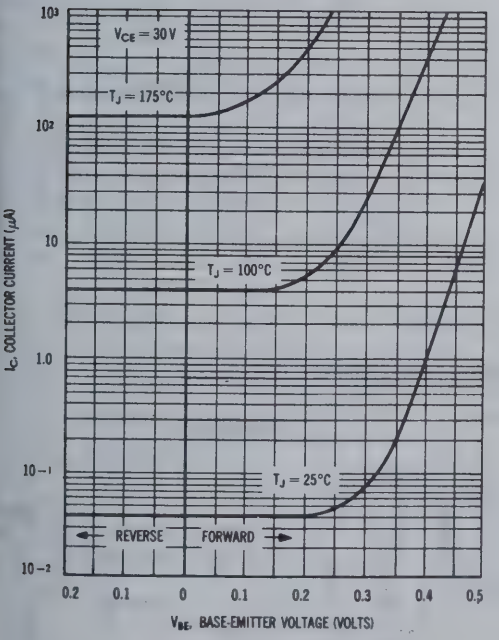


INPUT ADMITTANCE

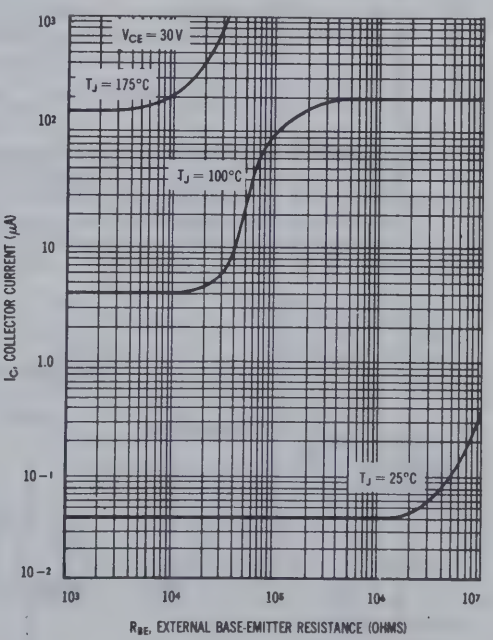


"OFF" CONDITION CHARACTERISTICS

TRANSCONDUCTANCE



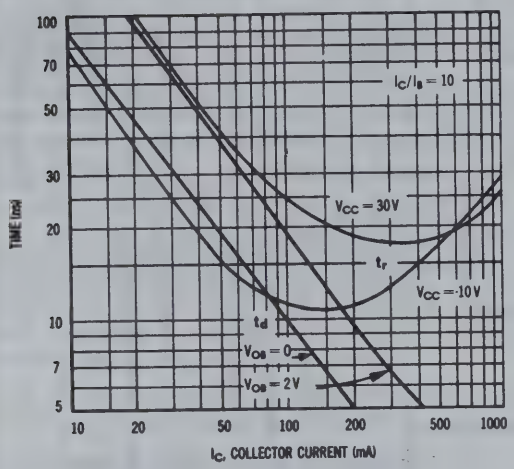
EFFECT OF BASE-EMITTER RESISTANCE



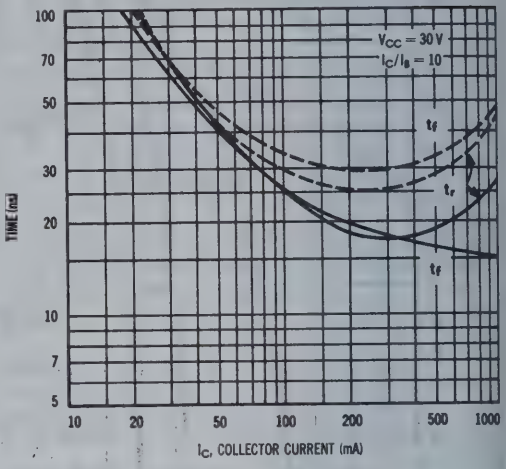
SWITCHING CHARACTERISTICS

— $T_J = 25°C$ -- $T_J = 150°C$

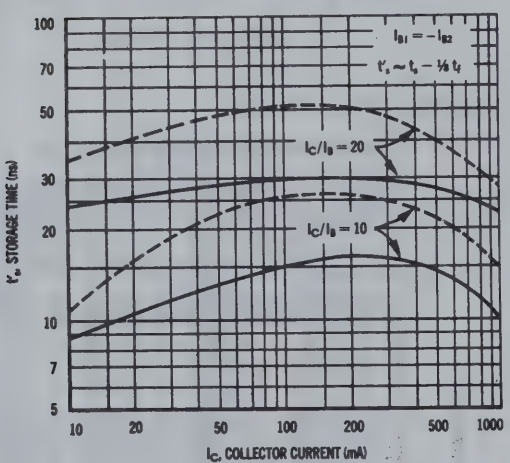
TURN-ON TIME



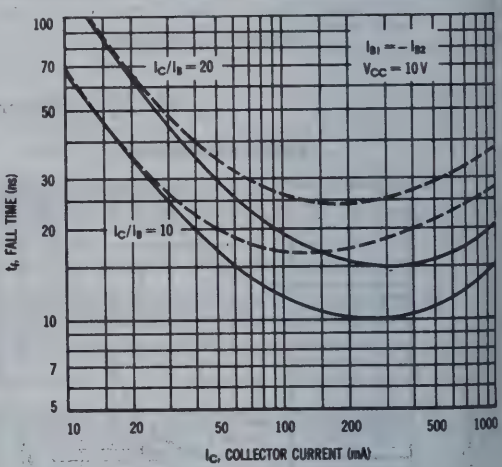
RISE AND FALL TIMES



STORAGE TIME

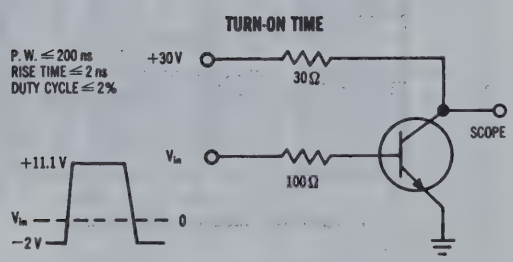


FALL TIME

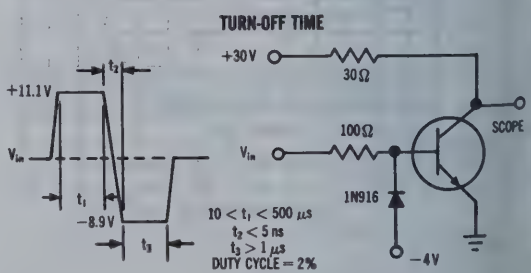


SWITCHING TIME EQUIVALENT TEST CIRCUITS

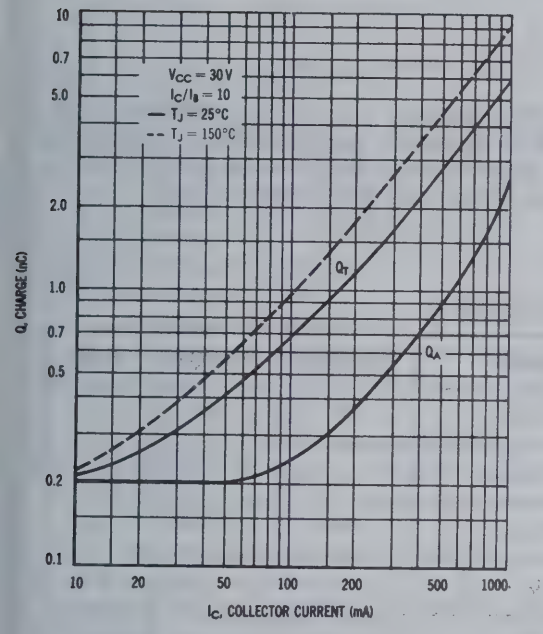
TURN-ON TIME



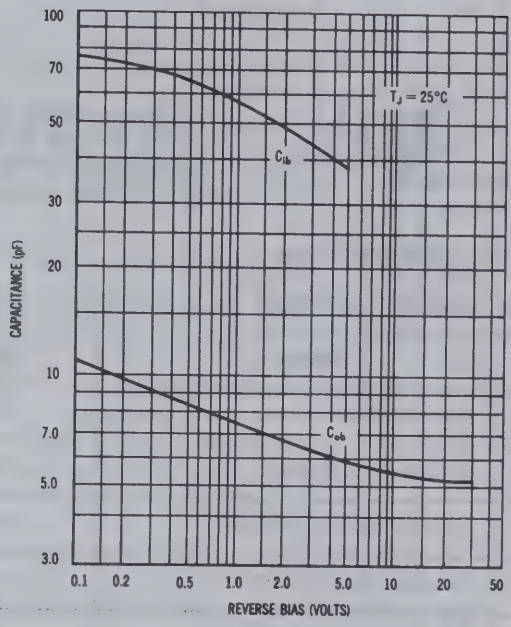
TURN-OFF TIME



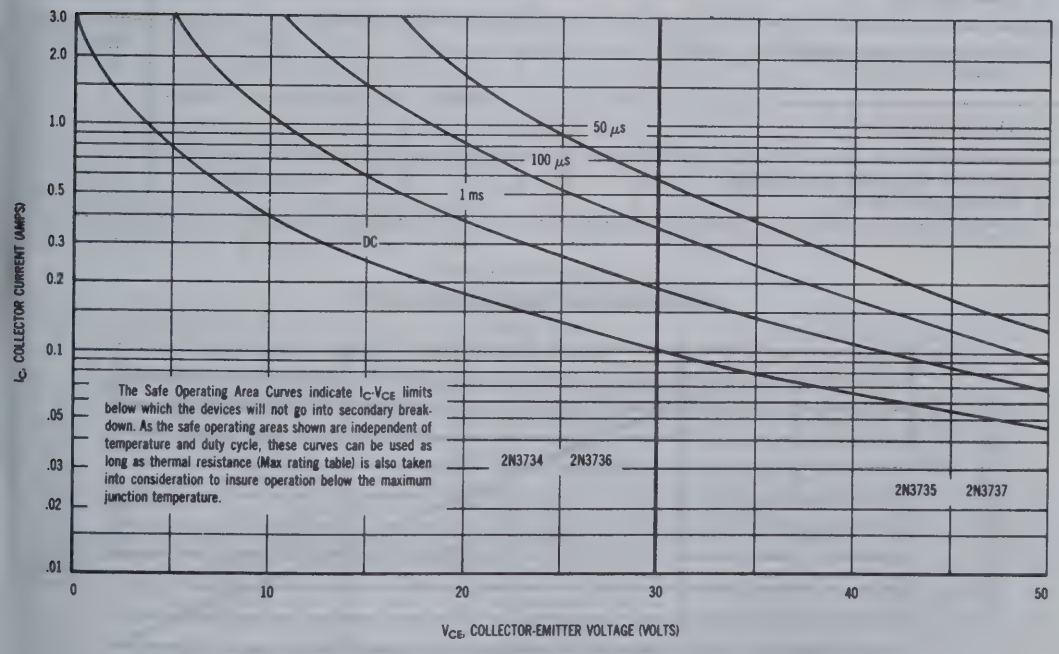
CHARGE DATA



CAPACITANCE



ACTIVE REGION SAFE OPERATING AREAS



2N3738 (SILICON)
2N3739



CASE 80
(TO-66)

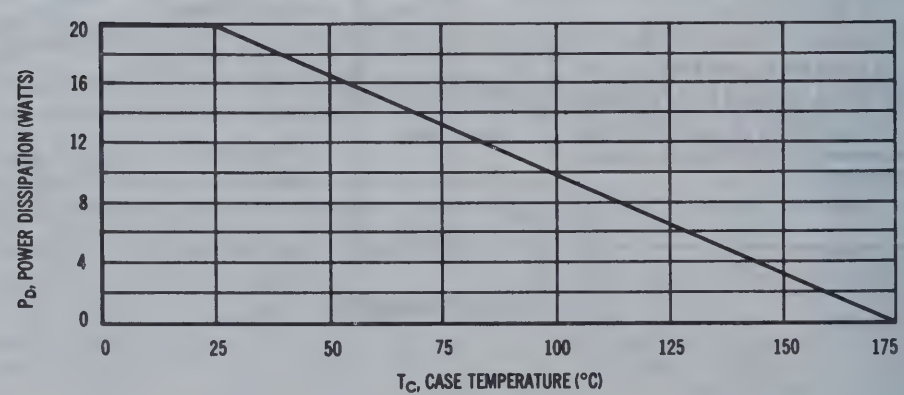
Collector connected to case

High-voltage NPN silicon power transistors, designed for use in line operated equipment such as audio output amplifiers; low-current, high-voltage converters; and AC line relays, featuring excellent dc gain.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	2N3738	2N3739	Unit
Collector-Base Voltage	V_{CB}	250	325	Vdc
Emitter-Base Voltage	V_{EB}	6	6	Vdc
Collector-Emitter Voltage	V_{CEO}	225	300	Vdc
Collector Current (Continuous)	I_C	3		Adc
Collector Current (Peak)	I_C	3		Amp
Base Current	I_B	1		Amp
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	20 0.133		Watts W/°C
Thermal Resistance	θ_{JC}	7.5		°C/W
Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +175		°C

POWER-TEMPERATURE DERATING CURVE



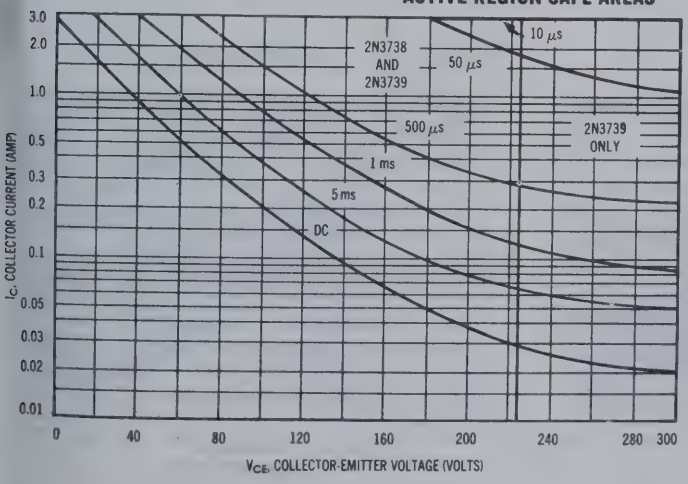
2N3738, 2N3739 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 5 mAdc, I_B = 0)	2N3738	$V_{CEO(sus)}$*	225	—	Vdc
	2N3739		300	—	
Emitter-Base Cutoff Current (V_{EB} = 6 Vdc)		I_{EBO}	—	0.1	mAdc
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 250 Vdc, V_{BE} = 1.5 Vdc)	2N3738		—	0.5	
(V_{CE} = 300 Vdc, V_{BE} = 1.5 Vdc)	2N3739		—	0.5	
(V_{CE} = 125 Vdc, V_{BE} = 1.5 Vdc, T_C = 100°C)	2N3738		—	1.0	
(V_{CE} = 200 Vdc, V_{BE} = 1.5 Vdc, T_C = 100°C)	2N3739		—	1.0	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 125 Vdc, I_B = 0)	2N3738		—	0.25	
(V_{CE} = 200 Vdc, I_B = 0)	2N3739		—	0.25	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 250 Vdc, I_E = 0)	2N3738		—	0.1	
(V_{CB} = 325 Vdc, I_E = 0)	2N3739		—	0.1	
ON CHARACTERISTICS					
DC Current Gain *		h_{FE}*			—
(I_C = 50 mAdc, V_{CE} = 10 Vdc)			30	—	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)			40	200	
(I_C = 250 mAdc, V_{CE} = 10 Vdc)			25	—	
Collector-Emitter Saturation Voltage * (I_C = 250 mAdc, I_B = 25 mAdc)		$V_{CE(sat)}$*	—	2.5	Vdc
Base-Emitter Voltage * (I_C = 100 mAdc, V_{CE} = 10 Vdc)		V_{BE}*	—	1.0	Vdc
TRANSIENT CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	10	—	MHz
Common Base Output Capacitance (V_{CB} = 100 Vdc, I_C = 0, f = 100 kHz)		C_{ob}	—	20	pF
Small Signal Current Gain (I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 1 kHz)		h_{fe}	35	—	—

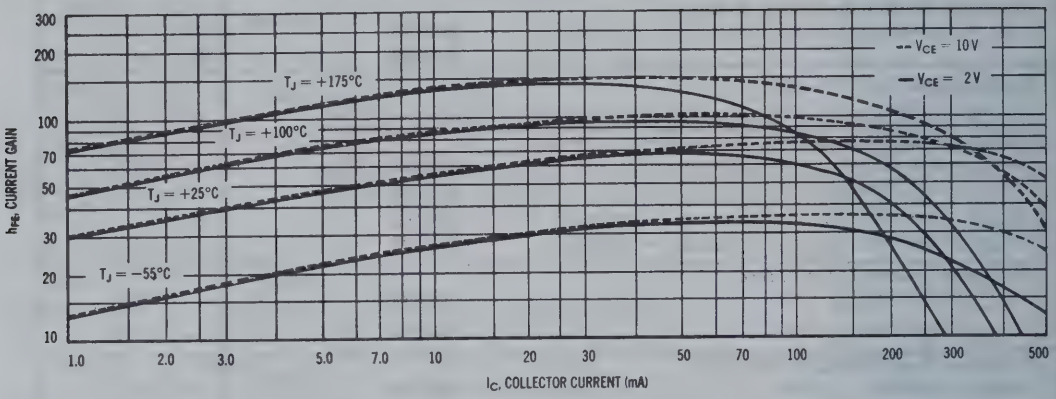
*PULSE TEST: PW ≤ 300 μs, Duty Cycle ≤ 2%

ACTIVE REGION SAFE AREAS

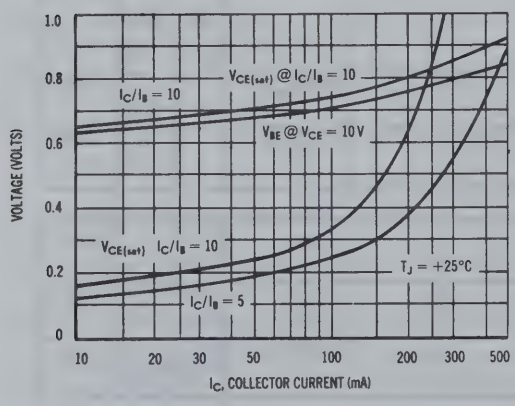


The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CEO} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CEO} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

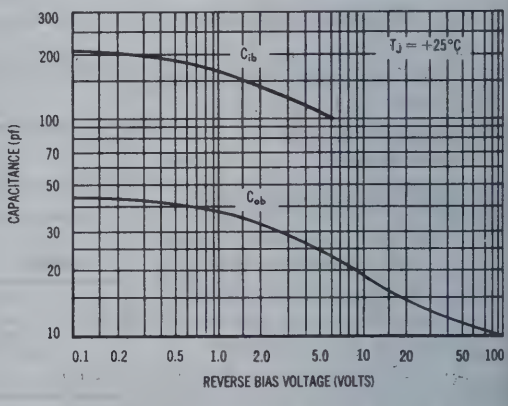
CURRENT GAIN



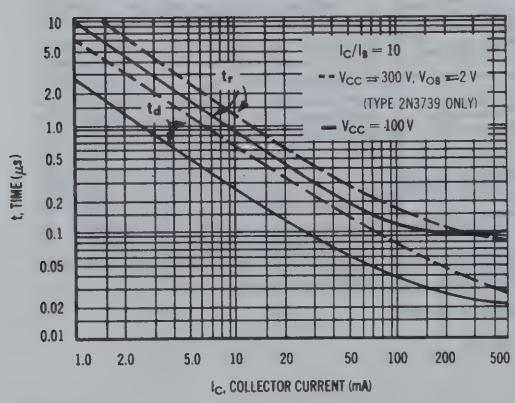
"ON" VOLTAGES



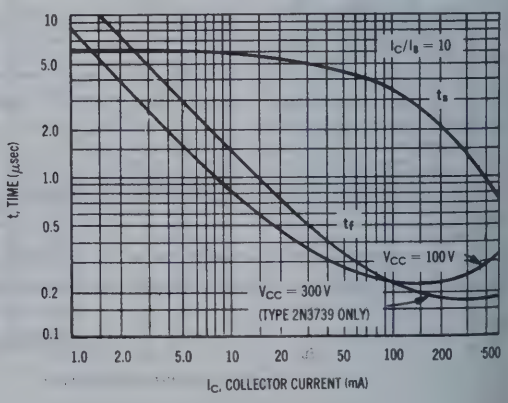
CAPACITANCE



TURN-ON TIME

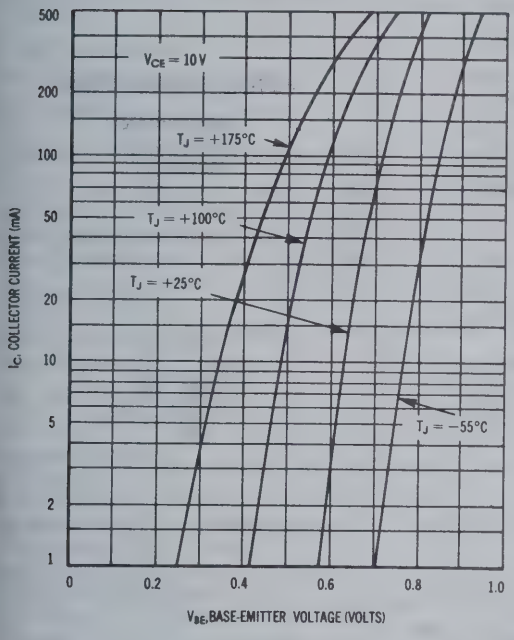


TURN-OFF TIME



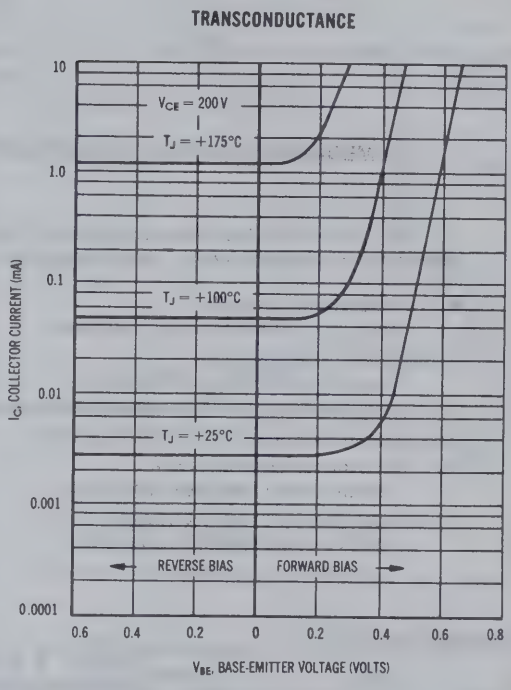
LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

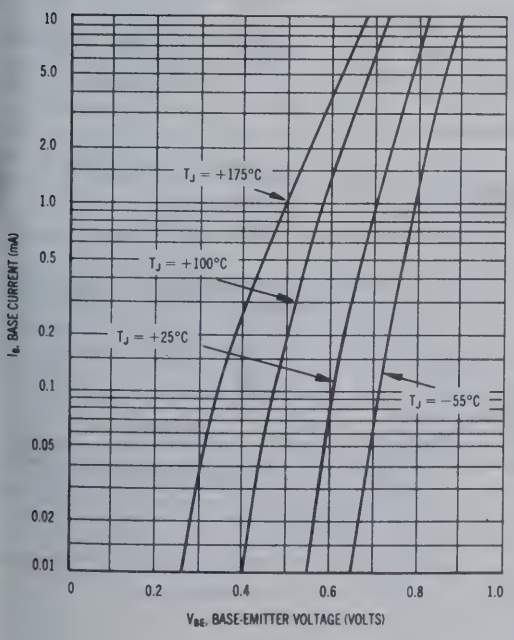


CUT-OFF CHARACTERISTICS

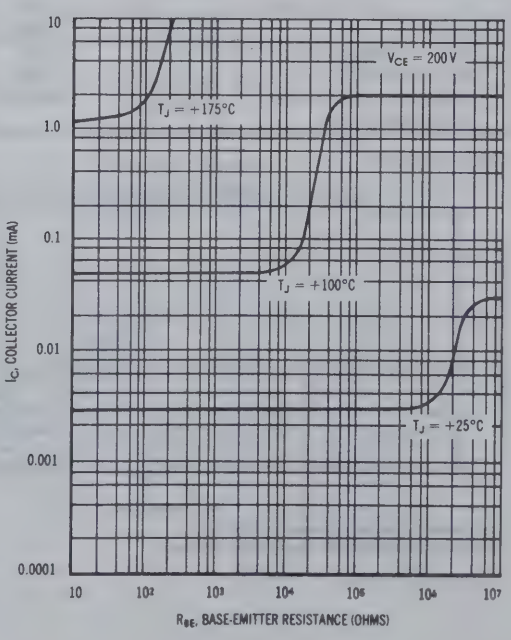
TRANSCONDUCTANCE



INPUT ADMITTANCE



EFFECT OF BASE-EMITTER RESISTANCE



2N3740, A (SILICON)
2N3741, A

MEDIUM-POWER PNP TRANSISTORS

. . . ideal for use as drivers, switches and direct replacement of germanium medium-power devices. These devices feature:

- Low Saturation Voltage —
  $V_{CE(sat)}$ = 0.6 Vdc @ I_C = 1.0 Amp
- High Gain Characteristics —
  h_{FE} = 30–100 @ I_C = 250 mAdc
- Direct Substitution for Germanium Equivalents
- Excellent Safe Area Limits (See Figure 2)
- Low Collector Cutoff Current —
  100 nA (Max) 2N3740A, 2N3741A
- Complementary to NPN 2N3766
  (2N3740) and 2N3767 (2N3741)

POWER TRANSISTORS

PNP SILICON
60–80 VOLTS
25 WATTS

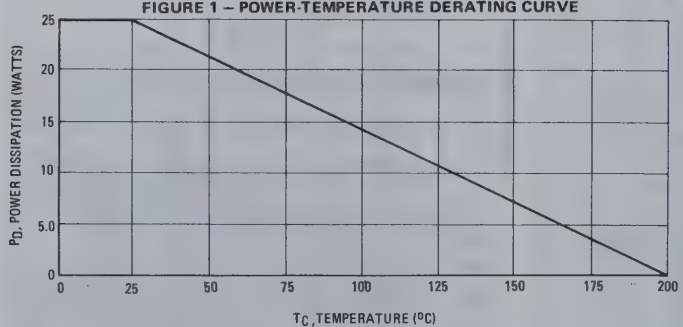


*MAXIMUM RATINGS

Rating	Symbol	2N3740 2N3740A	2N3741 2N3741A	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0	7.0	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Collector Current — Continuous — Peak (Note 1)	I_C	4.0 10		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	25 0.143		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

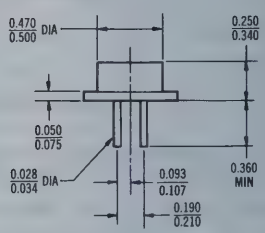
Note 1: See Figure 2

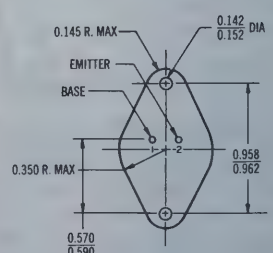
FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.
Both limits are applicable and must be observed.

*Indicates JEDEC Registered Data.





CASE 80
(TO-66)

COLLECTOR CONNECTED TO CASE

2N3740,A, 2N3741,A (continued)

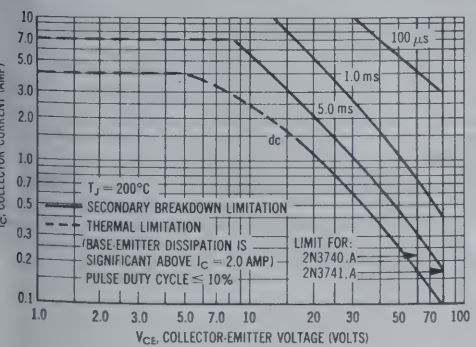
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage ① (I_C = 100 mAdc, I_B = 0)	2N3740, 2N3740A	2	$V_{CEO(sus)}$ ①	60	–	Vdc
	2N3741, 2N3741A			80	–	
Emitter Base Cutoff Current (V_{EB} = 7.0 Vdc)	2N3740, 2N3741	–	I_{EBO}	–	0.5	mAdc
	2N3740A, 2N3741A			–	100	nAdc
Collector Cutoff Current		5, 6②	I_{CEX}			
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3740			–	100	μAdc
	2N3740A			–	100	nAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3741			–	100	μAdc
	2N3741A			–	100	nAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N3740			–	1.0	mAdc
	2N3740A			–	0.5	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N3741			–	1.0	mAdc
	2N3741A			–	0.5	
Collector-Emitter Cutoff Current		5, 6②	I_{CEO}			
(V_{CE} = 40 Vdc, I_B = 0)	2N3740			–	1.0	mAdc
	2N3740A			–	1.0	μAdc
(V_{CE} = 60 Vdc, I_B = 0)	2N3741			–	1.0	mAdc
	2N3741A			–	1.0	μAdc
Collector Base Cutoff Current		–	I_{CBO}			
(V_{CB} = 60 Vdc, I_E = 0)	2N3740			–	100	μAdc
	2N3740A			–	100	nAdc
(V_{CB} = 80 Vdc, I_E = 0)	2N3741			–	100	μAdc
	2N3741A			–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain		7	h_{FE}①			–
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)				40	–	
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)				30	100	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)				20	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)				10	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 125 mAdc)		8, 9, 10	$V_{CE(sat)}$①	–	0.6	Vdc
Base-Emitter Voltage (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		3, 4, 9, 10	V_{BE}①	–	1.0	Vdc
TRANSIENT CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		–	f_T	3.0	–	MHz
				4.0†	–	
Common Base Output Capacitance (V_{CB} = 10 Vdc, I_C = 0, f = 100 kHz)		14	C_{ob}	–	100	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		–	h_{fe}	25	–	–

*Indicates JEDEC Registered Data.
†Motorola guarantees this value in addition to the JEDEC registered data shown.

① Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
② Figures 5 and 6 apply to 2N3740 and 2N3741 only.

FIGURE 2 – ACTIVE REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS

FIGURE 3 – TRANSCONDUCTANCE

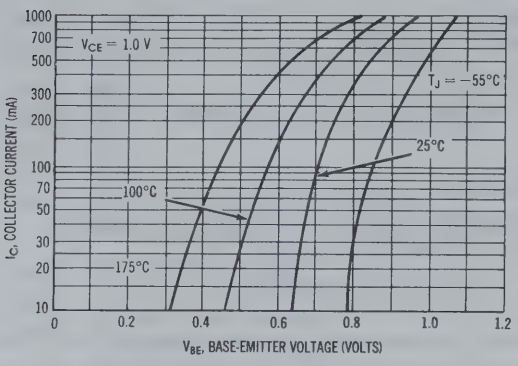
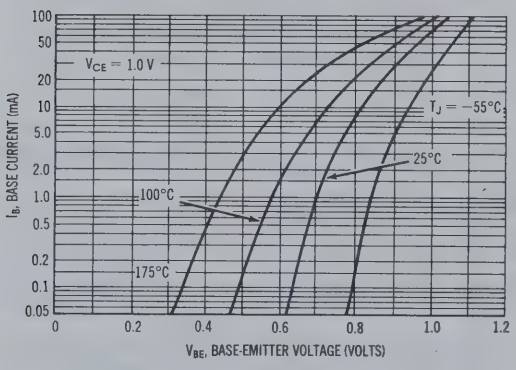


FIGURE 4 – INPUT ADMITTANCE



"OFF" REGION CHARACTERISTICS

FIGURE 5 – TRANSCONDUCTANCE

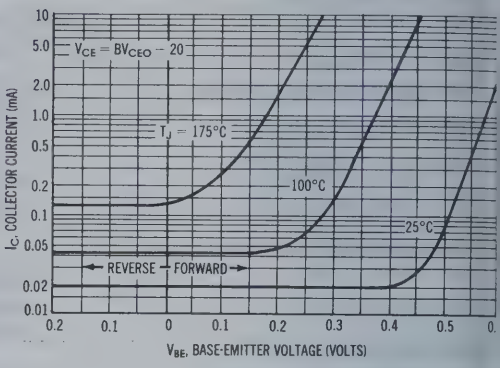
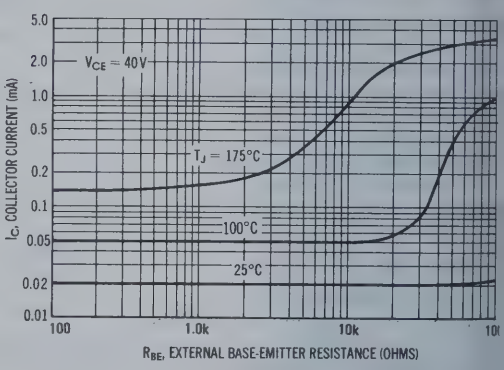


FIGURE 6 – EFFECTS OF BASE-EMITTER RESISTANCE



② Figures 5 and 6 apply to 2N3740 and 2N3741.

FIGURE 7 – THERMAL RESPONSE

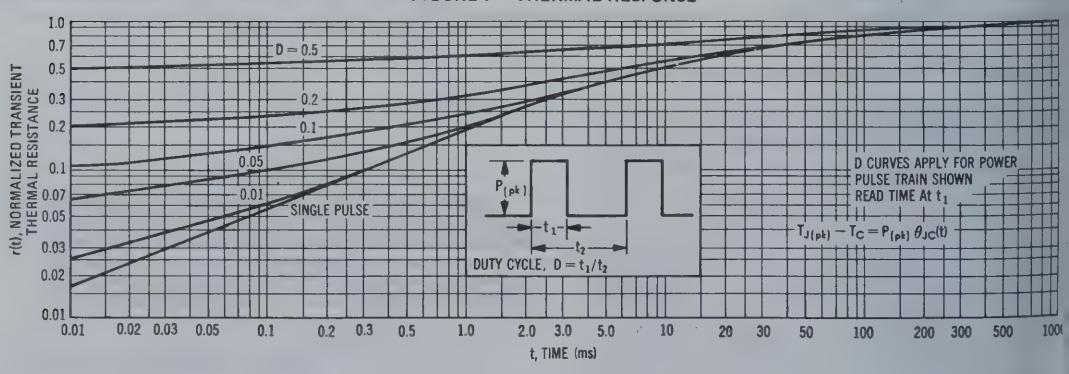
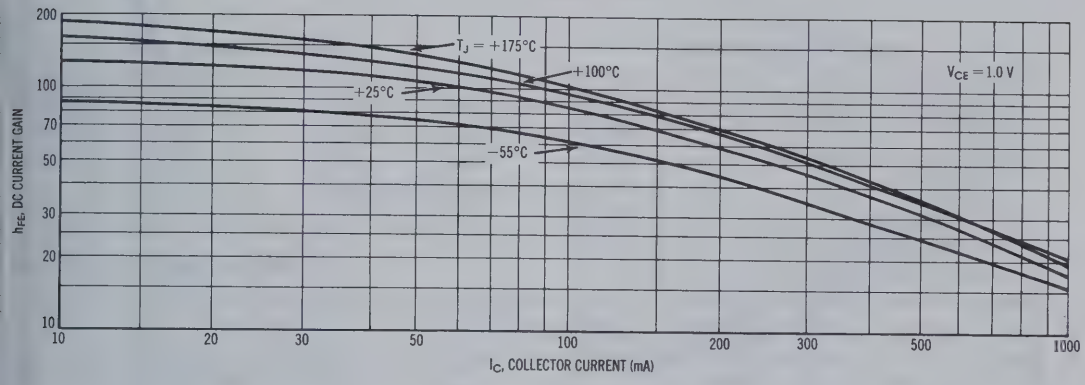


FIGURE 8 – CURRENT GAIN



SATURATION REGION CHARACTERISTICS

FIGURE 9 – COLLECTOR SATURATION REGION

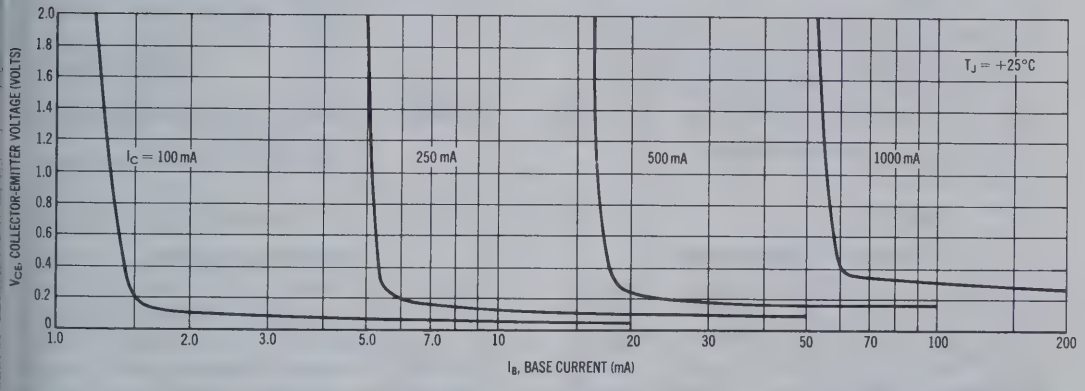


FIGURE 10 – "ON" VOLTAGES

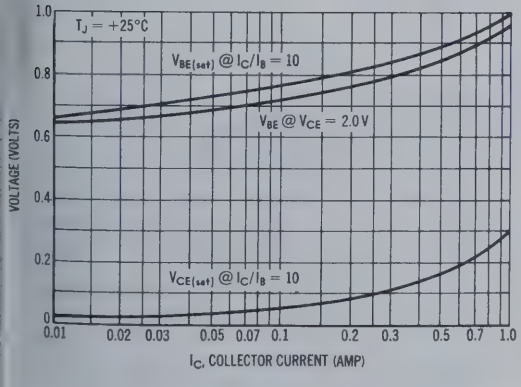


FIGURE 11 – TEMPERATURE COEFFICIENTS

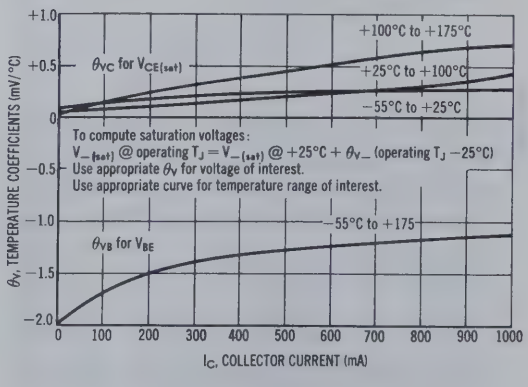


FIGURE 12 – TURN-ON TIME

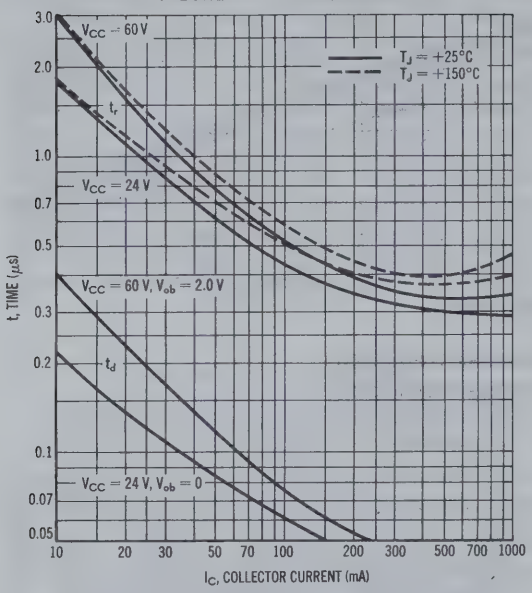


FIGURE 13 – CAPACITANCE

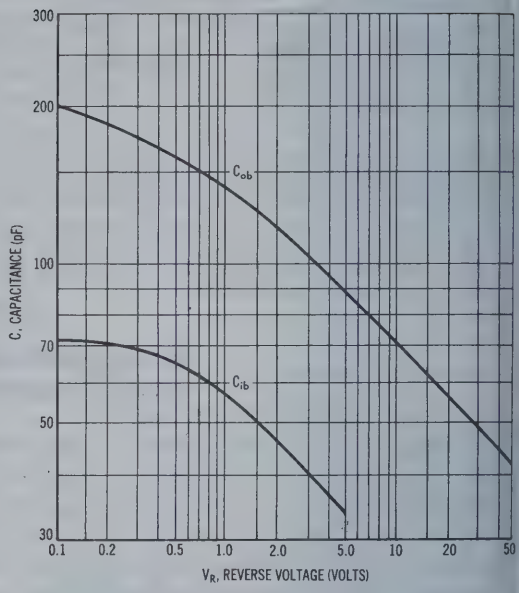


FIGURE 14 – STORAGE TIME

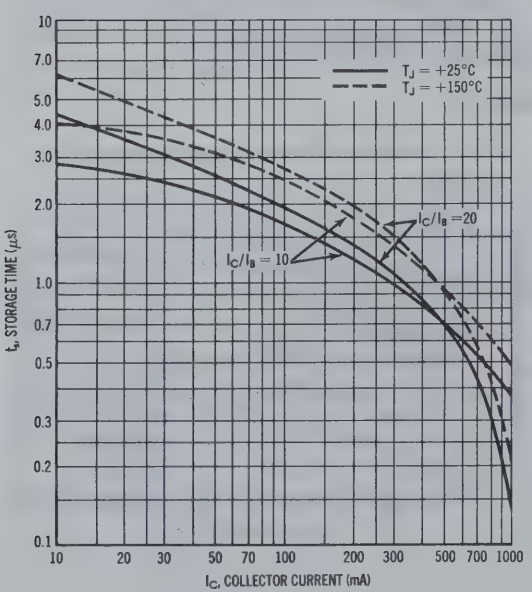
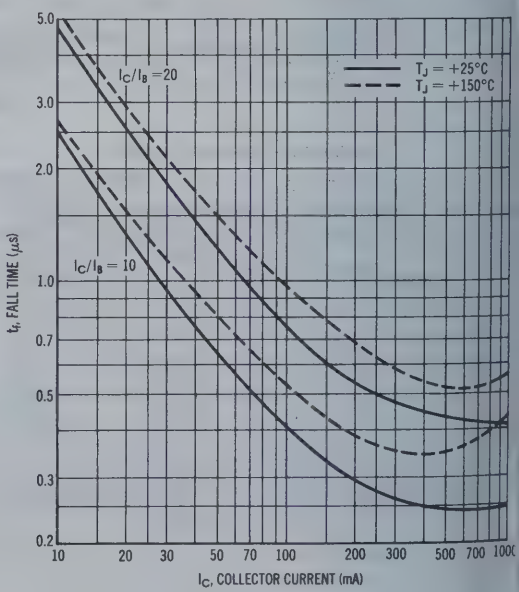


FIGURE 15 – FALL TIME



2N3742 (SILICON)



CASE 31
(TO-5)

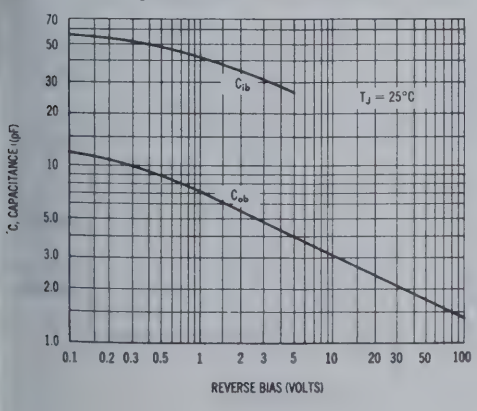
NPN silicon annular transistor for high-voltage amplifier applications from DC to VHF.

Collector connected to case

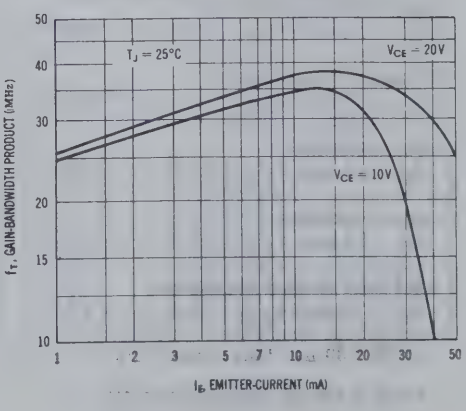
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	300	Vdc
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Emitter-Base Voltage	V_{EB}	7	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	5 28.6	Watts mW/°C
Operating Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

JUNCTION CAPACITANCE



GAIN-BANDWIDTH PRODUCT



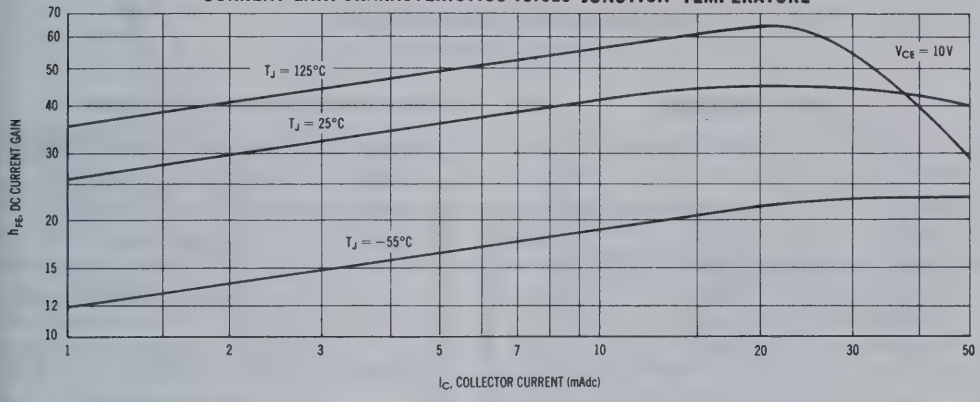
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	300	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100μAdc, I_C = 0)	BV_{EBO}	7	—	Vdc
Collector Saturation Voltage ** (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$**	—	1	Vdc
(I_C = 30 mAdc, I_B = 3 mAdc)		—	5	
Base-Emitter Saturation Voltage ** (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$**	—	1.0	Vdc
(I_C = 30 mAdc, I_B = 3 mAdc)		—	1.2	
DC Current Gain ** (I_C = 3 mAdc, V_{CE} = 10 Vdc)	h_{FE}**	10	—	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		15	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		20	200	
(I_C = 50 mAdc, V_{CE} = 20 Vdc)		20	—	
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.2	μAdc
(V_{CB} = 200 Vdc, I_E = 0, T_A = 100°C)		—	20	
Emitter Cutoff Current V_{EB} = 6 Vdc, I_C = 0)	I_{EBO}	—	0.2	μAdc
Small Signal Current Gain (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 20 MHz)	$\lvert h_{fe} \rvert$	1.5	—	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	6	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	80	pF
Small Signal Current Gain (I_C = 10 mA, V_{CE} = 10 V, f = 1 kHz)	h_{fe}	20	200	—
Voltage Feedback Ratio (I_C = 10 mA, V_{CE} = 10 V, f = 1 kHz)	h_{re}	—	1.0	$X10^{-4}$
Input Impedance (I_C = 10 mA, V_{CE} = 10 V, f = 1 kHz)	h_{ie}	—	0.5	Kohms
Output Admittance (I_C = 10 mA, V_{CE} = 10 V, f = 1 kHz)	h_{oe}	5	50	μmhos
Real Part of Input Impedance (I_C = 10 mA, V_{CE} = 10 V, f = 5 MHz)	$Re(h_{ie})$	—	40	ohms

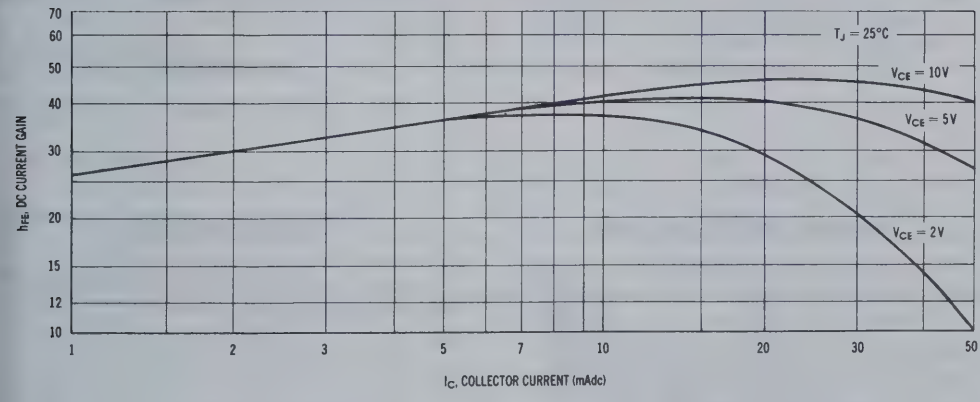
*PW ≤ 30 μs, Duty Cycle ≤ 1%

**PW ≤ 300 μs, Duty Cycle ≤ 2%

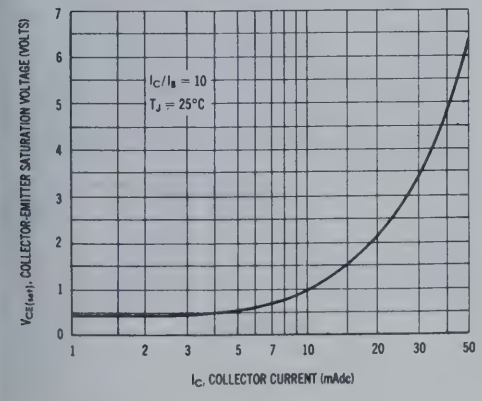
CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



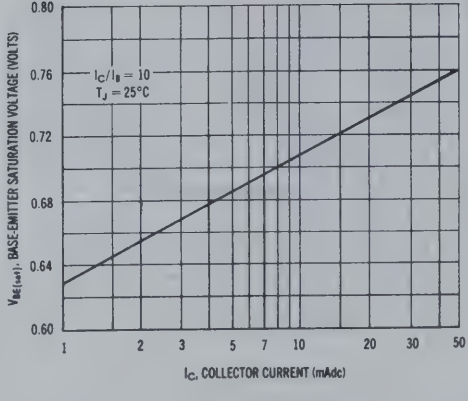
CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



COLLECTOR-EMITTER SATURATION VOLTAGE



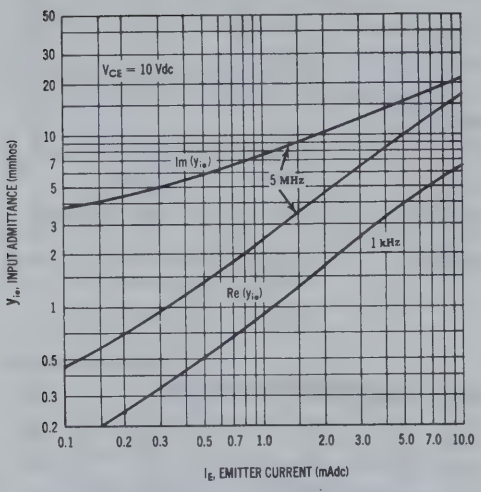
BASE -EMITTER SATURATION VOLTAGE



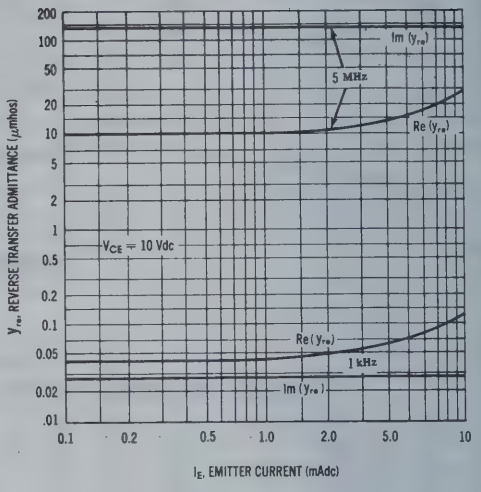
SMALL SIGNAL y PARAMETERS

$T_A = 25°C$

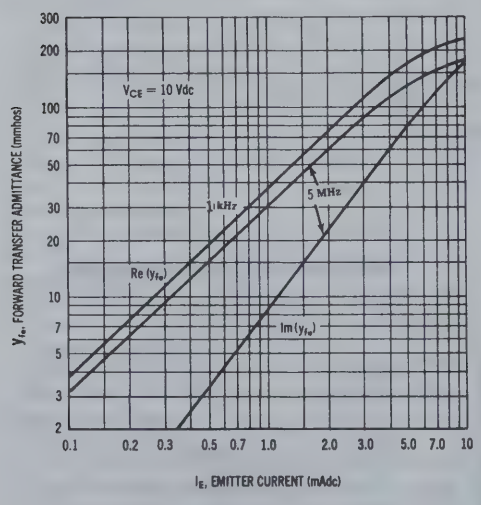
INPUT ADMITTANCE



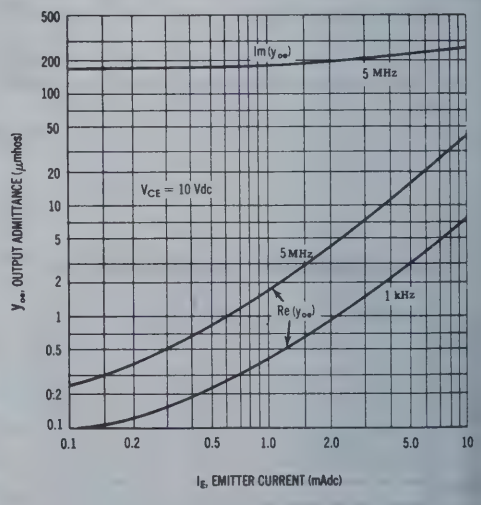
REVERSE TRANSFER ADMITTANCE



FORWARD TRANSFER ADMITTANCE



OUTPUT ADMITTANCE



2N3743 (SILICON)



CASE 31
(TO-5)

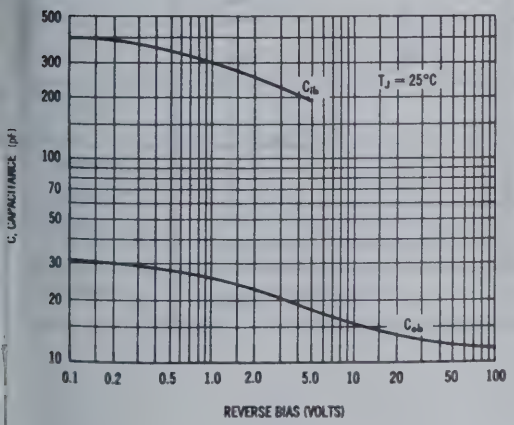
PNP silicon annular transistor for high-voltage amplifier applications from dc to VHF.

Collector connected to case

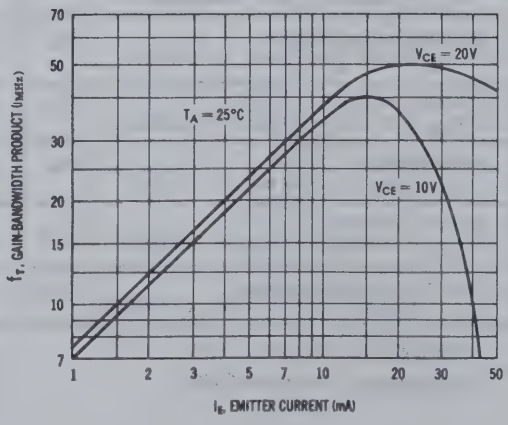
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	300	Vdc
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate Above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation@ $T_C = 25^oC$ Derate Above 25^oC	P_D	5.0 28.6	Watts mW/°C
Operating Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

JUNCTION CAPACITANCE



GAIN-BANDWIDTH PRODUCT



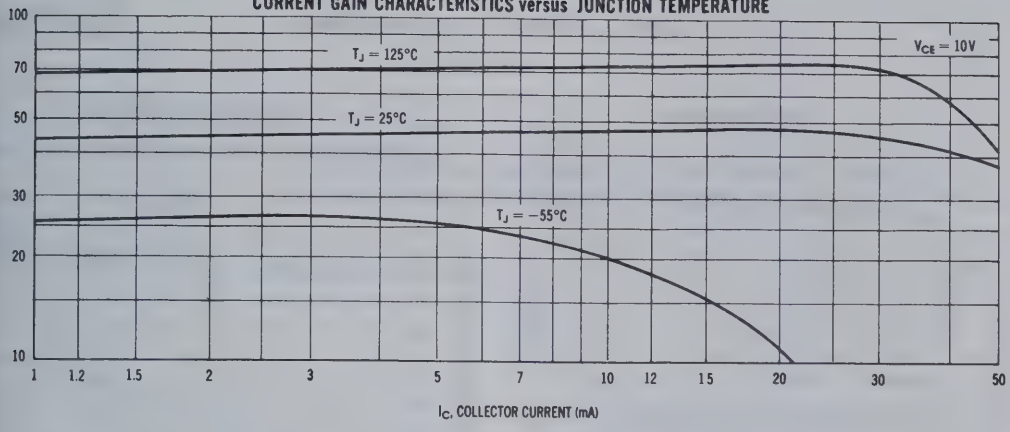
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	300	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector Saturation Voltage** (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$**	—	5	Vdc
(I_C = 30 mAdc, I_B = 3 mAdc)		—	8	
Base-Emitter Saturation Voltage** (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$**	—	1.0	Vdc
(I_C = 30 mAdc, I_B = 3 mAdc)		—	1.2	
DC Forward Current Gain** (I_C = 100 μAdc, V_{CE} = 10 Vdc)	h_{FE}**	20	—	—
(I_C = 1 mAdc, V_{CE} = 10 Vdc)		25	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		25	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		25	250	
(I_C = 50 mAdc, V_{CE} = 20 Vdc)		25	—	
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.3	μAdc
(V_{CB} = 200 Vdc, I_E = 0, T_A = 100°C)		—	30	
Emitter-Base Leakage Current (V_{EB} = 3 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f=20MHz)	$\|h_{fe}\|$	1.5	—	—
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	15	pF
Input Capacitance (V_{EB} = 1 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	400	pF
Small Signal Current Gain (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{fe}	30	300	—
Voltage Feedback Ratio (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{re}	—	4.0	X10^{-4}
Input Impedance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{ie}	—	1.0	kohms
Output Admittance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{oe}	—	200	μmhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5 MHz)	$Re(h_{ie})$	—	40	ohms

*PW ≤ 30 μs, Duty Cycle ≤ 1%

**PW ≤ 300 μs, Duty Cycle ≤ 2%

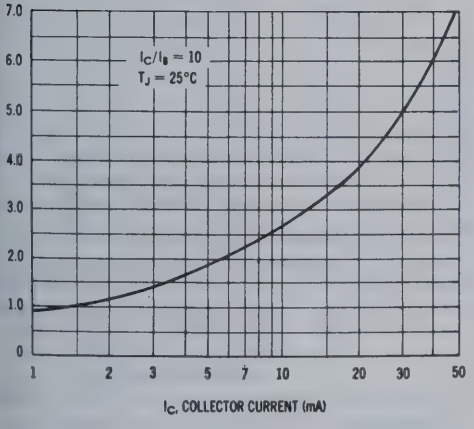
CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



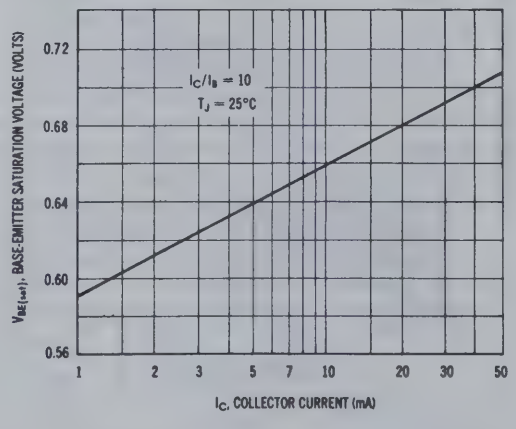
CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



COLLECTOR-EMITTER SATURATION VOLTAGE

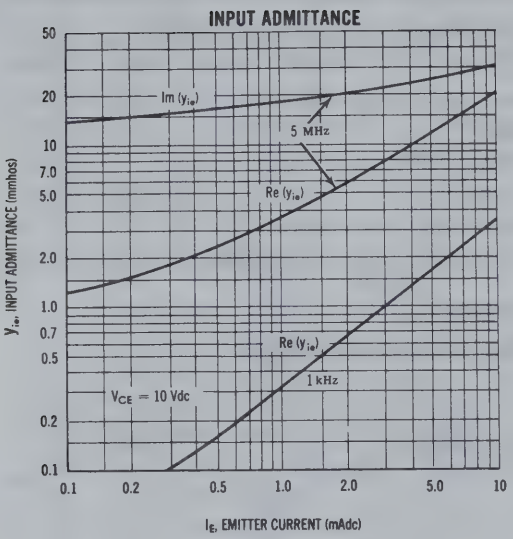


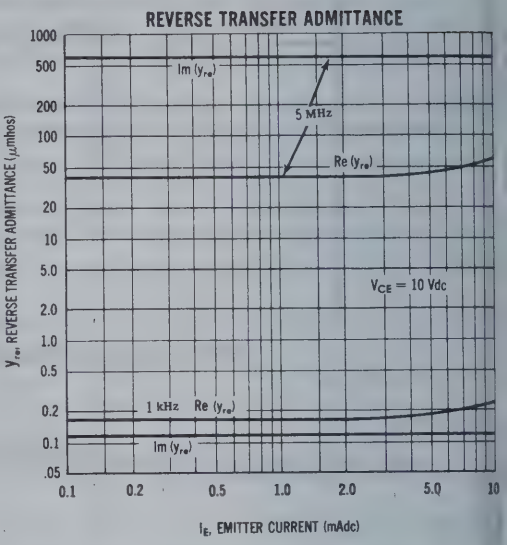
BASE-EMITTER SATURATION VOLTAGE

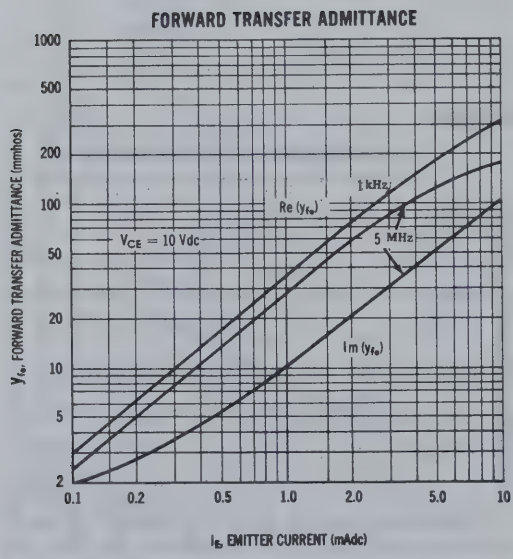


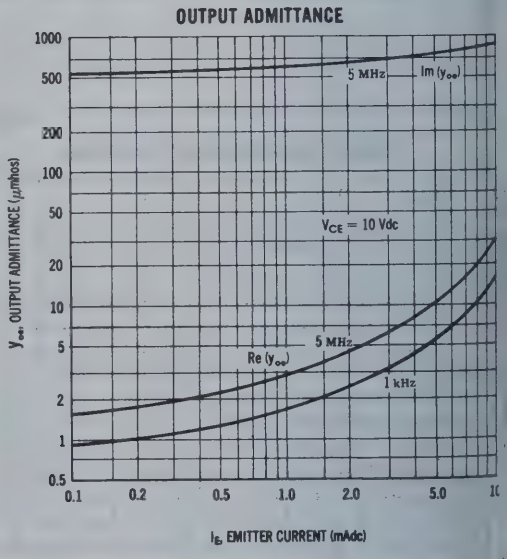
SMALL SIGNAL y PARAMETERS

$T_A = 25°C$









2N3762 (SILICON)
2N3763
2N3764
2N3765



Medium-current PNP silicon annular transistor, designed for high-speed switching and driver applications.

Collector connected to case

CASE 31
(TO-5)
2N3762
2N3763

CASE 26
(TO-46)
2N3764
2N3765

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

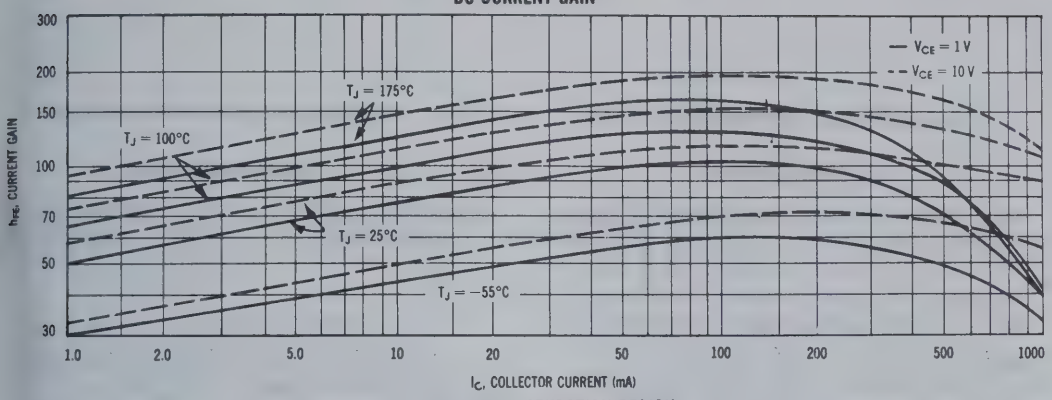
Rating	Symbol	2N3762 2N3764	2N3763 2N3765	Unit
Collector-Base Voltage	V_{CB}	40	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	1.5		Adc
		TO-5 2N3762 2N3763	TO-46 2N3764 2N3765	
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/°C
Thermal Resistance Junction to Ambient Junction to Case	 θ_{JA} θ_{JC}	 0.175 0.044	 0.35 0.088	°C/mW
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

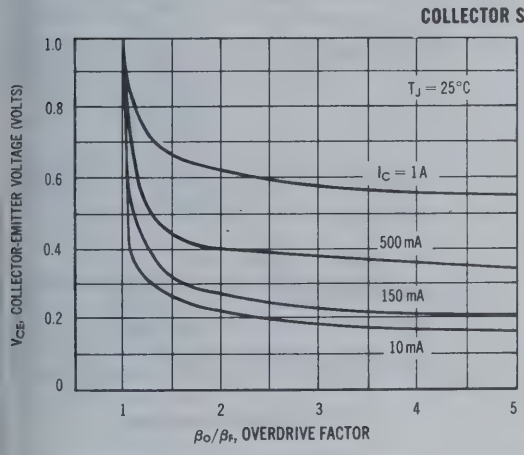
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3762, 2N3764	BV_{CBO}	40	—	Vdc
	2N3763, 2N3765		60	—	
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3762, 2N3764	BV_{CEO}*	40	—	Vdc
	2N3763, 2N3765		60	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	Vdc
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 20 Vdc, V_{EB} = 2 Vdc)	2N3762, 2N3764		—	0.10	
(V_{CE} = 20 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)			—	10	
(V_{CE} = 30 Vdc, V_{EB} = 2 Vdc)	2N3763, 2N3765		—	0.10	
(V_{CE} = 30 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)			—	10	
Base Cutoff Current		I_{BL}			μAdc
(V_{CE} = 20 Vdc, V_{EB} = 2 Vdc)	2N3762, 2N3764		—	0.2	
(V_{CE} = 30 Vdc, V_{EB} = 2 Vdc)	2N3763, 2N3765		—	0.2	
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			—
(I_C = 10 mAdc, V_{CE} = 1 Vdc)			35	—	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)			40	—	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)			35	—	
(I_C = 1 Adc, V_{CE} = 1.5 Vdc)	2N3762, 2N3764		30	120	
	2N3763, 2N3765		20	80	
(I_C = 1.5 Adc, V_{CE} = 5 Vdc)	2N3762, 2N3764		30	—	
	2N3763, 2N3765		20	—	
Collector Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			—	0.1	
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.22	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	0.5	
(I_C = 1 Adc, I_B = 100 mAdc)			—	0.9	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			—	0.8	
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.2	
(I_C = 1 Adc, I_B = 100 mAdc)			0.9	1.4	
TRANSIENT CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	80	pF
High Frequency Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3762, 2N3764	$\lvert h_{fe} \rvert$	1.8	—	—
	2N3763, 2N3765		1.5	—	
Delay Time	(V_{CC} = 30 V, $V_{BE(off)}$ = 2 V, I_C = 1 Amp, I_{B1} = 100 mA)	t_d	—	8	ns
Rise Time		t_r	—	35	ns
Storage Time	(V_{CC} = 30 V, I_C = 1 Amp, I_{B1} = $-I_{B2}$ = 100 mA)	t_s	—	80	ns
Fall Time		t_f	—	35	ns
Total Control Charge (I_C = 1 Amp, I_B = 100 mA, V_{CC} = 30 V)		Q_T	—	30	nC

*Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

FIGURE 1 "ON" CONDITION CHARACTERISTICS

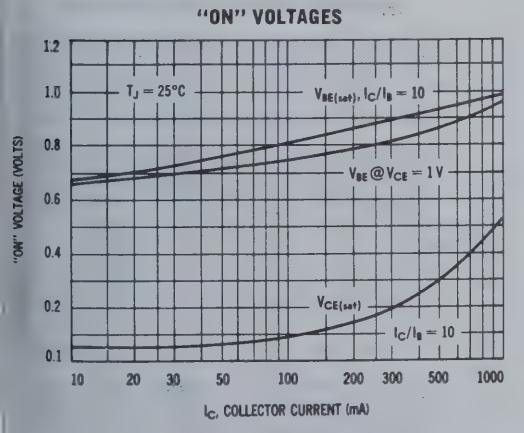


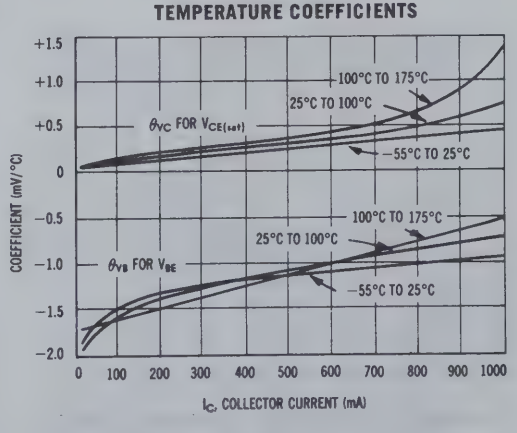


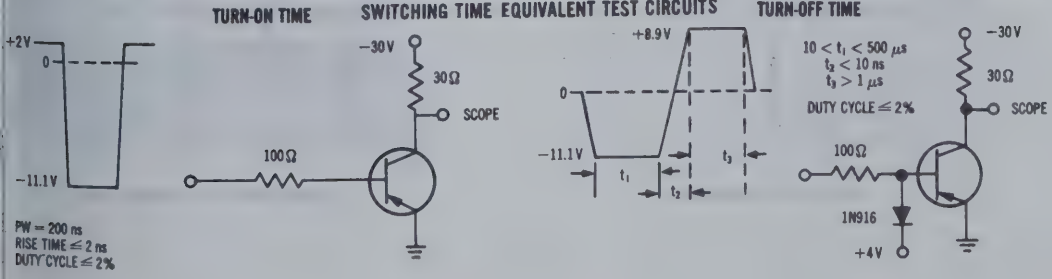
This graph shows the effect of base current on collector current. β_O (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3734, estimate a base current (I_{BF}) to ensure saturation at a temperature of 25°C and a collector of 500 mA.

Observe that at I_C = 500 mA an overdrive factor of at least 2.0 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 54 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design).

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE}@\,1\text{ Volt}}{I_C/I_{BF}} \qquad 2 = \frac{54}{500\text{ mA}/I_{BF}} \qquad I_{BF} \simeq 18.5\text{ mA typ}$$

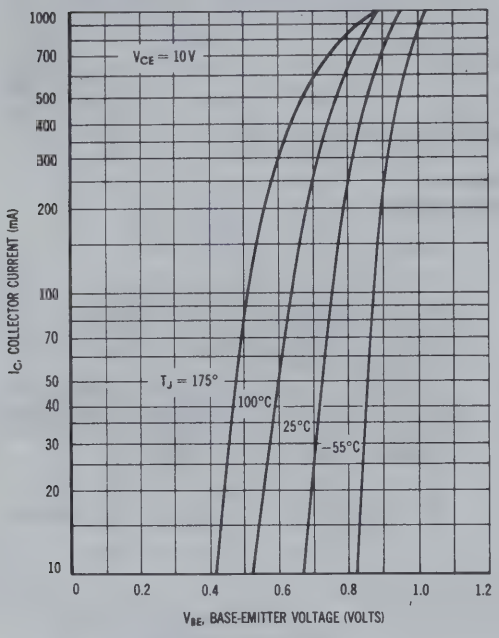




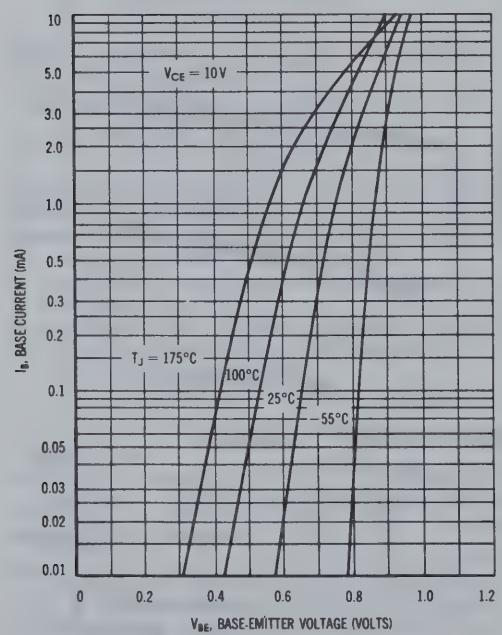


LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

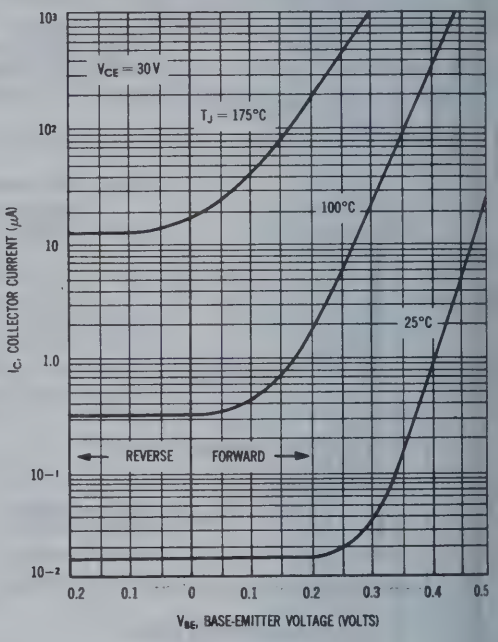


INPUT ADMITTANCE

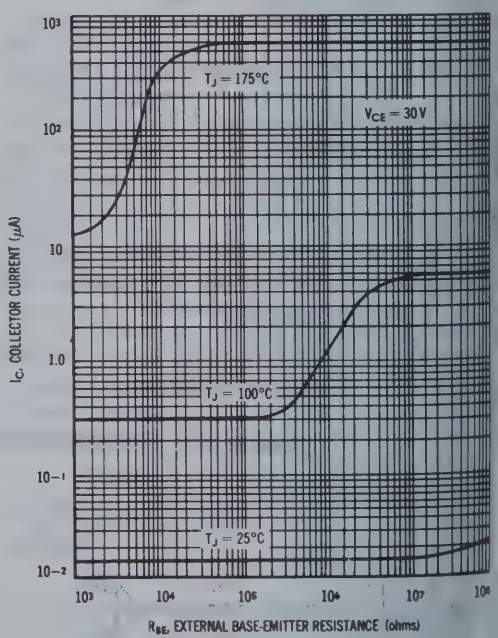


"OFF" CONDITION CHARACTERISTICS

TRANSCONDUCTANCE

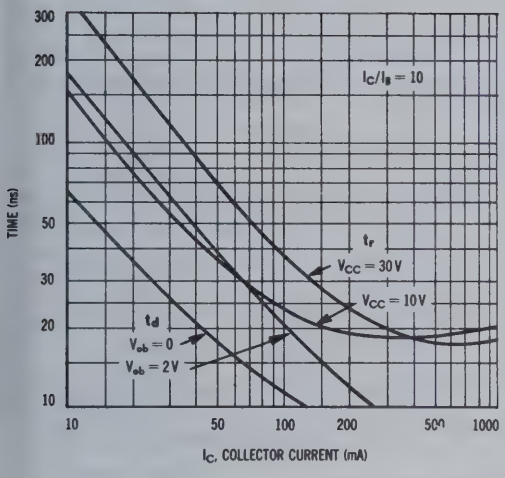


EFFECT OF BASE-EMITTER RESISTANCE

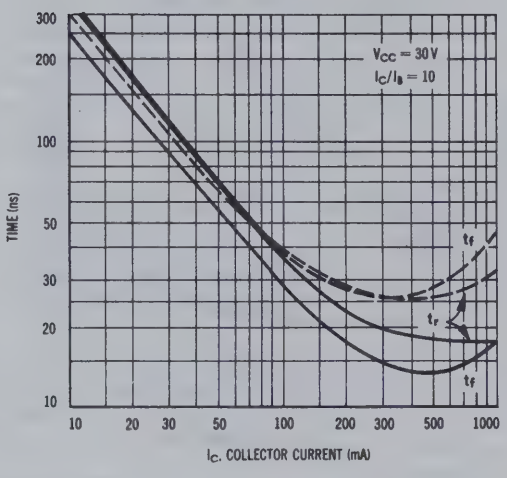


— $T_J = 25°C$ SWITCHING CHARACTERISTICS -- $T_J = 150°C$

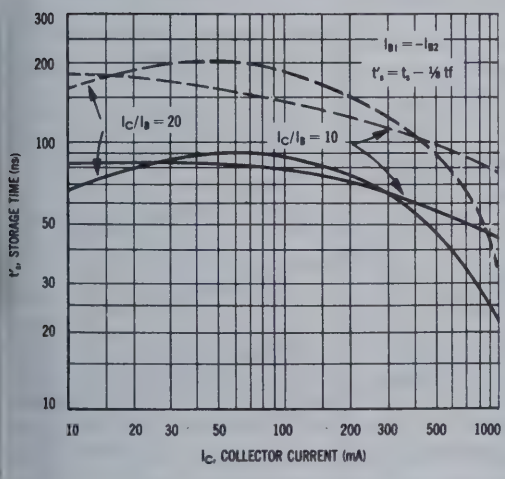
TURN-ON TIME



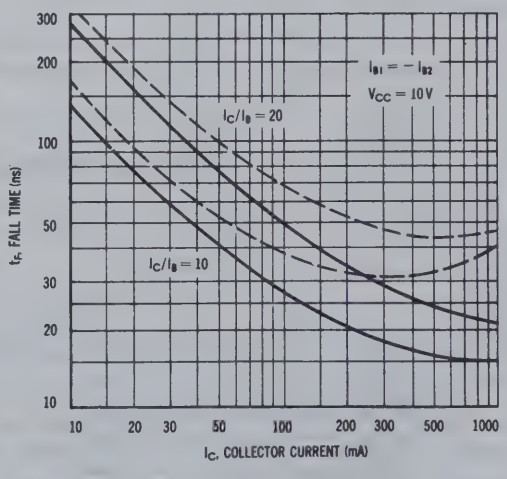
RISE AND FALL TIME



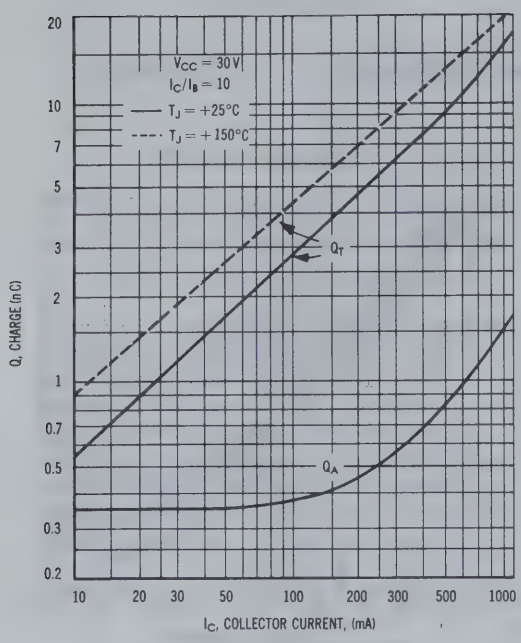
STORAGE TIME



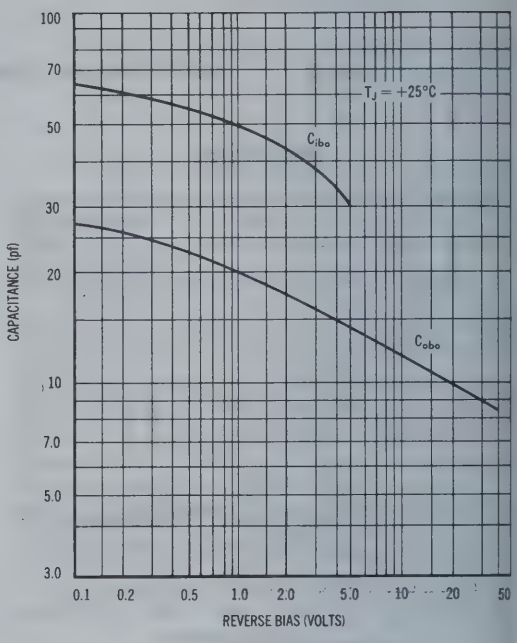
FALL TIME



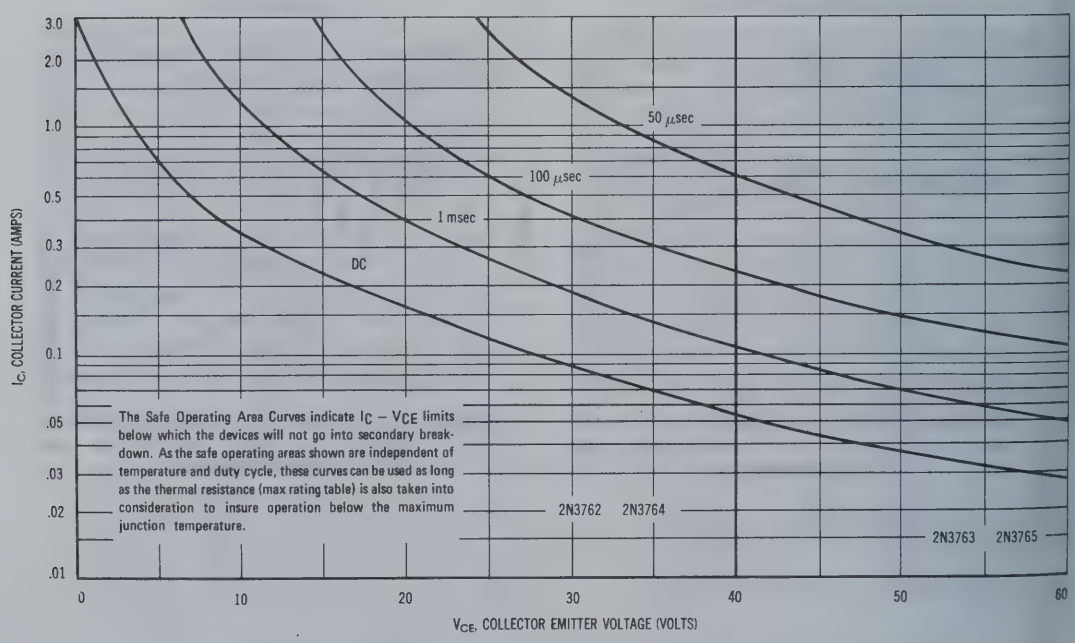
CHARGE DATA



CAPACITANCE



ACTIVE REGION SAFE OPERATING AREAS



2N3766 (SILICON)
2N3767



CASE 80
(TO-66)

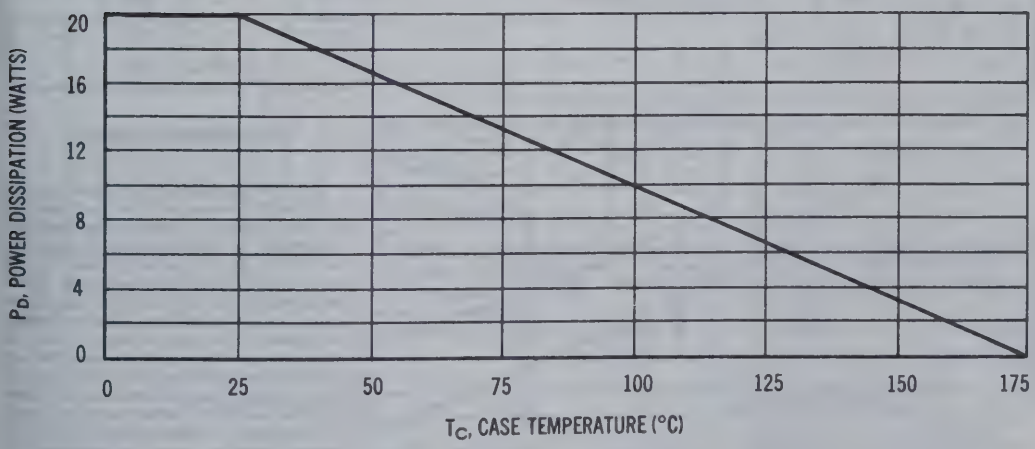
Medium-power NPN silicon transistors, for use in switching, and medium-power-amplifier applications. Complement to PNP 2N3740 (2N3766) 2N3741 (2N3767).

Collector connected to case

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	2N3766	2N3767	Unit
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6	6	Vdc
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector Current - Continuous	I_C	4.0		Adc
Peak		4.0		
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 25° C	P_D	20		Watts
Derate above 25° C		0.133		W/°C
Thermal Resistance	θ_{JC}	7.5		°C/W
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to °175		°C

POWER-TEMPERATURE DERATING CURVE



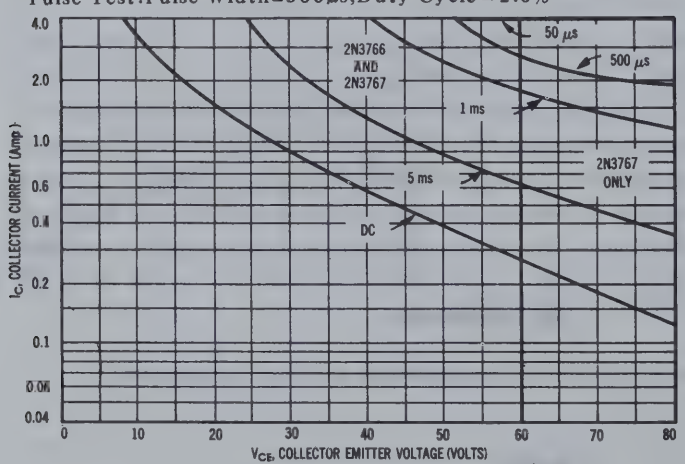
Safe area curves are indicated. Both limits are applicable and must be observed.

2N3766, 2N3767 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Voltage* (I_C = 100 mAdc, I_B = 0)	2N3766	BV_{CEO}*	60	—	Vdc
	2N3767		80	—	
Emitter-Base Cutoff Current (V_{EB} = 6 Vdc)		I_{EBO}	—	0.75	mAdc
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 80 Vdc, V_{BE} = 1.5 Vdc)	2N3766		—	0.1	
(V_{CE} = 100 Vdc, V_{BE} = 1.5 Vdc)	2N3767		—	0.1	
(V_{CE} = 50 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	2N3766		—	1.0	
(V_{CE} = 70 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	2N3767		—	1.0	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 60 Vdc, I_B = 0)	2N3766		—	0.7	
(V_{CE} = 80 Vdc, I_B = 0)	2N3767		—	0.7	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 80 Vdc, I_E = 0)	2N3766		—	0.1	
(V_{CB} = 100 Vdc, I_E = 0)	2N3767		—	0.1	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 50 mAdc, V_{CE} = 5 Vdc)			30	—	
(I_C = 500 mAdc, V_{CE} = 5 Vdc)			40	160	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)			20	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 1 Adc, I_B = 0.1 Adc)			—	2.5	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.0	
Base-Emitter Voltage (I_C = 1.0 Adc, V_{CE} = 10 Vdc)		V_{BE}	—	1.5	Vdc
TRANSIENT CHARACTERISTICS					
Current-Gain - Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	10	—	MHz
Common-Base Output Capacitance (V_{CB} = 10 Vdc, I_C = 0 Adc, f = 100 kHz)		C_{ob}	—	50	pF
Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		h_{fe}	40	—	—

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

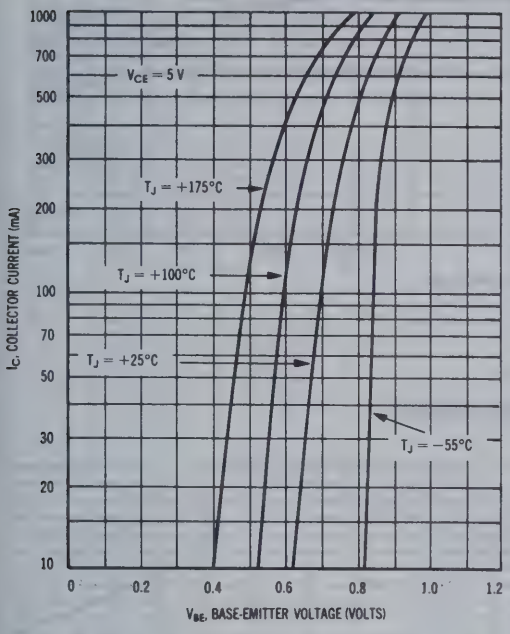


ACTIVE REGION SAFE AREAS

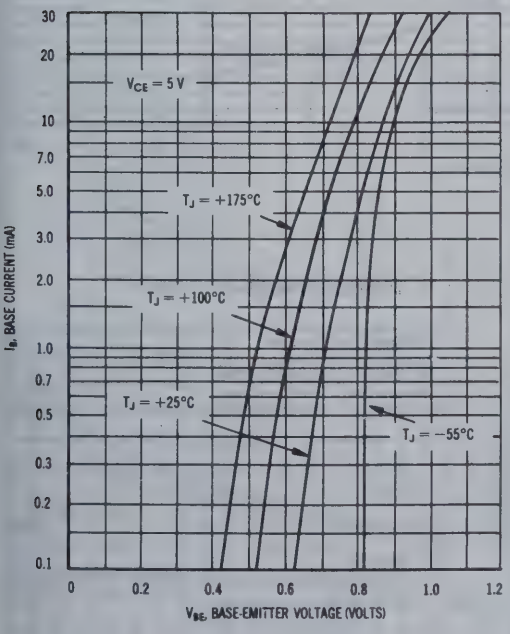
The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CEO} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CEO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

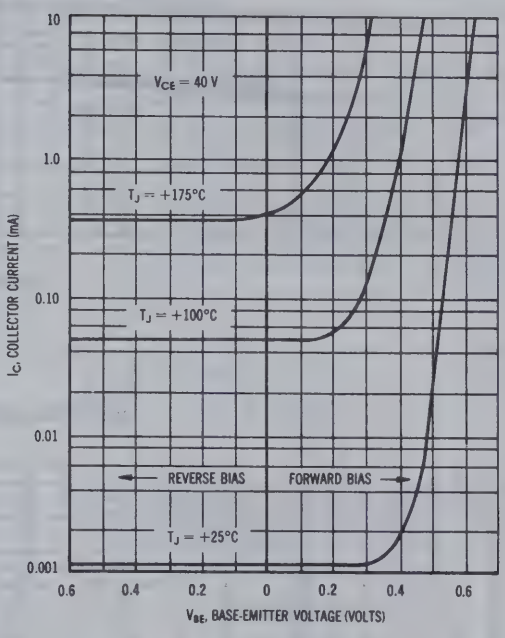


INPUT ADMITTANCE

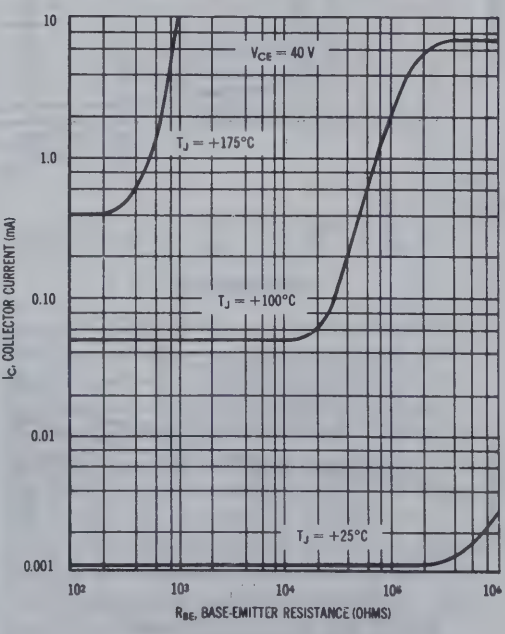


CUT-OFF CHARACTERISTICS

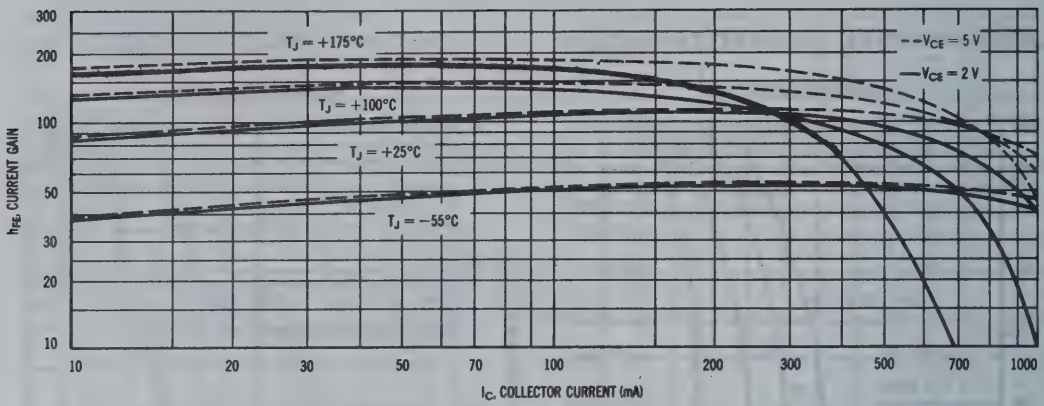
TRANSCONDUCTANCE



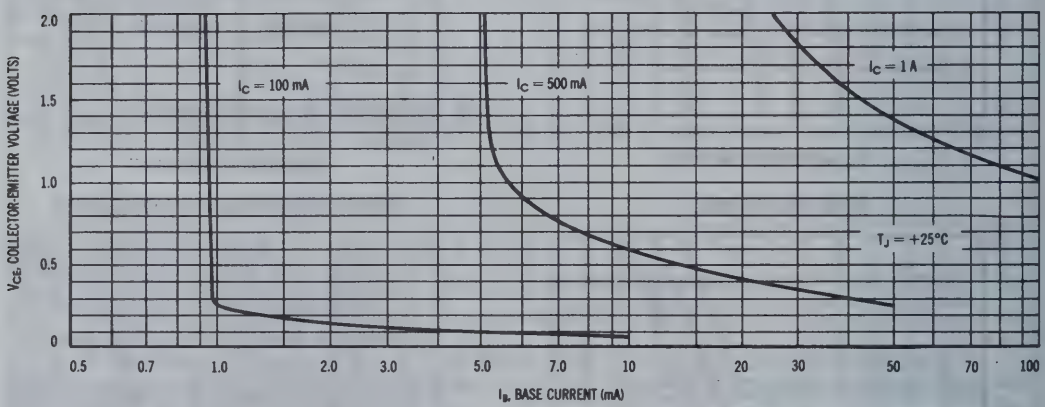
EFFECT OF BASE-EMITTER RESISTANCE



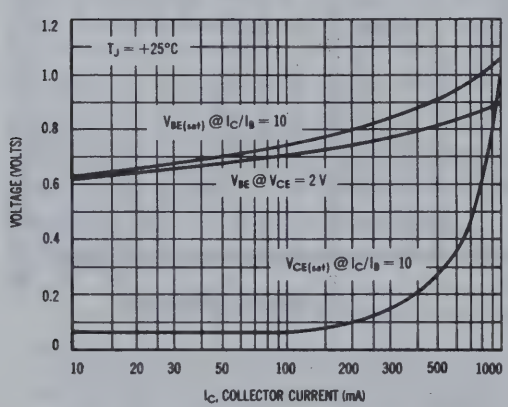
CURRENT GAIN



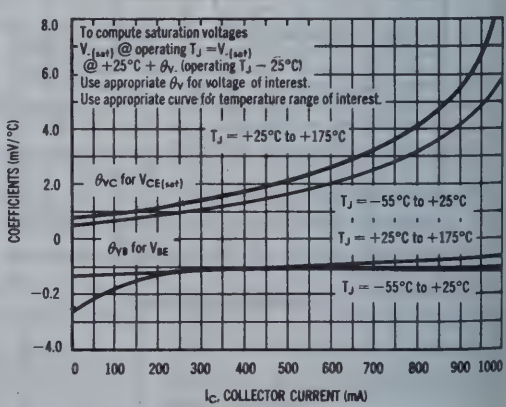
COLLECTOR SATURATION REGION



"ON" VOLTAGES



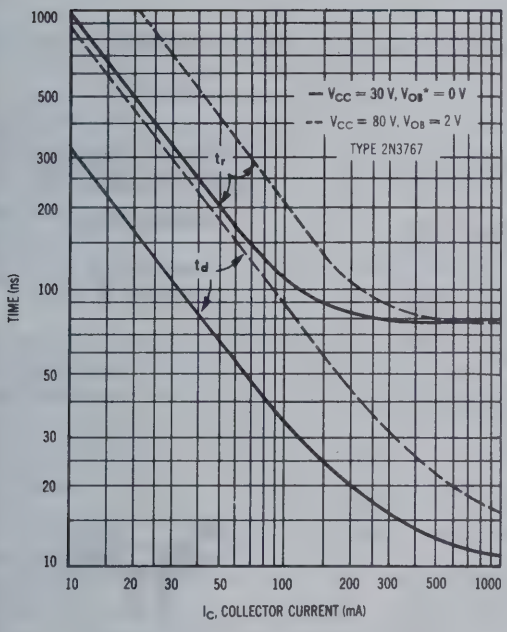
TEMPERATURE CO-EFFICIENTS



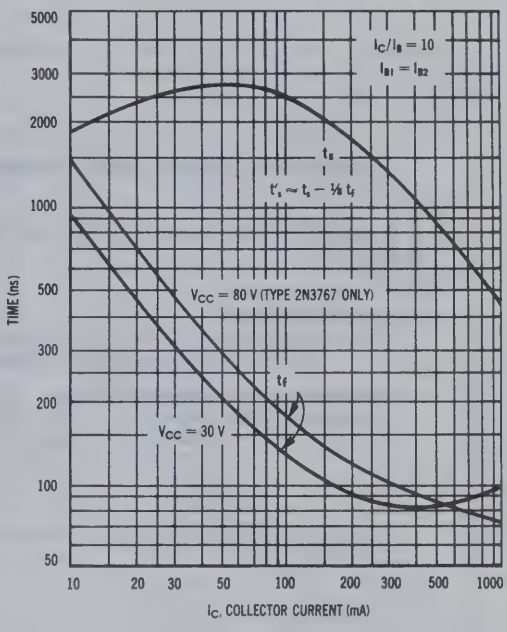
TRANSIENT CHARACTERISTICS

($T_J = 25°C$)

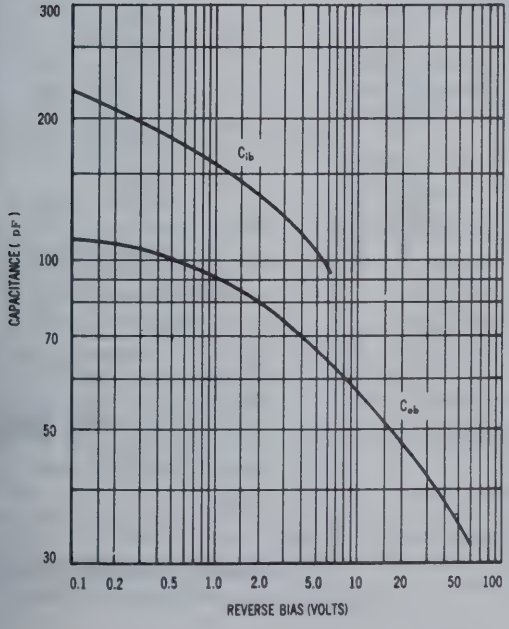
TURN-ON TIME



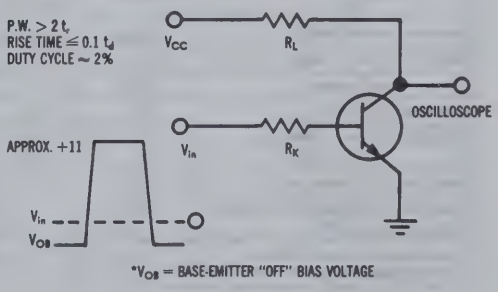
TURN-OFF TIME



CAPACITANCE

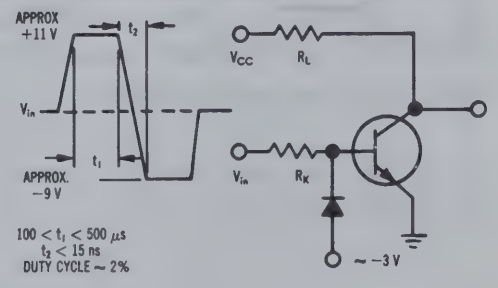


EQUIVALENT CIRCUIT FOR MEASURING DELAY AND RISE TIME



*V_{OB} = BASE-EMITTER "OFF" BIAS VOLTAGE

EQUIVALENT CIRCUIT FOR MEASURING STORAGE AND FALL TIMES



2N3771 (SILICON)
2N3772
MJ3771
MJ3772

HIGH-POWER NPN SILICON TRANSISTORS

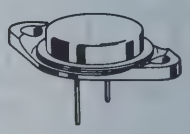
. . . designed for use in power amplifier and switching circuits applications.

- High DC Current Gain –
  h_{FE} = 15 (Min) @ I_C = 15 Adc – 2N3771, MJ3771
  15 (Min) @ I_C = 10 Adc – 2N3772, MJ3772
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 15 Adc – MJ3771
  1.0 Vdc (Max) @ I_C = 10 Adc – MJ3772

20 AND 30 AMPERE POWER TRANSISTORS

NPN SILICON

40-60 VOLTS
150 WATTS



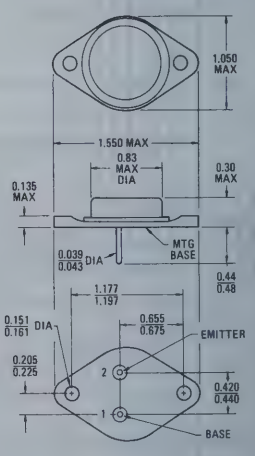
*MAXIMUM RATINGS

Rating	Symbol	2N3771 MJ3771	2N3772 MJ3772	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Emitter Voltage	V_{CEX}	50	80	Vdc
Collector-Base Voltage	V_{CB}	50	100	Vdc
Emitter-Base Voltage	V_{EB}	5.0	7.0	Vdc
Collector Current – Continuous Peak	I_C	30 30	20 30	Adc
Base Current – Continuous	I_B	7.5	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.86		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

*Indicates JEDEC Registered Data (2N3771, 2N3772).



CASE 11
TO-3

Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
*Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$				Vdc
(I_C = 200 mAdc, I_B = 0)	2N3771, MJ3771		40	–	–	
	2N3772, MJ3772		60	–	–	
*Collector Cutoff Current		I_{CEO}				mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N3771, MJ3771		–	–	10	
(V_{CE} = 50 Vdc, I_B = 0)	2N3772, MJ3772		–	–	10	
*Collector Cutoff Current		I_{CEX}				mAdc
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc)	2N3771, MJ3771		–	–	2.0	
	2N3772, MJ3772		–	–	5.0	
(V_{CE} = 30 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	All Types		–	–	10	
Collector Cutoff Current		I_{CBO}				mAdc
*(V_{CB} = Rated V_{CB}, I_E = 0)	2N3771, MJ3771		–	–	2.0	
	2N3772, MJ3772		–	–	5.0	
(V_{CB} = 30 Vdc, I_E = 0, T_C = 150°C)	All Types		–	–	10	
Emitter Cutoff Current		I_{EBO}				mAdc
(V_{BE} = Rated V_{BE}, I_C = 0)			–	–	5.0	
ON CHARACTERISTICS						
DC Current Gain (Note 1)		h_{FE}				–
(I_C = 15 Adc, V_{CE} = 4.0 Vdc)	2N3771, MJ3771		15	–	60	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)	2N3772, MJ3772		15	–	60	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)	2N3771, MJ3771		5.0	–	–	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)	2N3772, MJ3772		5.0	–	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$				Vdc
(I_C = 15 Adc, I_B = 1.5 Adc)	2N3771		–	–	2.0	
	MJ3771		–	–	1.0	
(I_C = 10 Adc, I_B = 1.0 Adc)	2N3772		–	–	1.4	
	MJ3772		–	–	1.0	
(I_C = 30 Adc, I_B = 6.0 Adc)	2N3771, MJ3771		–	–	4.0	
(I_C = 20 Adc, I_B = 4.0 Adc)	2N3772, MJ3772		–	–	4.0	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$				Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)	MJ3771, MJ3772		–	–	1.7	
(I_C = 15 Adc, I_B = 1.5 Adc)	MJ3771, MJ3772		–	–	1.8	
(I_C = 20 Adc, I_B = 2.0 Adc)	MJ3771, MJ3772		–	–	2.5	
Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$				Vdc
(I_C = 15 Adc, V_{CE} = 4.0 Vdc)	2N3771		–	–	2.7	
	MJ3771		–	–	1.7	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)	2N3772		–	–	2.2	
	MJ3772		–	–	1.7	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product		f_T				MHz
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 50 kHz)	2N3771, 2N3772		0.2	–	–	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	MJ3771, MJ3772		2.0	–	–	
Small Signal Current Gain		h_{fe}	40	–	–	–
(I_C = 10 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)						
SWITCHING CHARACTERISTICS						
Rise Time	MJ3771, MJ3772	t_r	–	350	–	ns
Storage Time (V_{CC} = 10 Vdc, I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)	MJ3771, MJ3772	t_s	–	700	–	ns
Fall Time	MJ3771, MJ3772	t_f	–	300	–	ns

*Indicates JEDEC Registered Data (2N3771, 2N3772).
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ACTIVE REGION DC SAFE OPERATING AREA

FIGURE 1 – 2N3771, 2N3772

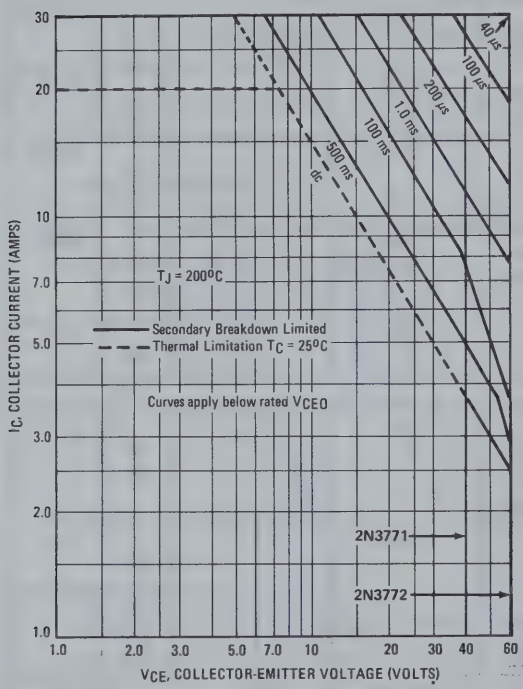
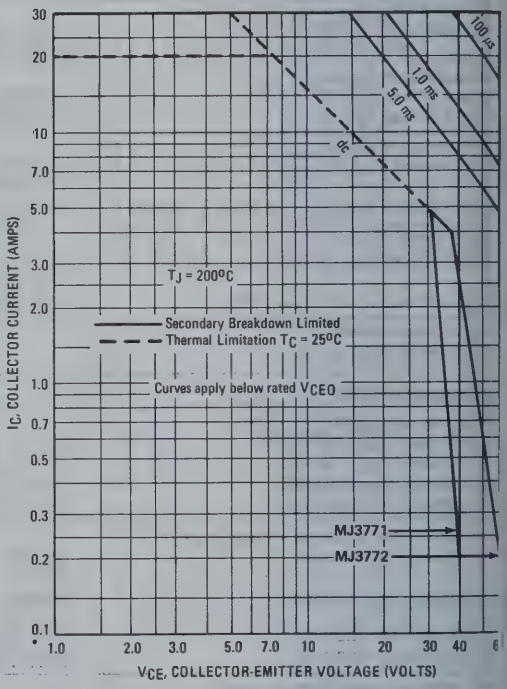


FIGURE 2 – MJ3771, MJ3772



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

2N3783 thru 2N3785
(GERMANIUM)



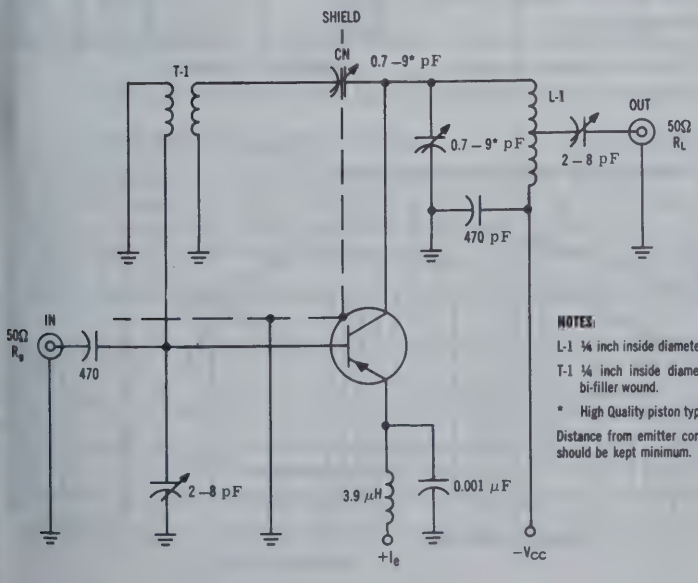
CASE 20
(TO-72)

PNP germanium epitaxial mesa transistors for high-gain, low-noise amplifier, oscillator and frequency multiplier applications.

MAXIMUM RATINGS

Rating	Symbol	2N3783 2N3784	2N3785	Unit
Collector-Base Voltage	V_{CB}	30	15	Vdc
Collector-Emitter Voltage	V_{CES}	30	15	Vdc
Collector-Emitter Voltage	V_{CEO}	20	12	Vdc
Emitter-Base Voltage	V_{EB}	0.5		Vdc
Collector Current	I_C	20		mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2		mW $mW/^oC$
Junction Operating & Storage Temperature Range	T_J, T_{stg}	-65 to +100		^oC

FIGURE 1 — 200 MHz TEST CIRCUIT: POWER GAIN & NOISE FIGURE



NOTES:

L-1 ¼ inch inside diameter, ½ inch length, 4 turns #20 solid copper wire, center tapped.

T-1 ¼ inch inside diameter, close wound, 3 turns #26 solid copper wire. 1:1 ratio bi-filler wound.

* High Quality piston type capacitor.

Distance from emitter contact of transistor to ground side of bypass capacitor should be kept minimum.

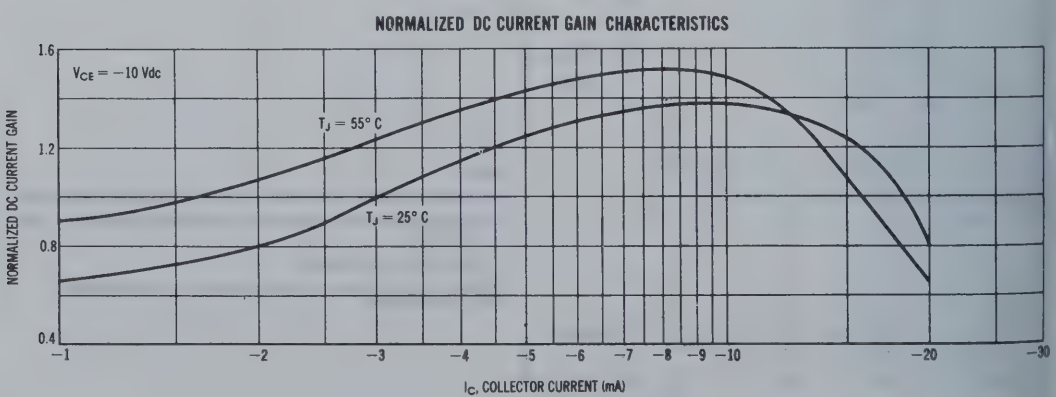
2N3783 thru 2N3785 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions		Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 100 μAdc, I_E = 0	2N3783, 2N3784	30	—	—	Vdc
			2N3785	15	—	—	
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 100 μAdc, V_{EB} = 0	2N3783, 2N3784	30	—	—	Vdc
			2N3785	15	—	—	
Collector-Emitter Breakdown Voltage	BV_{CEO}	I_C = 2 mAdc, I_B = 0	2N3783, 2N3784	20	—	—	Vdc
			2N3785	12	—	—	
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E = 100 μAdc, I_C = 0	All Types	0.5	—	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 Vdc, I_E = 0	All Types	—	—	5	μAdc
		V_{CB} = 10 Vdc, I_E = 0, T_A = +55°C	2N3783, 2N3784	—	—	50	
Emitter Cutoff Current	I_{EBO}	V_{EB} = 0.5 Vdc, I_C = 0	All Types	—	—	100	μAdc
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} = 10 Vdc, I_C = 3 mAdc	2N3783, 2N3784	20	—	200	—
			2N3785	15	—	200	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 5.0 mAdc, I_B = 1.0 mAdc	2N3783, 2N3784	—	—	0.25	Vdc
			2N3785	—	—	0.35	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 5.0 mAdc, I_B = 1.0 mAdc	2N3783, 2N3784	—	—	0.55	Vdc
			2N3785	—	—	0.65	
Small-Signal Forward Current Transfer Ratio	h_{fe}	I_C = 3 mAdc, V_{CE} = 10 Vdc, f = 1 kHz	2N3783, 2N3784	20	—	200	—
			2N3785	15	—	200	
Current Gain - Bandwidth Product	f_T	I_C = 3 mAdc, V_{CE} = 10 Vdc, f = 200 MHz	2N3783	800	—	1600	MHz
			2N3784, 2N3785	700	—	1600	
Collector-Base Time Constant	$r'_b C_c$	V_{CB} = 10 Vdc, I_E = 3 mAdc, f = 31.8 MHz	2N3783, 2N3784	1	—	6	ps
			2N3785	1	—	10	
Collector-Base Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz	2N3783, 2N3784	—	—	1.0	pF
			2N3785	—	—	1.2	
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 200 MHz	2N3783, 2N3784	20	—	33	dB
			2N3785	18	—	33	
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 200 MHz	2N3783	—	—	2.2	dB
		R_G = 50 ohms	2N3784	—	—	2.5	
			2N3785	—	—	2.9	
Power Gain (AGC) Note 1	G_e(AGC)	V_{CE} = 10 Vdc, I_C = 15 mAdc, f = 200 MHz	2N3783	—	—	0	dB
			2N3784, 2N3785	—	0	—	
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 1000 MHz	2N3783	—	—	6.5	dB
		R_G = 50 ohms (Note 2)	2N3784	—	7.0	—	
			2N3785	—	7.5	—	

NOTE 1: AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = 10 Vdc and I_C = 3 mAdc.

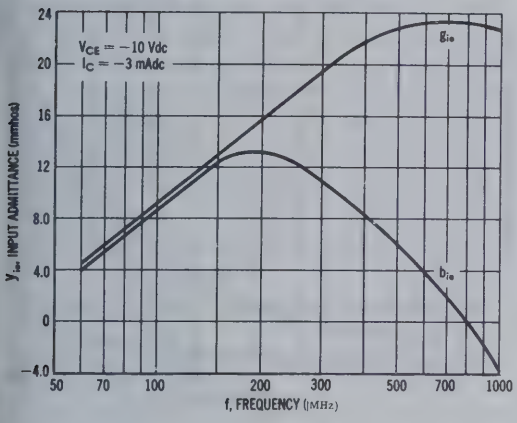
NOTE 2: This Noise Figure was obtained using Hewlett-Packard Type 342A Noise Figure Meter and Type 349A Noise Source.



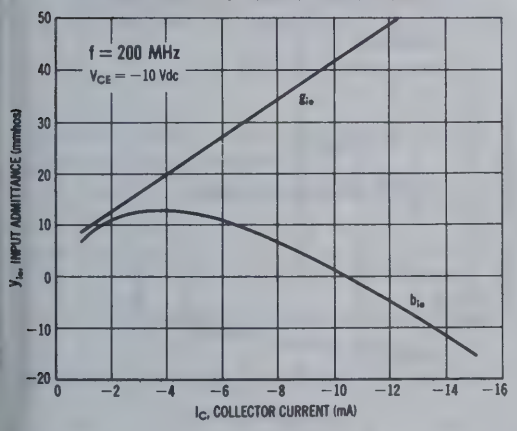
y_{ie}, INPUT ADMITTANCE CHARACTERISTICS

(T_A = 25° C unless otherwise noted)

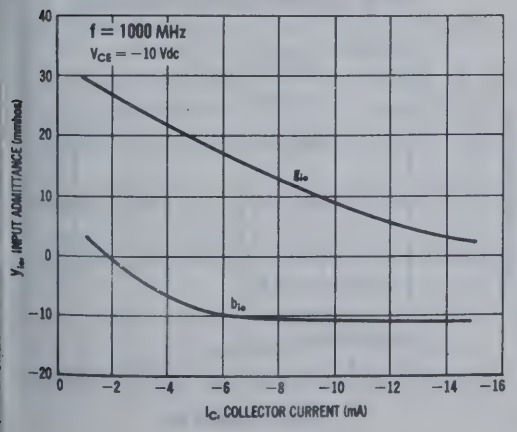
INPUT ADMITTANCE versus FREQUENCY



INPUT ADMITTANCE versus COLLECTOR CURRENT



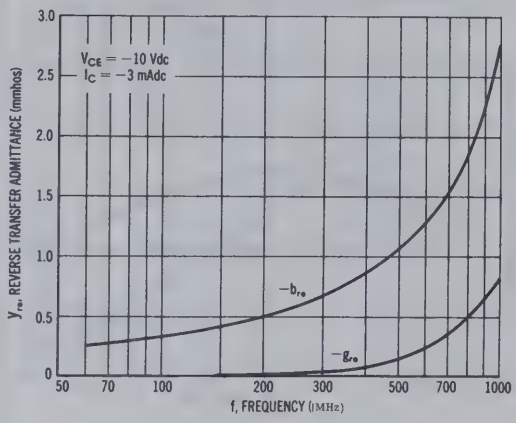
INPUT ADMITTANCE versus COLLECTOR CURRENT



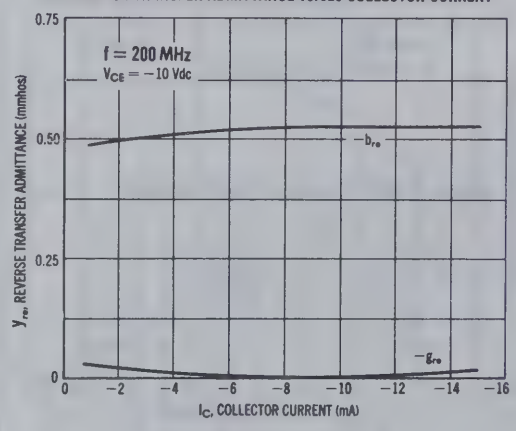
y_{re}, REVERSE TRANSFER ADMITTANCE CHARACTERISTICS

(T_A = 25° C unless otherwise noted)

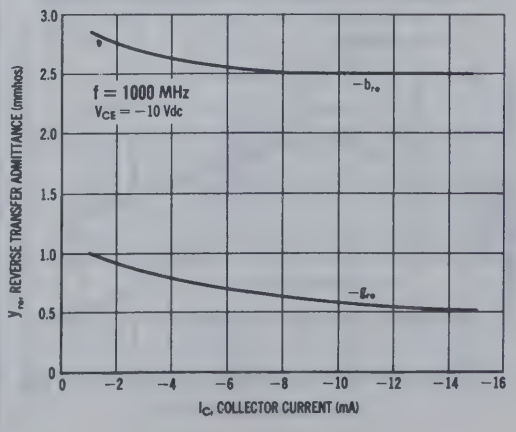
REVERSE TRANSFER ADMITTANCE versus FREQUENCY



REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT



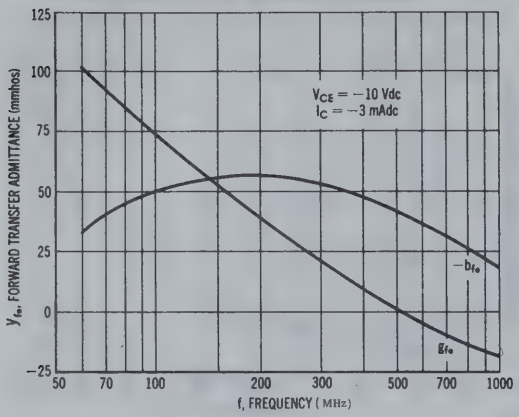
REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT



y_{fe}, FORWARD TRANSFER ADMITTANCE CHARACTERISTICS

(T_A = 25° C unless otherwise noted)

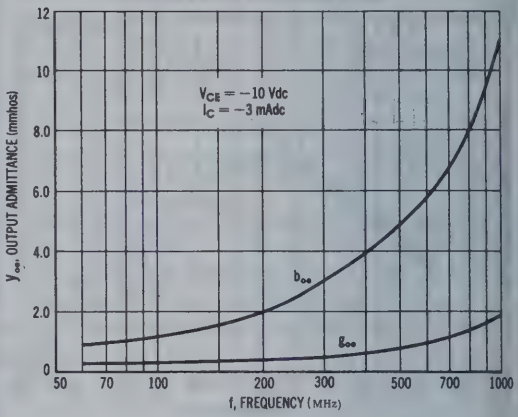
FORWARD TRANSFER ADMITTANCE versus FREQUENCY



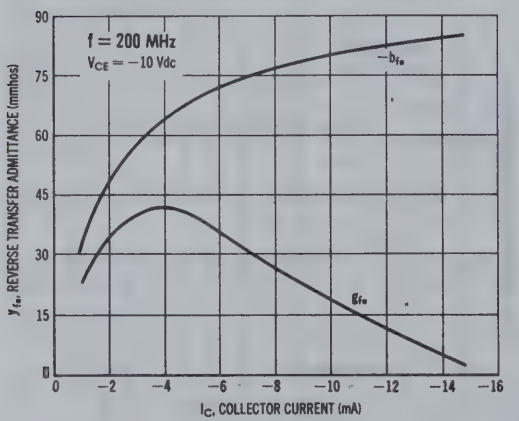
y_{oe}, OUTPUT ADMITTANCE CHARACTERISTICS

(T_A = 25° C unless otherwise noted)

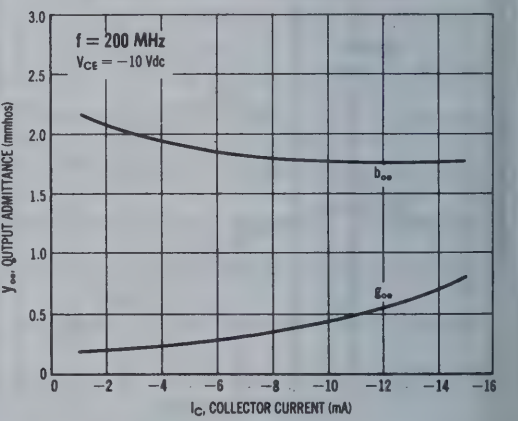
OUTPUT ADMITTANCE versus FREQUENCY



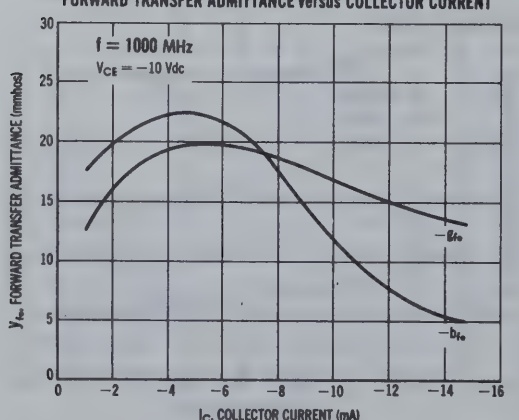
FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT



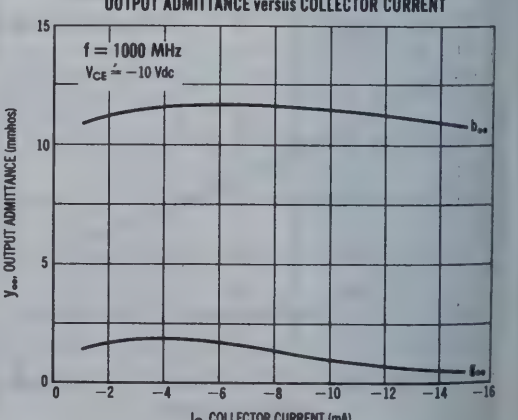
OUTPUT ADMITTANCE versus COLLECTOR CURRENT



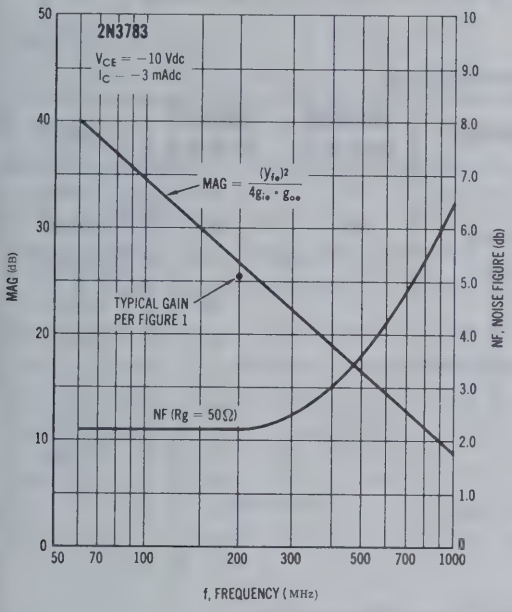
FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT



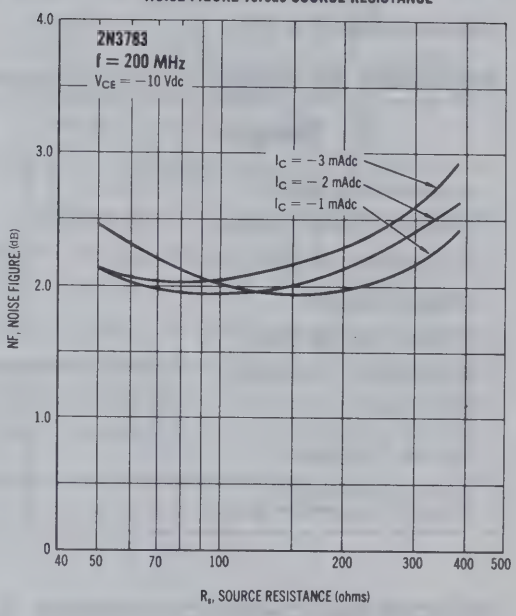
OUTPUT ADMITTANCE versus COLLECTOR CURRENT



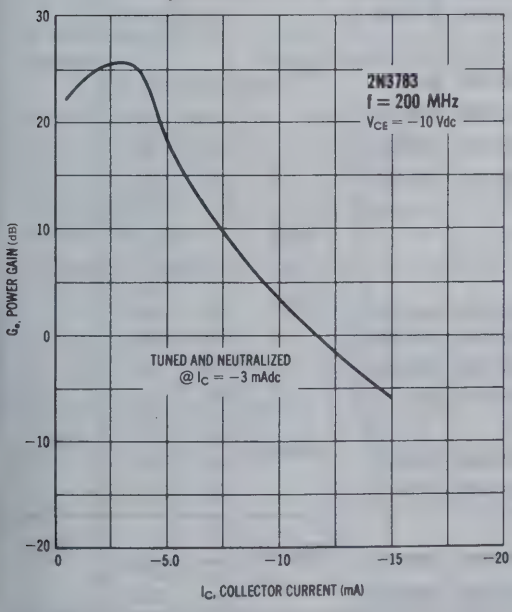
MAG & MAXIMUM NF versus FREQUENCY



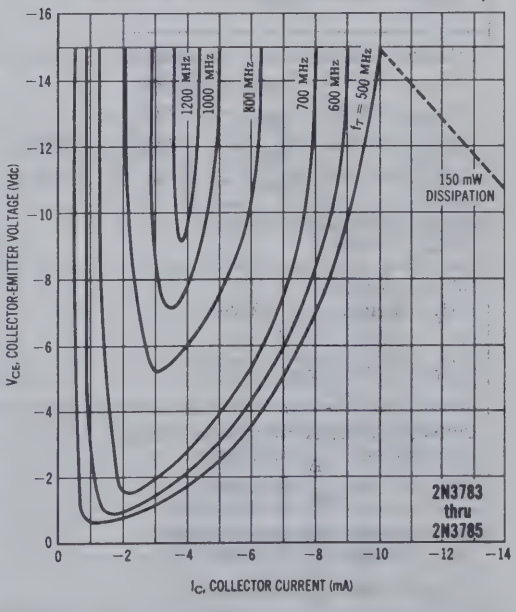
NOISE FIGURE versus SOURCE RESISTANCE



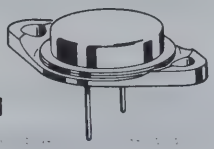
GAIN versus COLLECTOR CURRENT



CONTOURS OF CURRENT-GAIN — BANDWIDTH PRODUCT — f_T



2N3789 thru 2N3792 (SILICON)



CASE 11
(TO-3)

Collector connected to case

PNP silicon power transistors for medium-speed switching and amplifier applications. Complement to NPN type 2N3713 thru 2N3716.

MAXIMUM RATINGS (Tc = 25°C unless otherwise noted)

Rating	Symbol	2N3789 2N3791	2N3790 2N3792	Unit
Collector-Base Voltage	V_{CB}	60	80	Volts
Collector-Emitter Voltage	V_{CEO}	60	80	Volts
Emitter-Base Voltage	V_{EB}	7	7	Volts
Collector Current	I_C	10	10	Amp
Collector Current (Peak)	I_C	10	10	Amp
Base Current (Continuous)	I_B	4.0	4.0	Amp
Power Dissipation	P_D	150	150	Watts
Thermal Resistance	θ_{JC}	1.17	1.17	°C/W
Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +200		°C

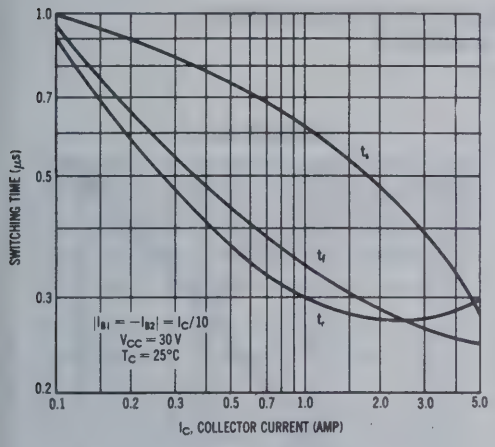
ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

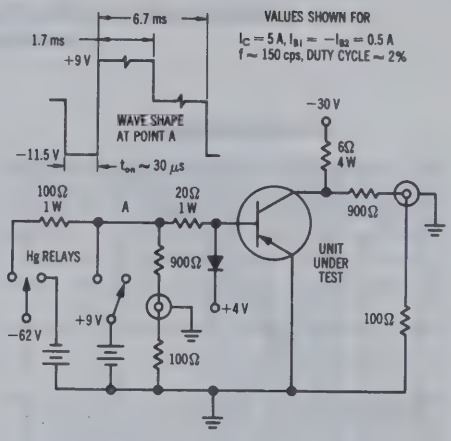
Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)	2N3789, 2N3791	$V_{CEO(sus)}$*	60	—	Vdc
	2N3790, 2N3792		80	—	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc)	2N3789, 2N3791		—	1	
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc)	2N3790, 2N3792		—	1	
(V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3789, 2N3791		—	5	
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3790, 2N3792		—	5	
Emitter-Base Cutoff Current (V_{EB} = 7 Vdc)		I_{EBO}	—	5	mAdc
DC Current Gain*		h_{FE}*			—
(I_C = 1 Adc, V_{CE} = 2 Vdc)	2N3789, 2N3790		25	90	
	2N3791, 2N3792		50	150	
(I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3789, 2N3790		15	—	
	2N3791, 2N3792		30	—	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 4 Adc, I_B = 0.4 Adc)	2N3789, 2N3790		—	1.0	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3791, 2N3792		—	1.0	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 4 Adc, I_B = 0.4 Adc)	2N3789, 2N3790		—	2.0	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3791, 2N3792		—	1.5	
Current Gain — Bandwidth Product (V_{CE} = 10 Vdc, I_C = 0.5 Adc f = 1.0 MHz)		f_T	4	—	MHz

*Sweep Test: 1/2 sine wave cycle @ 60 Hz .

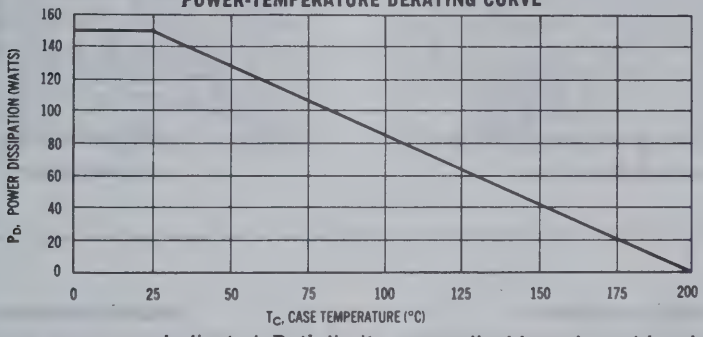
2N3789 thru 2N3792 (continued)

TYPICAL SWITCHING TIMES AND TEST CIRCUIT





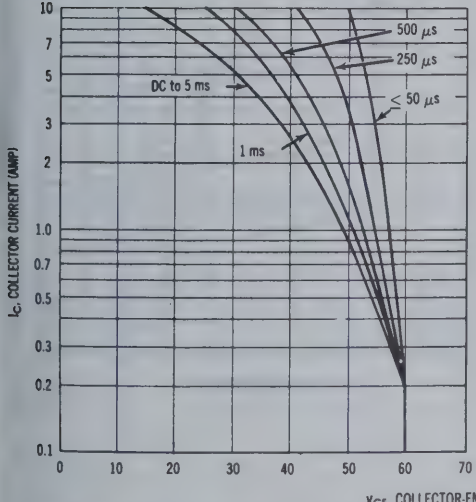
POWER-TEMPERATURE DERATING CURVE



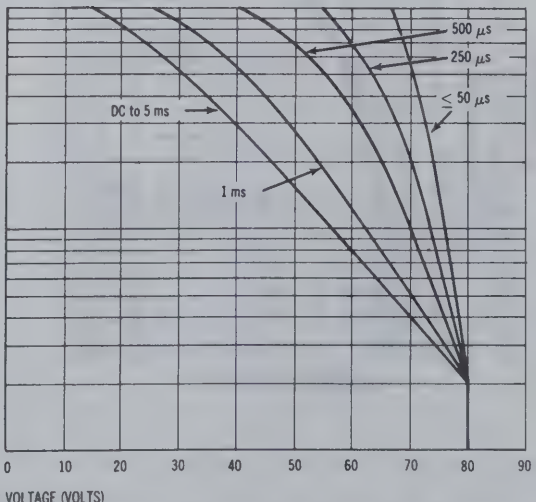
Safe area curves are indicated. Both limits are applicable and must be observed.

ACTIVE-REGION SAFE OPERATING AREAS

2N3789, 2N3791



2N3790, 2N3792



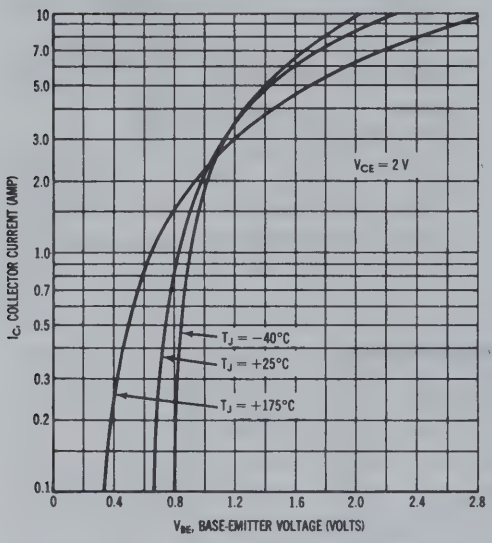
V_{CE}, COLLECTOR-EMITTER VOLTAGE (VOLTS)

The Safe Operating Area Curves indicate I_C - V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursion make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

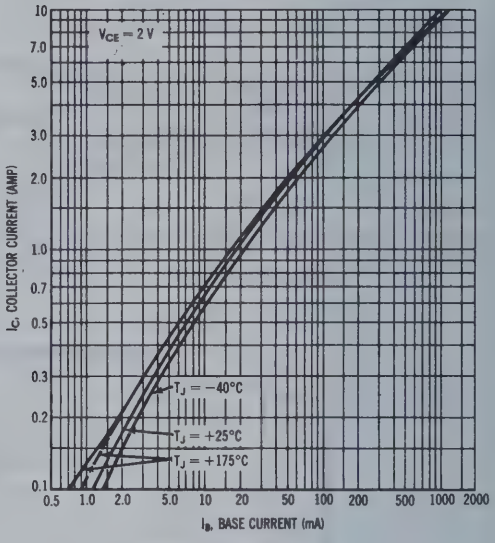
LARGE SIGNAL CHARACTERISTICS – TYPE 2N3789, 2N3790

(PULSE TEST: pulse width ≈ 200 μs, duty cycle ≈ 1%)

TRANSCONDUCTANCE

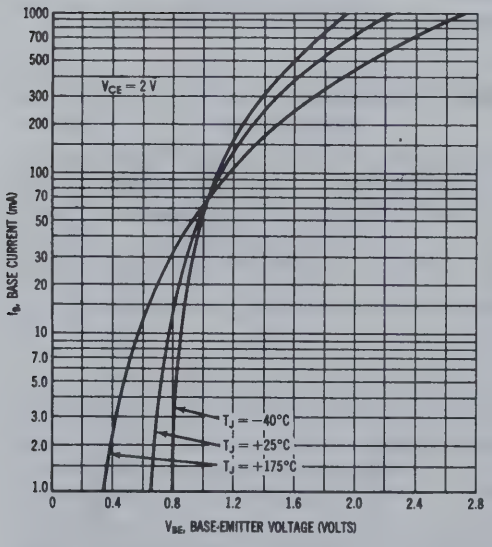


CURRENT GAIN *

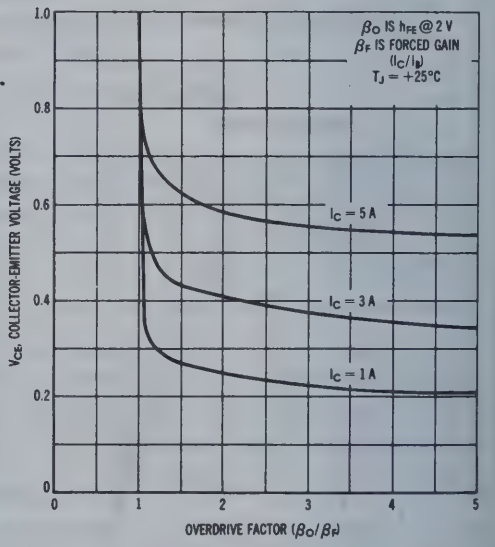


*Dashed line indicates metered base current minus I_{CBO} of the transistor at 175°C.

INPUT ADMITTANCE



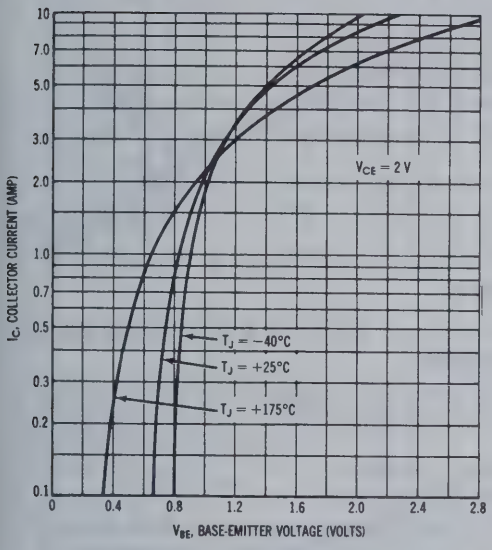
SATURATION REGION



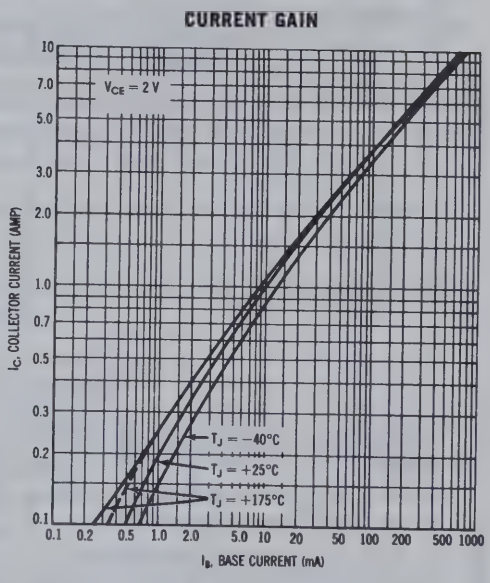
LARGE SIGNAL CHARACTERISTICS – TYPE 2N3791, 2N3792

(PULSE TEST: pulse width ~ 200 μsec, duty cycle ~ 1%)

TRANSCONDUCTANCE

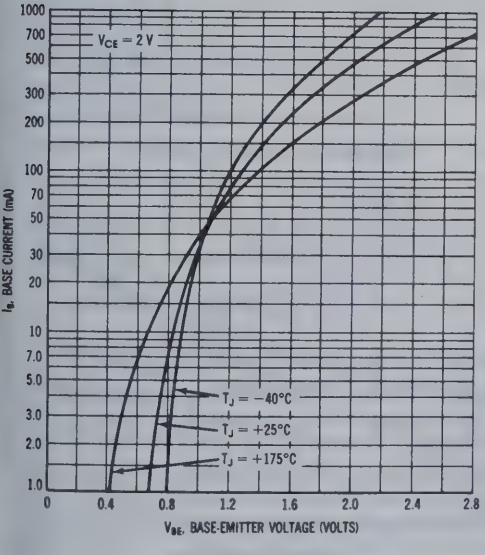


CURRENT GAIN

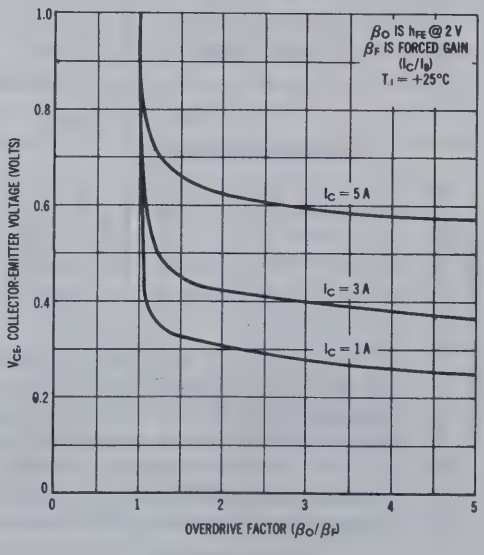


Dashed line indicates metered base current minus I_{CBO} of the transistor at 175°C.

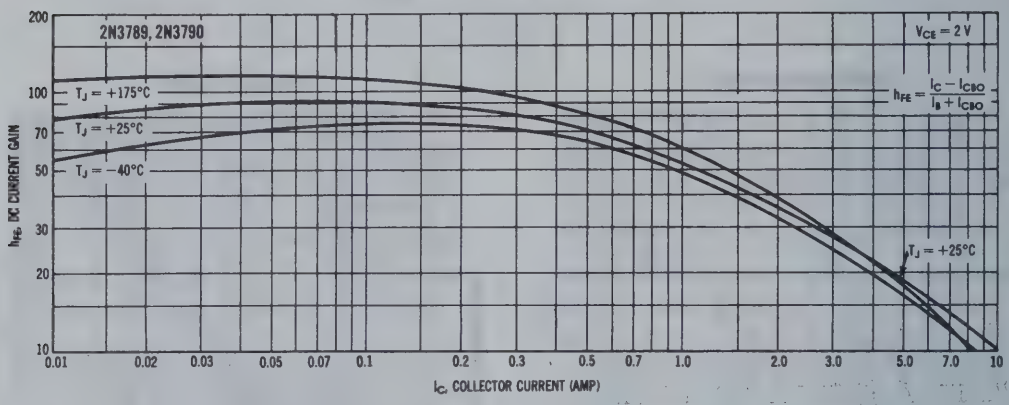
INPUT ADMITTANCE



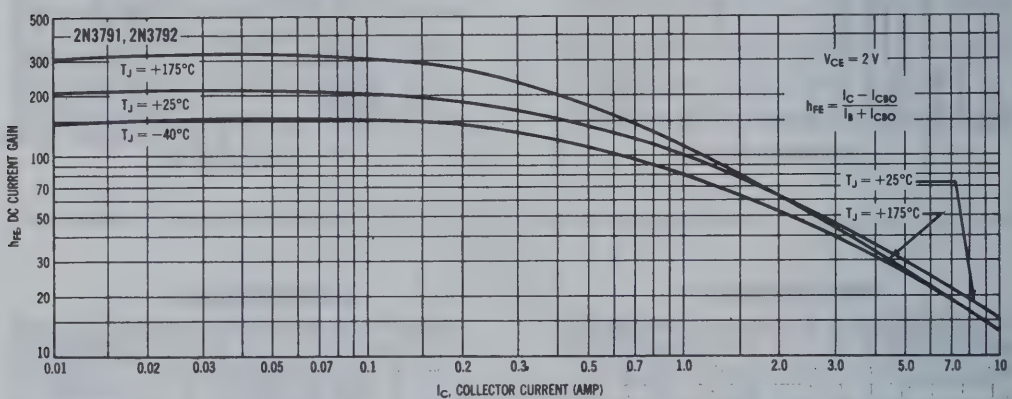
SATURATION REGION



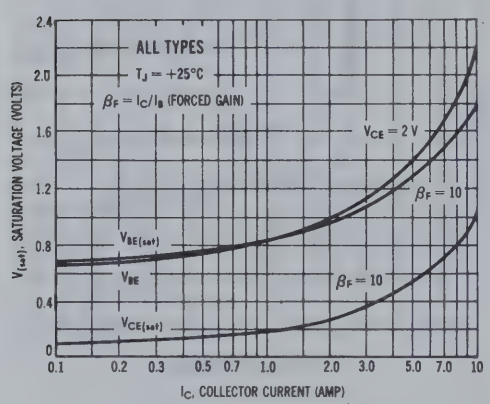
CURRENT GAIN VARIATIONS



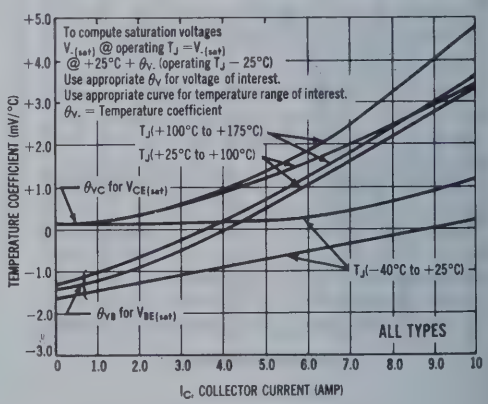
CURRENT GAIN VARIATIONS



SATURATION VOLTAGES



TEMPERATURE COEFFICIENTS



2N3796 (SILICON)
2N3797



CASE 22 (2)
(TO-18)

Silicon N-channel MOS field-effect transistor designed for low-power applications in the audio frequency range.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage 2N3796 2N3797	V_{DS}	 25 20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	20	mAdc
Power Dissipation at $T_A = 25^oC$ Derate above 25^oC	P_D	300 1.7	mW mW/^oC
Operating Junction Temperature	T_J	+200	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Drain-Source Breakdown Voltage		BV_{DSX}				Vdc
(V_{GS} = -4.0 V, I_D = 5.0 μA)	2N3796		25	30	—	
(V_{GS} = -7.0 V, I_D = 5.0 μA)	2N3797		20	25	—	
Zero-Gate-Voltage Drain Current		I_{DSS}				mAdc
(V_{DS} = 10 V, V_{GS} = 0)	2N3796		0.5	1.5	3.0	
	2N3797		2.0	2.9	6.0	
Gate-Source Voltage Cutoff		$V_{GS(off)}$				Vdc
(I_D = 0.5 μA, V_{DS} = 10 V)	2N3796		—	3.0	4.0	
(I_D = 2.0 μA, V_{DS} = 10 V)	2N3797		—	5.0	7.0	
"On" Drain Current		$I_{D(on)}$				mAdc
(V_{DS} = 10 V, V_{GS} = +3.5 V)	2N3796		7.0	8.3	14	
	2N3797		9.0	14	18	
Drain-Gate Reverse Current*		I_{DGO}*				pAdc
(V_{DG} = 10 V, I_S = 0)			—	—	1.0	
Gate-Reverse Current*		I_{GSS}*				pAdc
(V_{GS} = -10 V, V_{DS} = 0)			—	—	1.0	
(V_{GS} = -10 V, V_{DS} = 0, T_A = 150°C)			—	—	200	
Small-Signal, Common-Source Forward Transfer Admittance		$\lvert y_{fs} \rvert$				μmhos
(V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz)	2N3796		900	1200	1800	
	2N3797		1500	2300	3000	
(V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)	2N3796		900	—	—	
	2N3797		1500	—	—	
Small-Signal, Common-Source, Output Admittance		$\lvert y_{os} \rvert$				μmhos
(V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz)	2N3796		—	12	25	
	2N3797		—	27	60	
Small-Signal, Common-Source, Input Capacitance		C_{iss}				pF
(V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)	2N3796		—	5.0	7.0	
	2N3797		—	6.0	8.0	
Small-Signal, Common-Source, Reverse Transfer Capacitance		C_{rss}				pF
(V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)			—	0.5	0.8	
Noise Figure		NF				dB
(V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz, R_S = 3 megohms)			—	3.8	—	

* This value of current includes both the FET leakage current as well as the leakage current associated with the test socket and fixture when measured under best attainable conditions.

TYPICAL DRAIN CHARACTERISTICS

FIGURE 1 — 2N3796

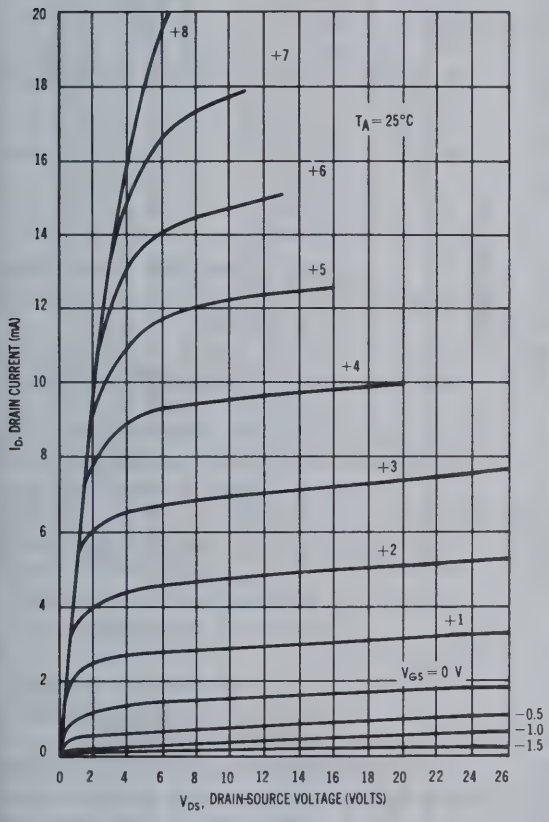
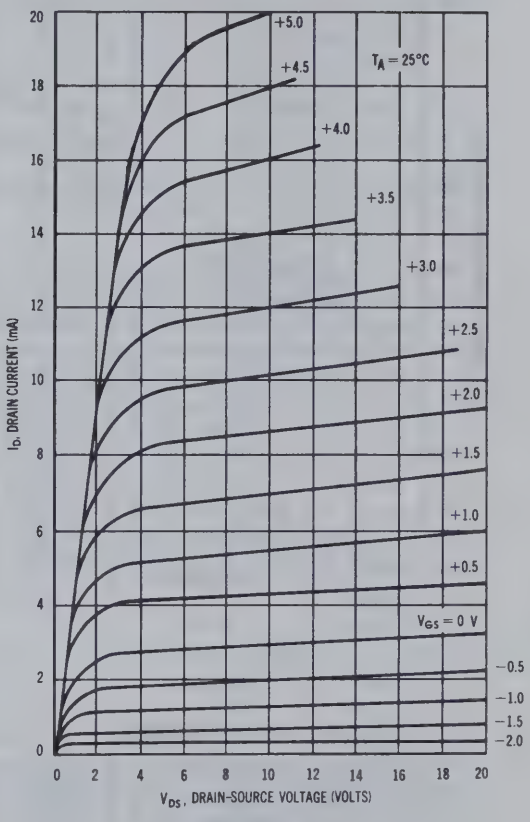


FIGURE 2 — 2N3797



COMMON SOURCE TRANSFER CHARACTERISTICS

FIGURE 3 — 2N3796

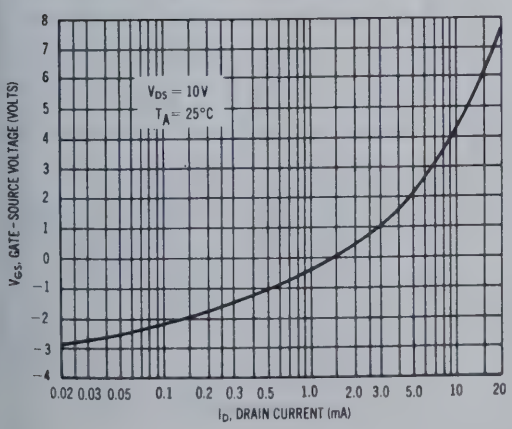


FIGURE 4 — 2N3797

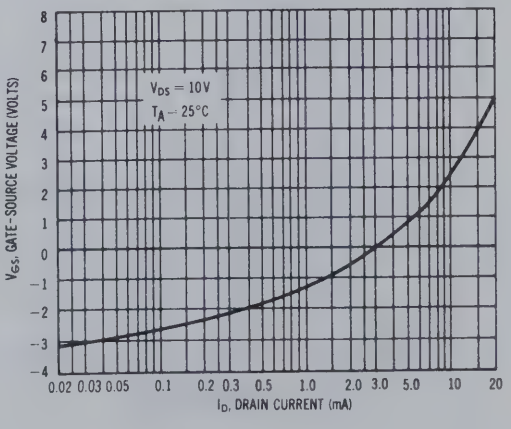


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

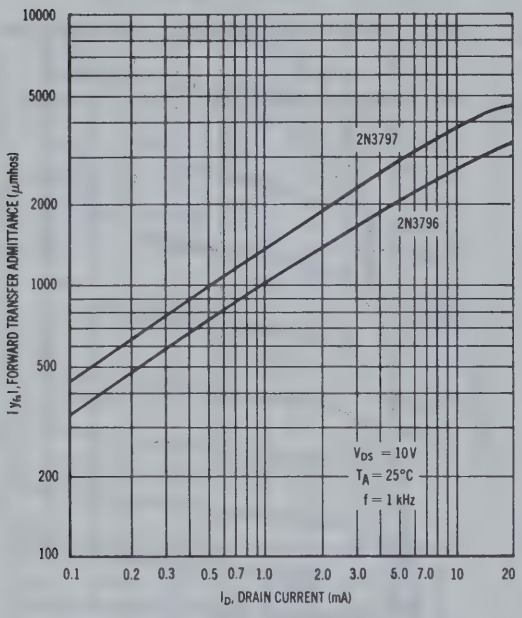


FIGURE 6 — AMPLIFICATION FACTOR

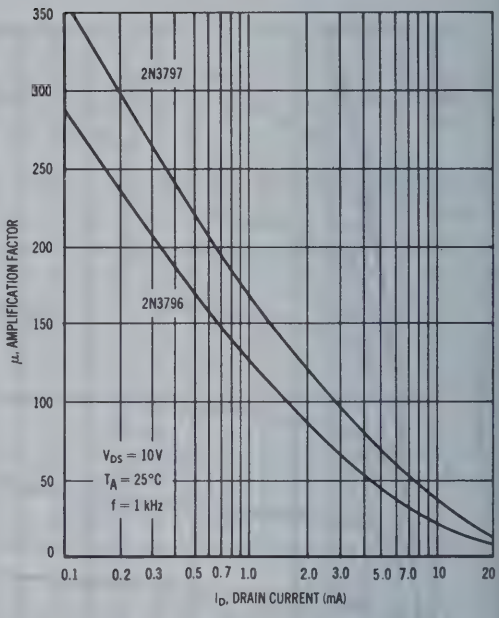


FIGURE 7 — OUTPUT ADMITTANCE

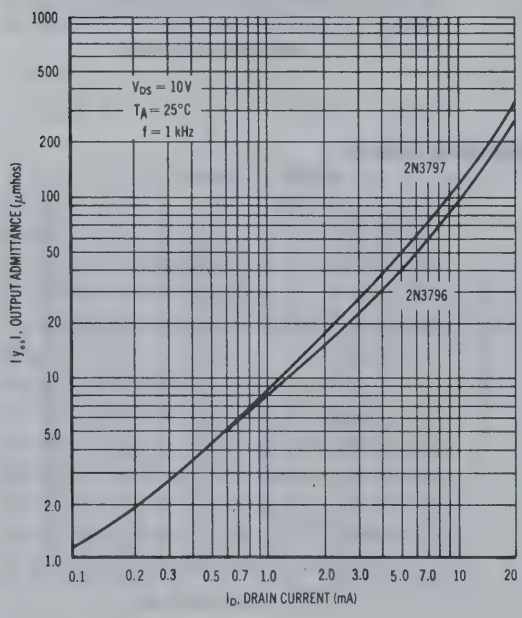
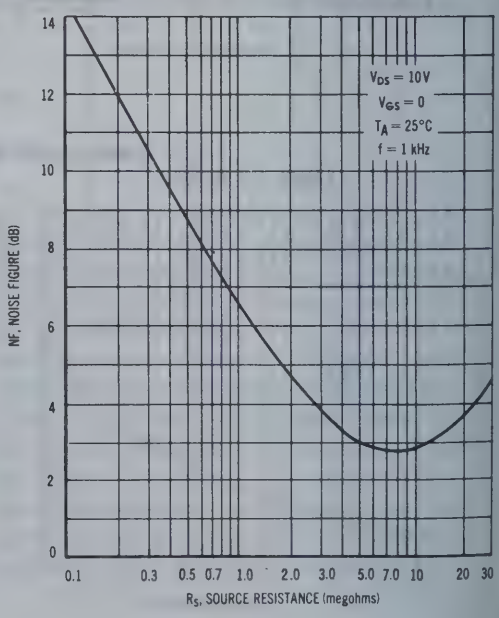


FIGURE 8 — NOISE FIGURE



2N3798 (SILICON)
2N3799



CASE 22
(TO-18)

PNP silicon annular transistors for low-level, low-noise amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	1.2 6.9	Watts mW/°C
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	0.36 2.06	Watt mW/°C
Junction Operating Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

2N3798, 2N3799 (continued)

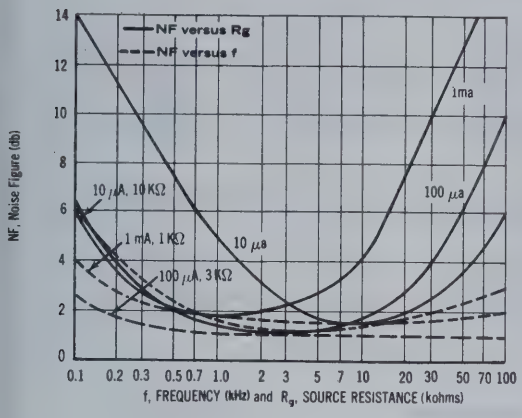
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	60	90	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	.010	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)					10	
Emitter Cutoff Current (V_{OB} = 4 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
Collector-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{CE(sat)}$*	—	—	0.2	Vdc
(I_C = 1 mAdc, I_B = 100 μAdc)			—	—	0.25	
Base-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{BE(sat)}$*	—	—	0.7	Vdc
(I_C = 1 mAdc, I_B = 100 μAdc)			—	—	0.8	
DC Forward Current Transfer Ratio* (I_C = 1 μAdc, V_{CE} = 5 Vdc)	2N3799	h_{FE}*	75	—	—	—
(I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N3798		100	—	—	
	2N3799		225	—	—	
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N3798		150	—	450	
	2N3799		300	—	900	
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	2N3798		75	—	—	
	2N3799		150	—	—	
(I_C = 500 μAdc, V_{CE} = 5 Vdc)	2N3798		150	—	450	
	2N3799		300	—	900	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N3798		150	—	450	
	2N3799		300	—	900	
(I_C = 10 mAdc, V_{CE} = 5 Vdc)	2N3798		125	—	—	
	2N3799		250	—	—	
Base Emitter "ON" Voltage (I_C = 100 μAdc, V_{CE} = 5 V)		$V_{BE(ON)}$	—	—	0.7	Vdc
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	—	4	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	—	8	pF
Small Signal Current Gain (I_C = 500 μA, V_{CE} = 5 V, f = 30 MHz)		h_{fe}	1.0	—	—	—
(I_C = 1 mA, V_{CE} = 5 V, f = 100 MHz)			1.0	—	5.0	
(I_C = 1 mA, V_{CE} = 10 V, f = 1 kHz)	2N3798		150	—	600	
	2N3799		300	—	900	
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)		h_{re}	—	—	25	$X10^{-4}$
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3798	h_{ie}	3	—	15	k ohms
	2N3799		10	—	40	
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)		h_{oe}	5	—	60	μmhos
Noise Figure (I_C = 100 μA, V_{CE} = 10 V, R_G = 3 kΩ)		NF				dB
f = 100 Hz	2N3798		—	4	7	
	2N3799		—	2.5	4	
f = 1 kHz	2N3798		—	1.5	3	
	2N3799		—	0.8	1.5	
f = 10 kHz	2N3798		—	1.0	2.5	
	2N3799		—	0.8	1.5	
Noise Bandwidth 10 Hz to 15.7 kHz	2N3798		—	2.5	3.5	
	2N3799		—	1.5	2.5	

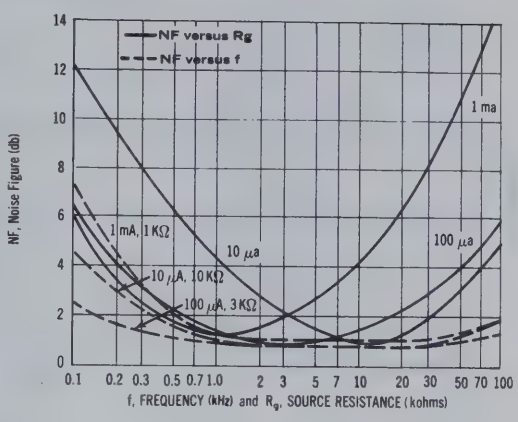
* Pulse Test ≤ 300 μs, duty cycle ≤ 2% V_{OB} - Base-Emitter Reverse Bias

NOISE FIGURE versus FREQUENCY AND SOURCE RESISTANCE

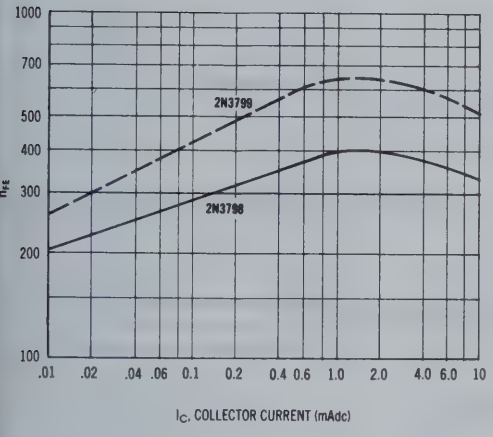
2N3798



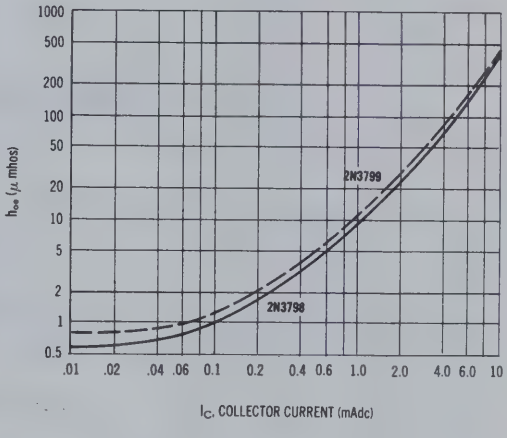
2N3799



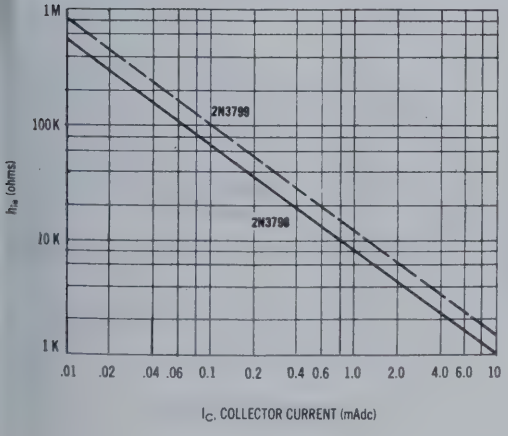
CURRENT GAIN



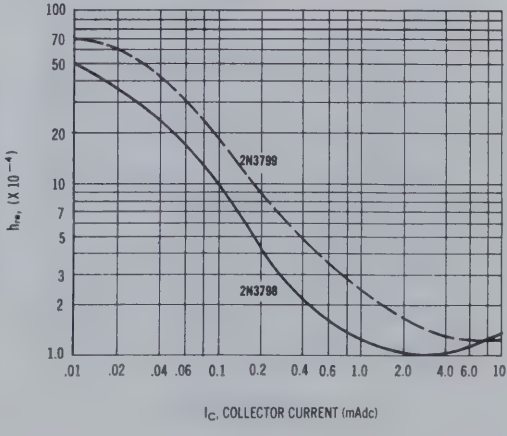
OUTPUT ADMITTANCE



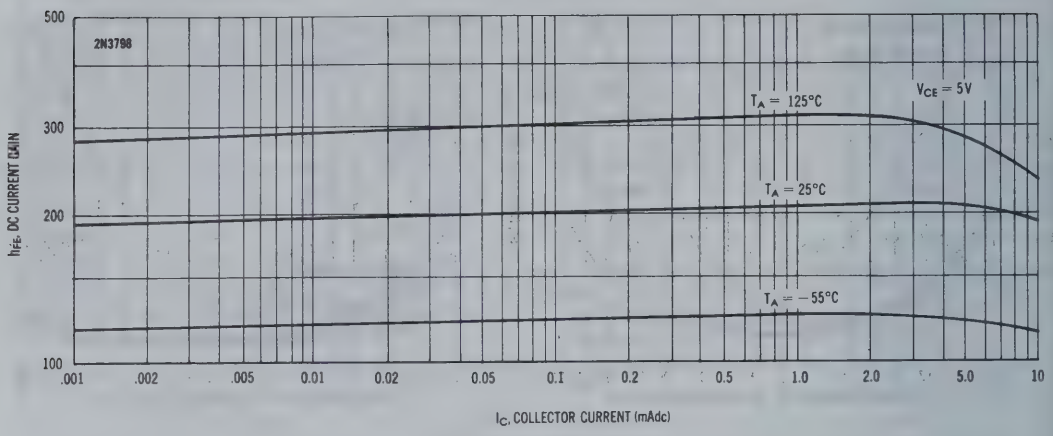
INPUT IMPEDANCE

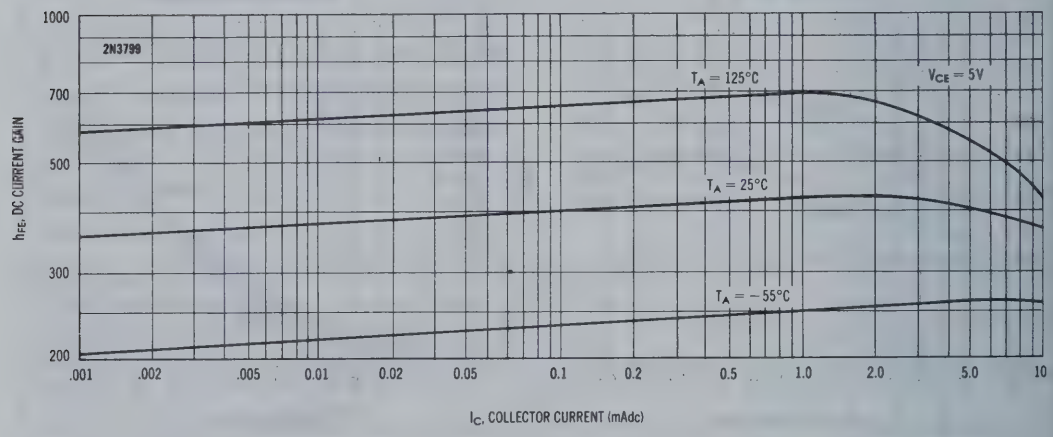


VOLTAGE FEEDBACK RATIO

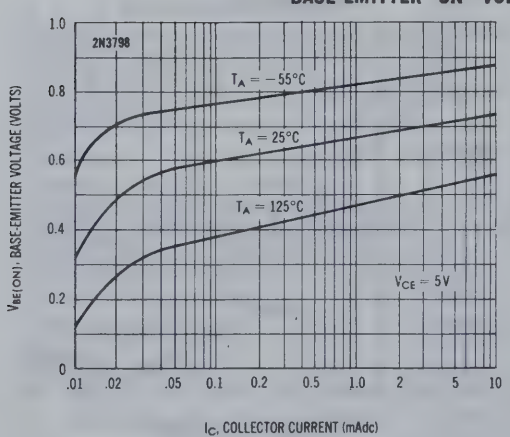


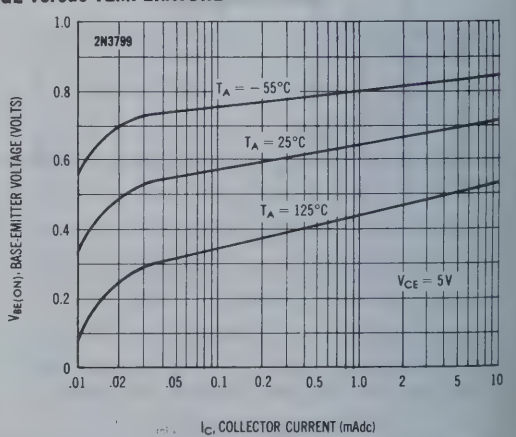
CURRENT GAIN CHARACTERISTICS





BASE-EMITTER "ON" VOLTAGE versus TEMPERATURE





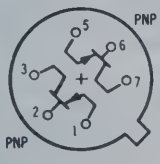
2N3800 thru 2N3817 (SILICON)

Dual PNP silicon annular transistors specifically designed for differential amplifier applications.



CASE 35
(TO-71)

2N3800 thru 2N3805

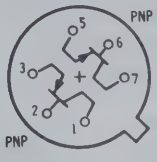


PINS 4 AND 8 OMITTED

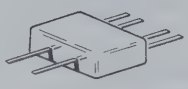


CASE 32C

2N3806 thru 2N3811

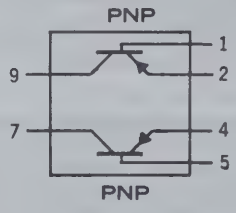


PINS 4 AND 8 OMITTED



CASE 33
(TO-89)

2N3812 thru 2N3817



Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can (2N3800 thru 2N3811)		250	360	mW
Derate above 25°C		1.5	2.06	mW/°C
Flat Package (2N3812 thru 2N3817)		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C

2N3800 thru 2N3817 (continued)

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)
Characteristics apply also to corresponding flat package type numbers

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	60		—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	0.01	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			—	—	10	
Emitter Cutoff Current ($V_{BE(off)}$ = 4.0 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)	2N3801, 3, 5, 7, 9, 11, 13, 15, 17	h_{FE}*	75	—	—	—
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16		100	—	—	
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		225	—	—	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16		150	—	450	
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		300	—	900	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16		75	—	—	
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		150	—	—	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16		150	—	450	
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		300	—	900	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16		150	—	450	
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		300	—	900	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16		125	—	—	
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		250	—	—	
Collector-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{CE(sat)}$*	—	—	0.2	Vdc
(I_C = 1.0 mAdc, I_B = 100 μAdc)			—	—	0.25	
Base-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{BE(sat)}$*	—	—	0.7	Vdc
(I_C = 1.0 mAdc, I_B = 100 μAdc)			—	—	0.8	
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	—	—	0.7	Vdc
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)		f_T	30	—	—	MHz
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)			100	—	500	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	—	4.0	pF
Input Capacitance ($V_{BE(off)}$ = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	—	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16	h_{ie}	3.0	—	15	k ohms
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		10	—	40	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	—	—	25	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16	h_{fe}	150	—	600	—
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		300	—	900	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	5.0	—	60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms,		NF				dB
f = 100 Hz)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16		—	4.0	7.0	
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		—	2.5	4.0	
f = 1.0 kHz)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16		—	1.5	3.0	
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		—	0.8	1.5	
f = 10 kHz)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16		—	1.0	2.5	
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		—	0.8	1.5	
Noise Bandwidth = 10 Hz to 15.7 kHz)	2N3800, 2, 4, 6, 8, 10, 12, 14, 16		—	2.5	3.5	
	2N3801, 3, 5, 7, 9, 11, 13, 15, 17		—	1.5	2.5	
MATCHING CHARACTERISTICS						
DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3802, 3, 8, 9, 14, 15	h_{FE1}/h_{FE2}**	0.8	—	1.0	—
	2N3804, 5, 10, 11, 16, 17		0.9	—	1.0	
Base Voltage Differential (I_C = 10 μAdc, to 10 mAdc, V_{CE} = 5.0 Vdc)	2N3802, 3, 8, 9, 14, 15	$\lvert V_{BE1}-V_{BE2}\rvert$	—	—	8.0	mVdc
	2N3804, 5, 10, 11, 16, 17		—	—	5.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3802, 3, 8, 9, 14, 15		—	—	5.0	
	2N3804, 5, 10, 11, 16, 17		—	—	3.0	
Base Voltage Differential Gradient (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +25°C)		$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$				μV/°C
	2N3802, 3, 8, 9, 14, 15		—	—	20	
	2N3804, 5, 10, 11, 16, 17		—	—	10	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)						
	2N3802, 3, 8, 9, 14, 15		—	—	20	
	2N3804, 5, 10, 11, 16, 17		—	—	10	

*Pulse Test: Pulse width ≤300 μs, duty cycle ≤2% **The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

FIGURE 1 — FREQUENCY EFFECTS

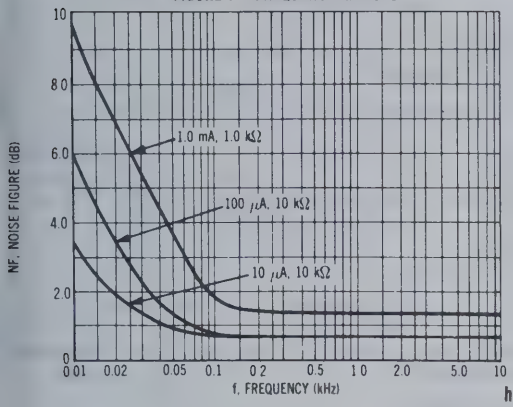
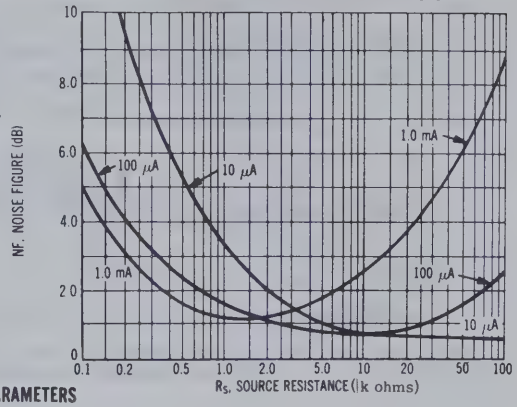


FIGURE 2 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1 kHz, T_A = 25°C

FIGURE 3 — INPUT IMPEDANCE

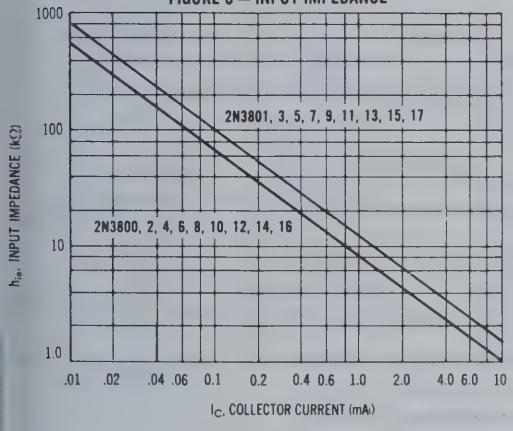


FIGURE 4 — VOLTAGE FEEDBACK RATIO

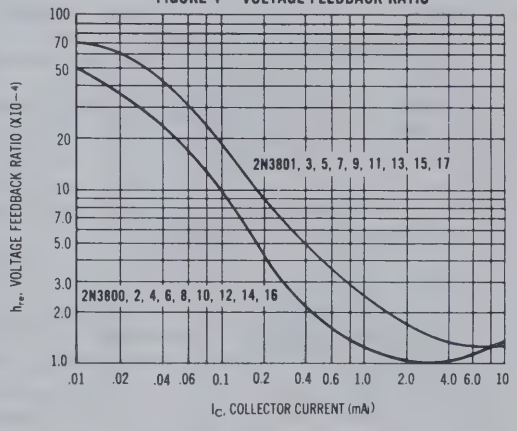


FIGURE 5 — CURRENT GAIN

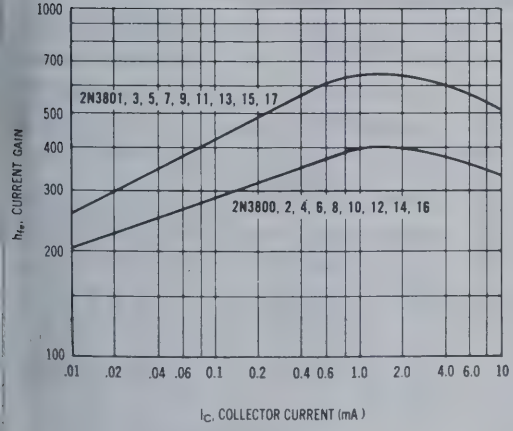


FIGURE 6 — OUTPUT ADMITTANCE

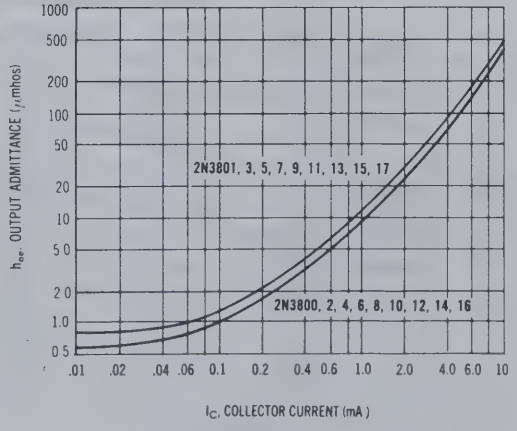
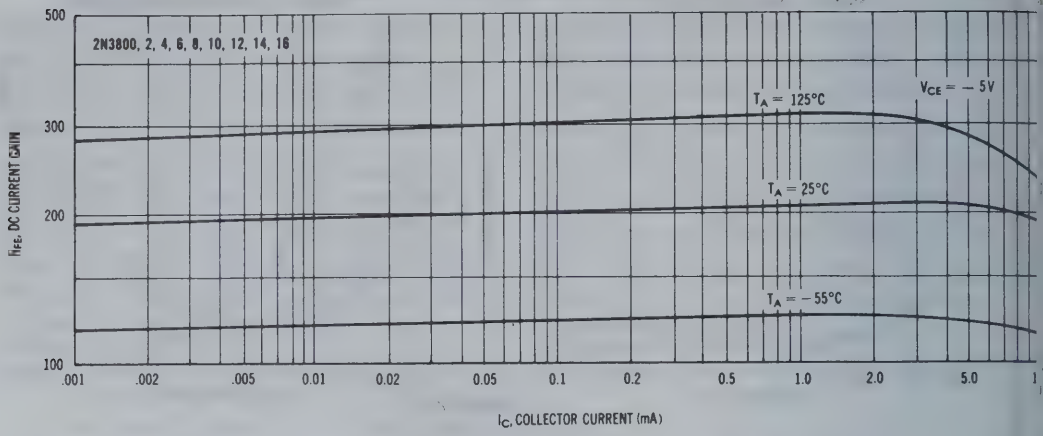


FIGURE 7 — TYPICAL CURRENT-GAIN CHARACTERISTICS



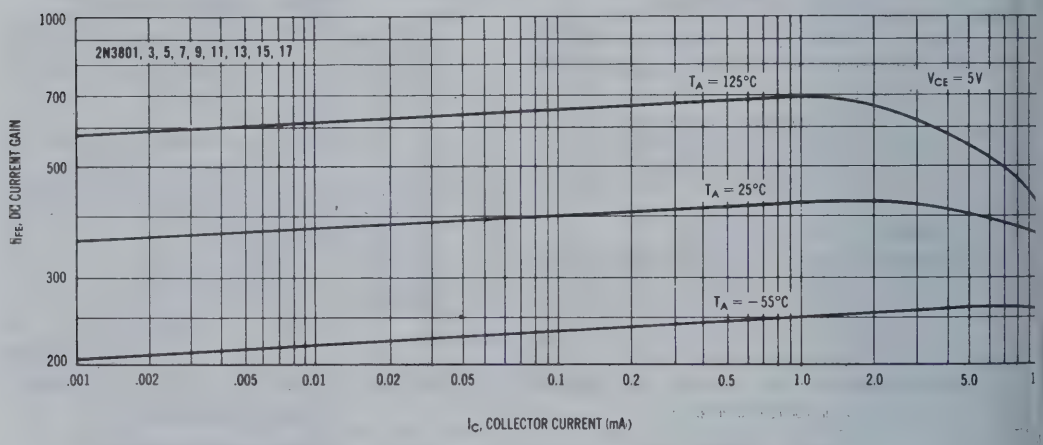
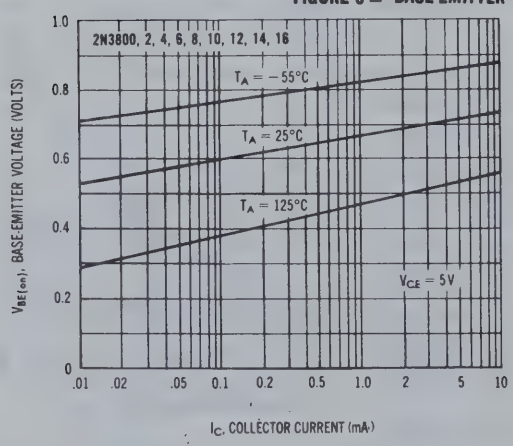
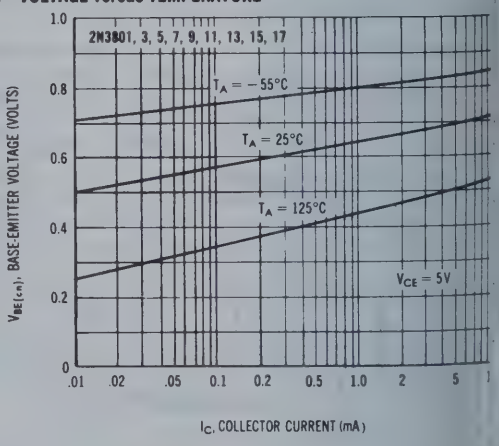


FIGURE 8 — BASE-EMITTER "ON" VOLTAGE versus TEMPERATURE





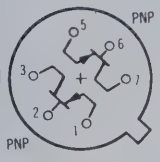
2N3804A, 2N3805A (SILICON)
2N3810A, 2N3811A
2N3816A, 2N3817A

Dual PNP silicon annular transistors specifically designed for differential amplifier applications.

2N3804A
2N3805A



CASE 35
(TO-71)

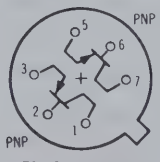


Pin Connections
Bottom View

2N3810A
2N3811A



CASE 32C



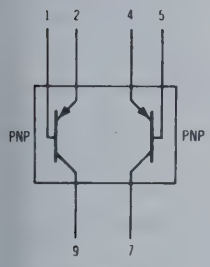
Pin Connections
Bottom View

2N3816A
and 2N3817A



All leads electrically isolated from case

CASE 33A
(TO-89)



Pin Connections
Bottom View

Lead 1 identified by square impression or dot on underside of case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can (2N3804A and 2N3805A)		250	360	mW
Derate above 25°C		1.5	2.06	mW/°C
Metal Can (2N3810A and 2N3811A)		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
Flat Package (2N3816A and 2N3817A)		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristics apply also to corresponding flat package type numbers

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	60		—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	—	—	0.01	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		—	—	10	
Emitter Cutoff Current ($V_{BE(off)}$ = 4.0 Vdc, I_C = 0)	I_{EBO}	—	—	20	nAdc

(continued)

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristics apply also to corresponding flat package type numbers

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain *						—
(I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)	2N3805A, 11A, 17A	h_{FE}*	75	---	---	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N3804A, 10A, 16A		100	—	—	
	2N3805A, 11A, 17A		225	—	—	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3804A, 10A, 16A		150	—	450	
	2N3805A, 11A, 17A		300	—	900	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	2N3804A, 10A, 16A		75	—	---	
	2N3805A, 11A, 17A		150	—	—	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	2N3804A, 10A, 16A		150	—	450	
	2N3805A, 11A, 17A		300	—	900	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N3804A, 10A, 16A		150	—	450	
	2N3805A, 11A, 17A		300	—	900	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N3804A, 10A, 16A		125	---	---	
	2N3805A, 11A, 17A		250	---	---	
Collector-Emitter Saturation Voltage *		$V_{CE(sat)}$*				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)			—	—	0.2	
(I_C = 1.0 mAdc, I_B = 100 μAdc)			—	—	0.25	
Base-Emitter Saturation Voltage *		$V_{BE(sat)}$*				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)			—	—	0.7	
(I_C = 1.0 mAdc, I_B = 100 μAdc)			—	—	0.8	
Base-Emitter On Voltage		$V_{BE(on)}$				Vdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			—	—	0.7	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)			30	—	—	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)			100	—	500	
Output Capacitance		C_{ob}				pF
(V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)			—	—	4.0	
Input Capacitance		C_{ib}				pF
($V_{BE(off)}$ = 0.5 Vdc, I_C = 0, f = 100 kHz)			—	—	8.0	
Input Impedance		h_{ie}				kΩ
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3804A, 10A, 16A		3.0	—	15	
	2N3805A, 11A, 17A		10	—	40	
Voltage Feedback Ratio		h_{re}				X 10^{-4}
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			—	—	25	
Small-Signal Current Gain		h_{fe}				—
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3804A, 10A, 16A		150	—	600	
	2N3805A, 11A, 17A		300	—	900	
Output Admittance		h_{oe}				μmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			5.0	—	60	
Noise Figure		NF				dB
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 100 Hz)	2N2804A, 10A, 16A		—	4.0	7.0	
	2N3805A, 11A, 17A		—	2.5	4.0	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz)	2N3804A, 10A, 16A		—	1.5	3.0	
	2N3805A, 11A, 17A		—	0.8	1.5	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 10 kHz)	2N3804A, 10A, 16A		—	1.0	2.5	
	2N3805A, 11A, 17A		—	0.8	1.5	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, Noise Bandwidth = 10 Hz to 15.7 kHz)	2N3804A, 10A, 16A		—	2.5	3.5	
	2N3805A, 11A, 17A		—	1.5	2.5	
MATCHING CHARACTERISTICS						
DC Current Gain Ratio**		h_{FE1}/h_{FE2}**				—
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			0.95	---	1.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +125°C)			0.85	---	1.0	
Base Voltage Differential		$\lvert V_{BE1}-V_{BE2}\rvert$				mVdc
(I_C = 10 μAdc to 10 mAdc, V_{CE} = 5.0 Vdc)			—	---	5.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)			—	---	1.5	
Base Voltage Differential Gradient		$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$				μV/°C
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +25°C)			—	---	5.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25°C to +125°C)			---	---	5.0	

*Pulse Test: Pulse width ≤300 μs, duty cycle ≤2% **The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

FIGURE 1 — FREQUENCY EFFECTS

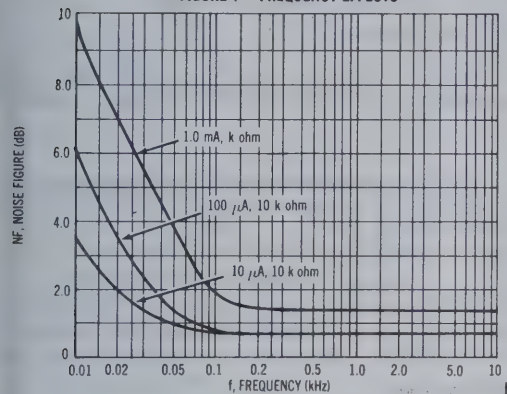
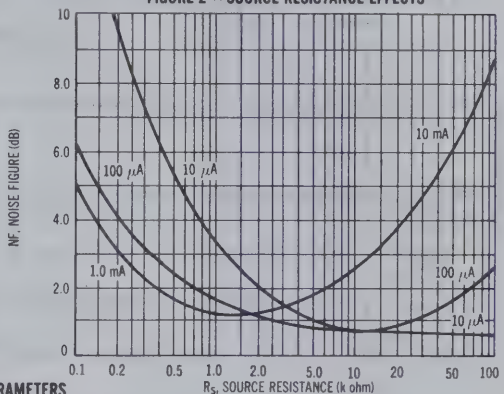


FIGURE 2 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

FIGURE 3 — INPUT IMPEDANCE

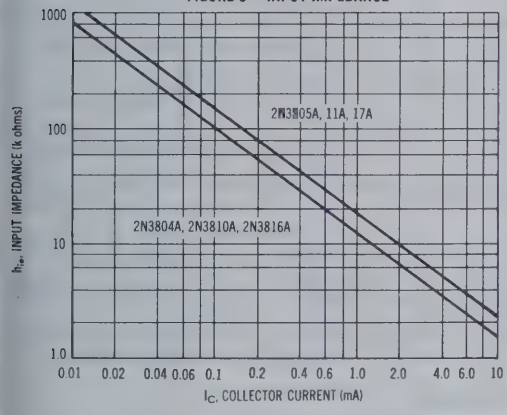


FIGURE 4 — VOLTAGE FEEDBACK RATIO

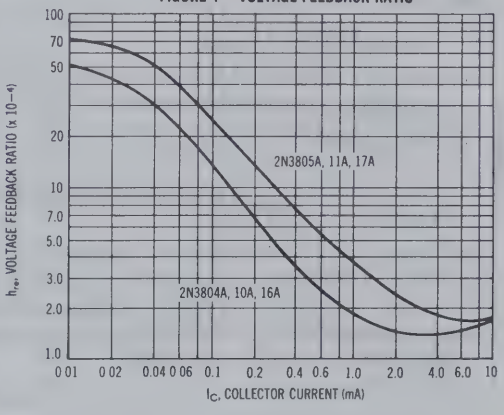


FIGURE 5 — CURRENT GAIN

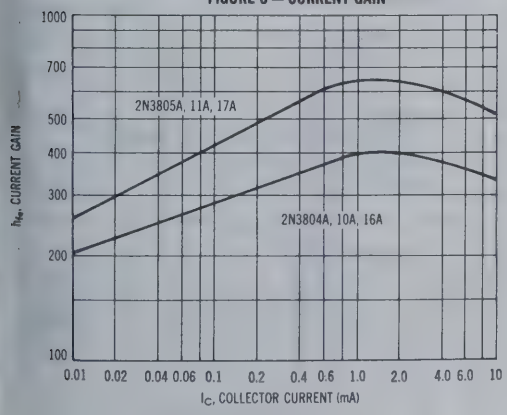


FIGURE 6 — OUTPUT ADMITTANCE

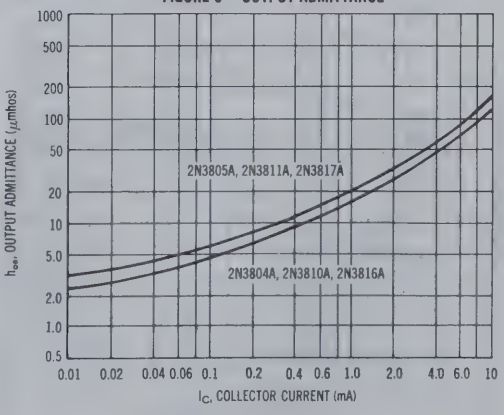
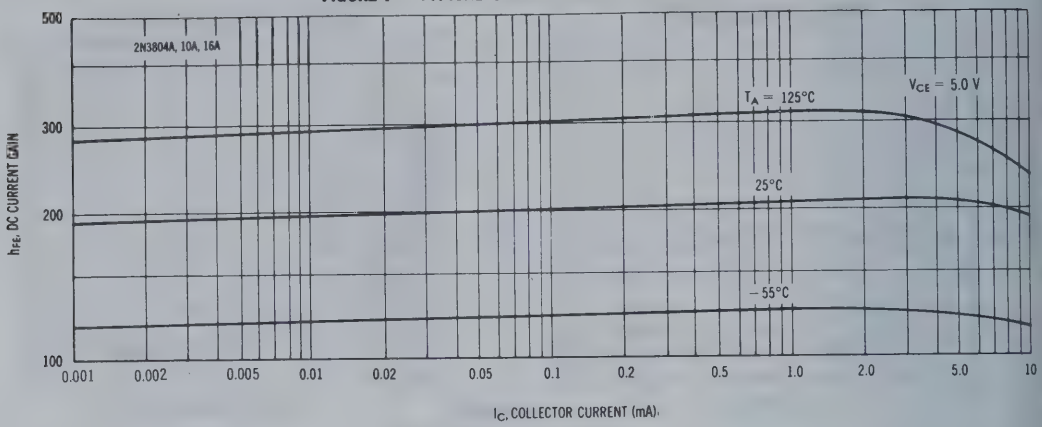


FIGURE 7 — TYPICAL CURRENT-GAIN CHARACTERISTICS



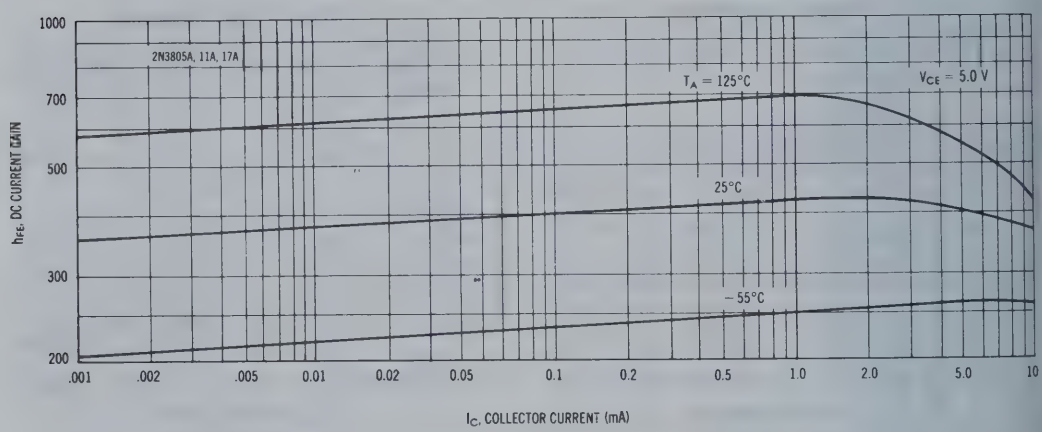
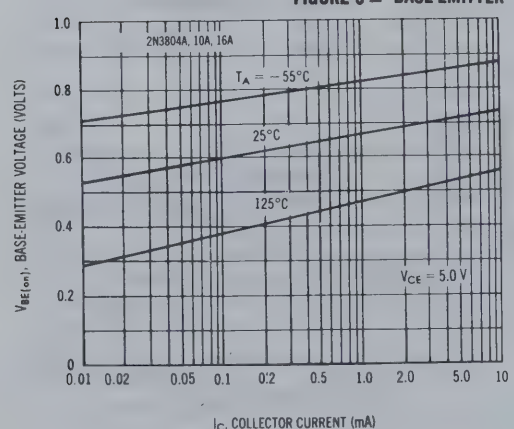
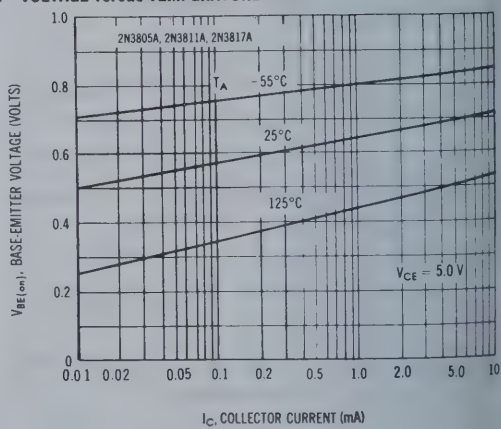


FIGURE 8 — BASE-EMITTER "ON" VOLTAGE versus TEMPERATURE





2N3818 (SILICON)



NPN silicon annular transistor for high-frequency power applications to 150 MHz.

All leads isolated from case

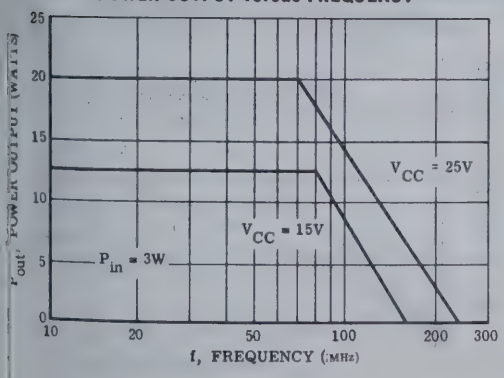
CASE 36
(TO-60)

MAXIMUM RATINGS *

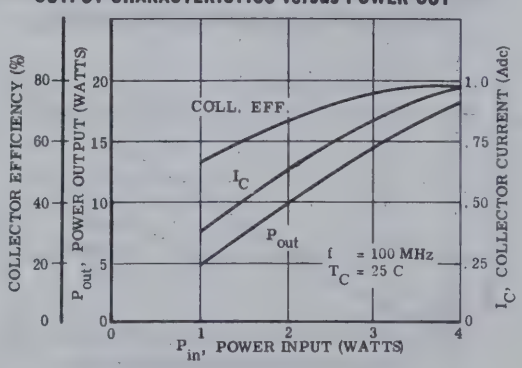
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector-Current (continuous)	I_C	2.0	Adc
Base-Current (continuous)	I_B	1.0	mAdc
Power Input (Nominal)	P_{in}	5.0	Watts
Power Output (Nominal)	P_{out}	20.0	Watts
Total Device Dissipation @ 25°C Case Temperature	P_D	25.0	Watts
Derating Factor above 25°C		167	mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

* The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See electrical characteristics.

POWER OUTPUT versus FREQUENCY



OUTPUT CHARACTERISTICS versus POWER OUT



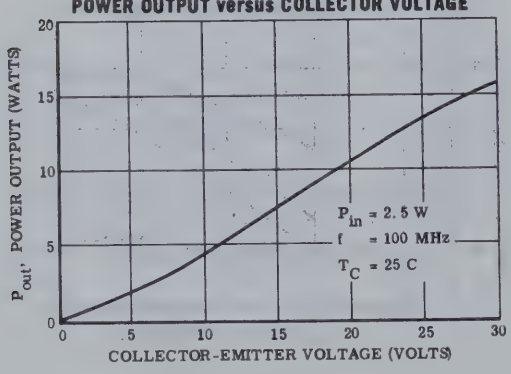
2N3818 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

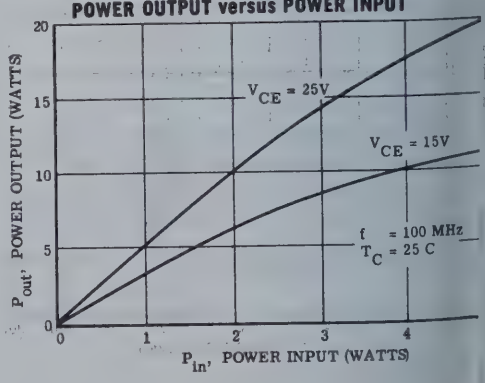
Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage $I_C = 0.25$ Adc, $R_{BE} = 0$	$V_{CES(sus)}$*	80	100	--	Vdc
Collector-Emitter-Open Base Sustain Voltage $I_C = 0.25$ Adc, $I_B = 0$	$V_{CEO(sus)}$*	40	--	--	Vdc
Collector-Emitter Current $V_{CE} = 60$ Vdc, $V_{BE} = 0$ $V_{CE} = 50$ Vdc, $V_{BE} = 0$, $T_C = 175°C$	I_{CES}	-- --	-- --	0.5 1.0	mAdc
Collector Cutoff Current $V_{CB} = 50$ Vdc, $I_E = 0$	I_{CBO}	--	--	1	μAdc
Emitter Cutoff Current $V_{EB} = 4$ Vdc, $I_C = 0$	I_{EBO}	--	--	100	μAdc
DC Current Gain $I_C = 400$ mAdc, $V_{CE} = 2$ Vdc $I_C = 1$ Adc, $V_{CE} = 2$ Vdc	h_{FE}	5.0 5.0	-- --	50 --	
Collector-Emitter Saturation Voltage $I_C = 1.0$ Adc, $I_B = 250$ mAdc	$V_{CE(sat)}$	--	--	0.5	Vdc
Base-Emitter Saturation Voltage $I_C = 1.0$ Adc, $I_B = 250$ mAdc	$V_{BE(sat)}$	--	--	2.0	Vdc
AC Current Gain $V_{CE} = 2.0$ Vdc, $I_C = 400$ mAdc, f = 50 mc	$\lvert h_{fe} \rvert$	3	--	--	
Collector Output Capacitance $V_{CB} = 25$ Vdc, $I_E = 0$, f = 100 kHz	C_{ob}	--	--	40	pF
Power Input $P_{out} = 15$ W, f = 100 MHz $V_{CE} = 25$ Vdc	P_{in}	--	3.0	3.75	Watts
Efficiency $I_{C(max.)} = 1$ Adc	η	60	70	--	%

*Pulse Measurement: Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 2.0%.

POWER OUTPUT versus COLLECTOR VOLTAGE



POWER OUTPUT versus POWER INPUT

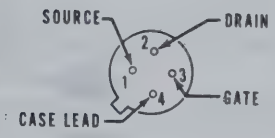


2N3821 (SILICON)
2N3822
2N3824



CASE 20 (1)
(TO-72)

N-channel junction silicon field-effect transistors designed for audio amplifier, chopper and switching applications.



Drain and Source
may be interchanged.

MAXIMUM RATINGS ($T_A = 25°C$)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Drain Current	I_D	10	mAdc
Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to + 200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -1 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	50	-	Vdc
Gate Reverse Current (V_{GS} = -30 Vdc, V_{DS} = 0)		I_{GSS}	-	0.1	nAdc
(V_{GS} = -30 Vdc, V_{DS} = 0, T_A = 150°C)			-	100	
Gate-Source Cutoff Voltage (I_D = 0.5 nAdc, V_{DS} = 15 Vdc)	2N3821	$V_{GS(off)}$	-	4	Vdc
	2N3822		-	6	
Gate-Source Voltage (I_D = 50 μAdc, V_{DS} = 15 Vdc)	2N3821	V_{GS}	0.5	2.0	Vdc
(I_D = 200 μAdc, V_{DS} = 15 Vdc)	2N3822		1.0	4.0	
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = -8 Vdc)	2N3824	$I_{D(off)}$	-	0.1	nAdc
(V_{DS} = 15 Vdc, V_{GS} = -8 Vdc, T_A = 150°C)	2N3824		-	100	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	2N3821	I_{DSS}*	0.5	2.5	mAdc
	2N3822		2.0	10	
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)*	2N3821	$\lvert y_{fs} \rvert$	1500	4500	μmhos
	2N3822		3000	6500	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N3821		1500	-	
	2N3822		3000	-	
Output Admittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)	2N3821	$\lvert y_{os} \rvert$*	-	10	μmhos
	2N3822		-	20	
Drain-Source Resistance (V_{GS} = 0, I_D = 0, f = 1 kHz)	2N3824	$r_{ds(on)}$	-	250	Ohms
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)		C_{iss}	-	6	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)	2N3821	C_{rss}	-	3	pF
	2N3822		-	3	
(V_{GS} = -8 Vdc, V_{DS} = 0, f = 1 MHz)	2N3824		-	3	
Average Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1 megohm, f = 10 Hz, Noise Bandwidth = 5 Hz)	2N3821, 2N3822	NF	-	5	dB
Equivalent Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 10 Hz, Noise Bandwidth = 5 Hz)	2N3821, 2N3822	e_n	-	200	$nv/Hz^{\frac{1}{2}}$

*Pulse Test: Pulse Width ≤ 100 ms, Duty Cycle ≤ 10%

2N3823 (SILICON)



CASE 20 (1)
(TO-72)

Silicon N-channel junction field-effect transistor designed for VHF amplifier and mixer applications. Drain and source may be interchanged.

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mAdc
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

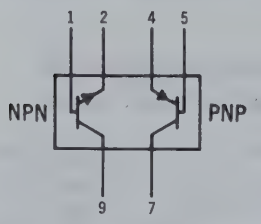
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = -1 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	-	Vdc
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0) (V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 150°C)	I_{GSS}	- -	0.50 500	nAdc
Gate-Source Cutoff Voltage (I_D = 0.50 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	-	8	Vdc
Gate-Source Voltage (I_D = 0.4 mAdc, V_{DS} = 15 Vdc)	V_{GS}	1.0	7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	4	20	mAdc
DYNAMIC CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$\lvert y_{fs} \rvert$*	3500 3200	6500 -	μmhos
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(y_{is})$	-	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$\lvert y_{os} \rvert$* $Re(y_{os})$	- -	35 200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	-	6	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)	C_{rss}	-	2	pF
Common-Source Spot Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1000 ohms, f = 100 MHz)	NF	-	2.5	dB

*Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%

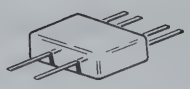
2N3824

For Specifications, See 2N3821 Data.

2N3838 (SILICON)



Pin Connections, Bottom View



CASE 33
(TO-89)

NPN-PNP complementary pair silicon annular transistor designed for switching and general purpose amplifier applications.

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage (Applicable from 0 to 10 mAdc)	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
Operating Junction Temperature Range	T_J	-65 to +175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	0.25	0.35	Watt
Derate above 25°C		1.67	2.34	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	0.7	1.4	Watt
Derate above 25°C		4.67	9.34	mW/°C

FIGURE 1 — TURN-ON TIME TEST CIRCUIT

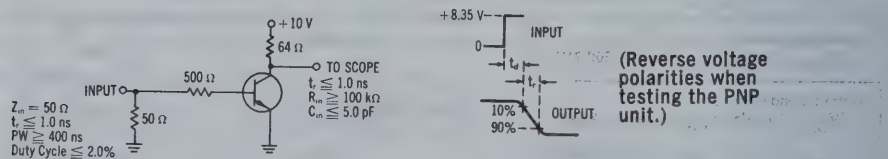


FIGURE 2 — TURN-OFF TIME TEST CIRCUIT

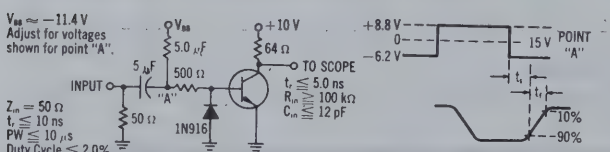
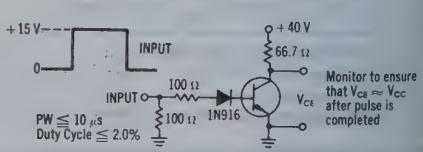


FIGURE 3 — COLLECTOR-EMITTER NONLATCHING VOLTAGE TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	40	-	Vdc
Collector-Emitter Nonlatching Voltage (Figure 3)† ($I_{C(on)}$ = 600 mAdc, $I_{B(on)}$ = 120 mAdc, $I_{B(off)}$ = 0)	$V_{CEO(NL)}$†	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc)	I_{CEV}	-	0.01	μAdc
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc, T_A = 150°C)		-	10	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	10	nAdc
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc)	I_{BEV}	-	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	h_{FE}	35	-	-
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)*		75	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*		100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)*		50	-	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$*	-	0.4	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$*	0.85	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	1.5	9.0	k ohm
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	60	300	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	-	50	μmho
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)	NF	-	8.0	dB
Delay Time	(V_{CC} = 10 Vdc, $V_{BE(off)}$ = 0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc, Figure 1) t_d	-	10	ns
Rise Time	t_r	-	40	ns
Storage Time	(V_{CC} = 10 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, Figure 2) t_s	-	250	ns
Fall Time	t_f	-	90	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

† The highest value of collector supply voltage that may be safely used with a resistive load switching circuit in which the collector current is 600 mAdc.

2N3839

For Specifications, See 2N2857 Data.

2N3866 (SILICON)



CASE 79
(TO-39)

NPN silicon transistor, designed for amplifier, frequency-multiplier, or oscillator applications in military and industrial equipment. Suitable for uses as output, driver, or pre-driver stages in VHF and UHF equipment.

Collector connected to case

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current	I_C	0.4	Amp
Total Device Dissipation @ $T_C = 25°C$	P_D	5	Watts
Derate above 25°C		28.6	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 5 mAdc, I_B = 0)	$BV_{CEO(sus)}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_E = 0, I_C = 0.1 mAdc)	BV_{CBO}	55	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	—	—	20	μA
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.36 Adc, V_{CE} = 5 Vdc)	h_{FE}	5	—	—	—
(I_C = 0.05 Adc, V_{CE} = 5 Vdc)		10	—	200	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	800	—	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	2.0	3.0	pF
FUNCTIONAL TEST					
Power Gain	G_{pe}	10	—	—	dB
Power Output	P_{out}	1.0	—	—	Watts
Collector Efficiency	η	45	—	—	%

Test Circuit-Figure 1
P_{in} = 0.1 W, V_{CE} = 28 Vdc
f = 400 MHz, T_C = 25°C

FIGURE 1 — 400 MHz RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST

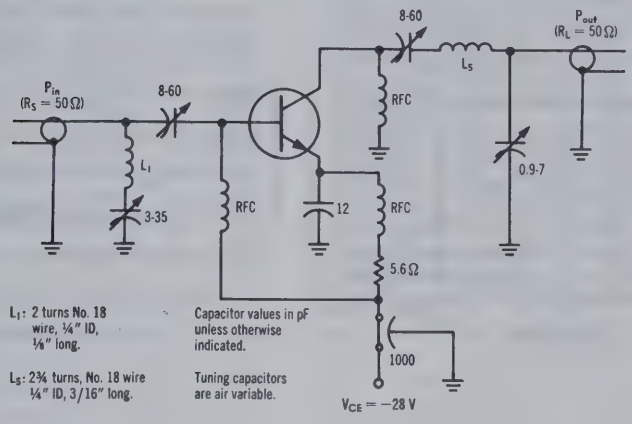


FIGURE 2 — POWER OUTPUT versus FREQUENCY (Class C)

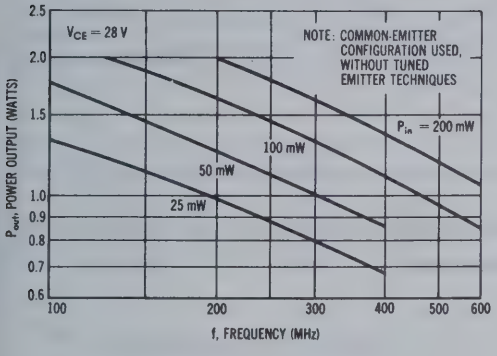


FIGURE 3 — POWER OUTPUT versus POWER INPUT (Class C)

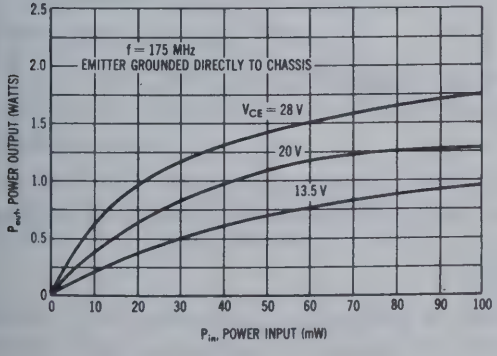


FIGURE 4 — PARALLEL INPUT RESISTANCE AND CAPACITANCE versus FREQUENCY (Class C)

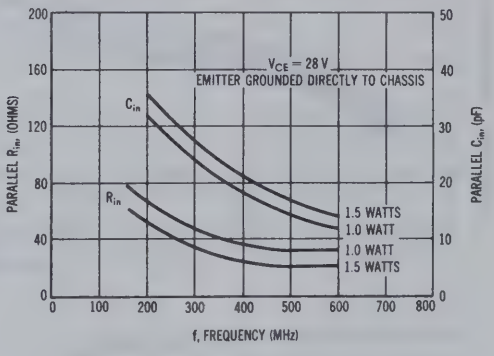


FIGURE 5 — PARALLEL OUTPUT CAPACITANCE versus FREQUENCY (Class C)

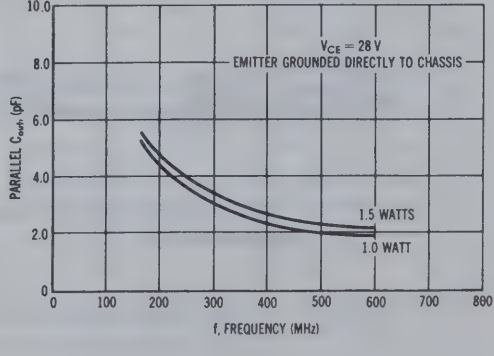


FIGURE 6 — SMALL-SIGNAL CURRENT GAIN versus FREQUENCY

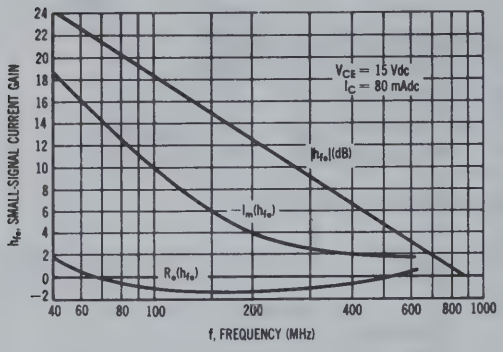


FIGURE 7 — OUTPUT CAPACITANCE versus COLLECTOR VOLTAGE

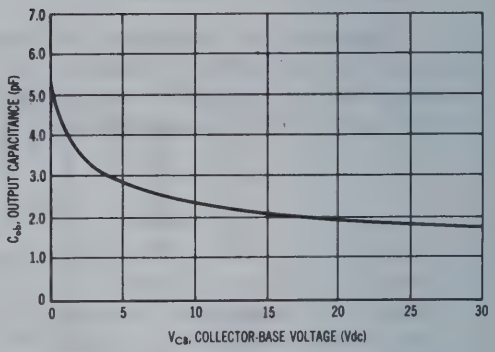


FIGURE 8 — f_T versus COLLECTOR CURRENT

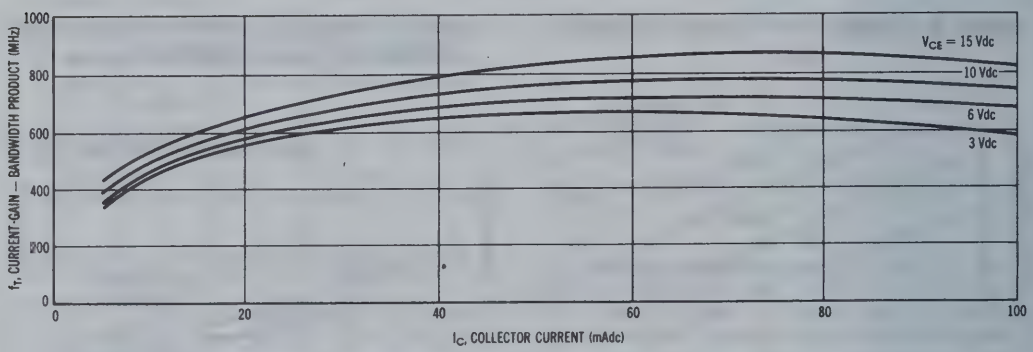


FIGURE 9 — $r_b'C_c$ versus COLLECTOR CURRENT

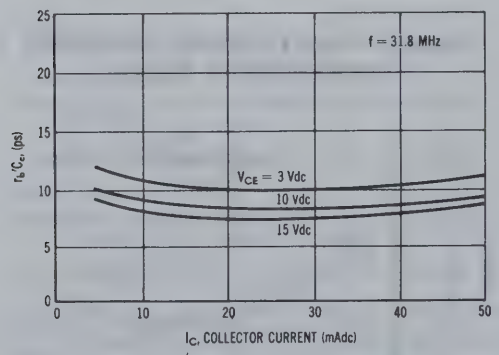
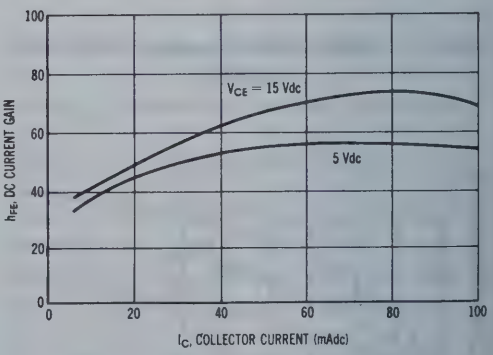


FIGURE 10 — DC CURRENT GAIN versus COLLECTOR CURRENT



y PARAMETER VARIATIONS

FIGURE 11 — SMALL-SIGNAL INPUT ADMITTANCE versus COLLECTOR CURRENT

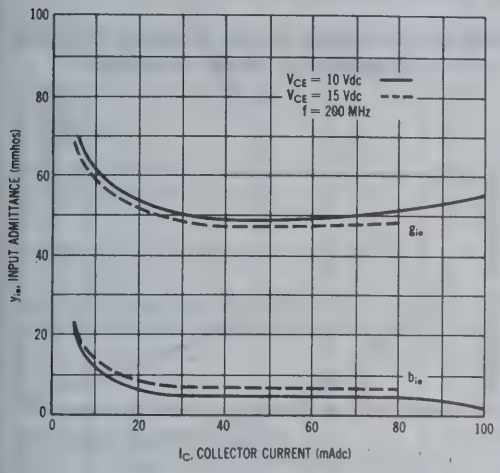


FIGURE 12 — SMALL-SIGNAL REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT

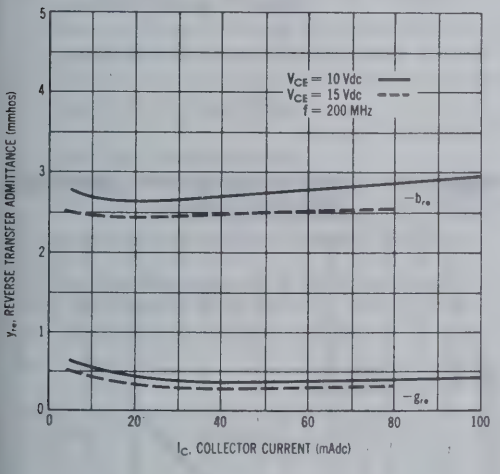


FIGURE 13 — SMALL-SIGNAL FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

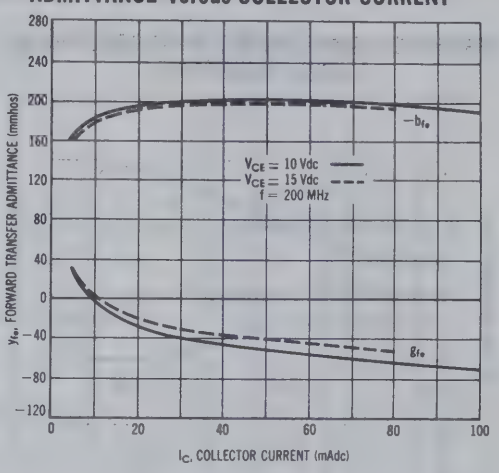
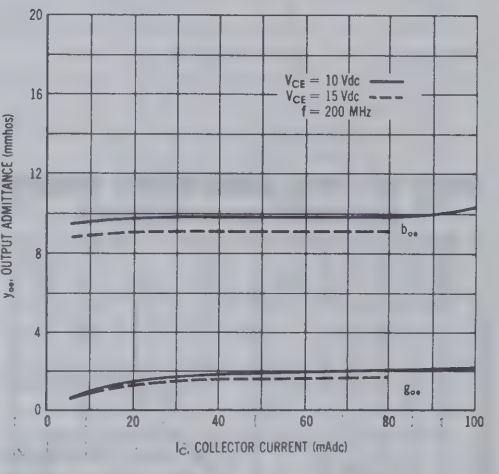


FIGURE 14 — SMALL-SIGNAL OUTPUT ADMITTANCE versus COLLECTOR CURRENT



DESIGN NOTE

Figures 11 through 18 show small-signal admittance-parameter data. This data can be used for Class A amplifier designs.

For Class C power-amplifier designs, the small-signal parameters are not applicable. Figures 4 and 5 give parallel output capacitance and the parallel input resistance and capacitance for Class C power-amplifier operation.

The parallel resistive portion of the collector load impedance for a power amplifier, R_L', may be computed by assuming a peak voltage swing equal to V_{CC}, and using the expression

$$R_L' = \frac{V_{CC}^2}{2P}$$

where P = RF power output. The computed R_L' may then be combined with the data in Figures 2 and 3 to comprise complete device impedance data for Class C power amplifier design.

y PARAMETER VARIATIONS

(V_{CE} = 15 Vdc, I_C = 80 mAdc, T_A = 25°C)

FIGURE 15 — SMALL-SIGNAL INPUT ADMITTANCE versus FREQUENCY

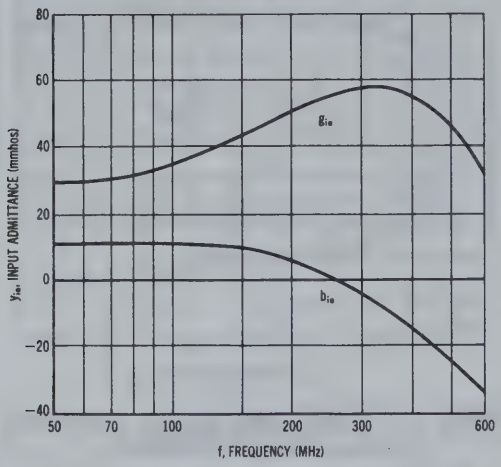


FIGURE 17 — SMALL-SIGNAL FORWARD TRANSFER ADMITTANCE versus FREQUENCY

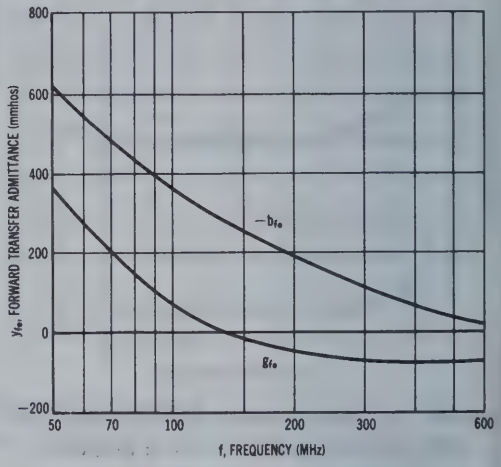


FIGURE 16 — SMALL-SIGNAL REVERSE TRANSFER ADMITTANCE versus FREQUENCY.

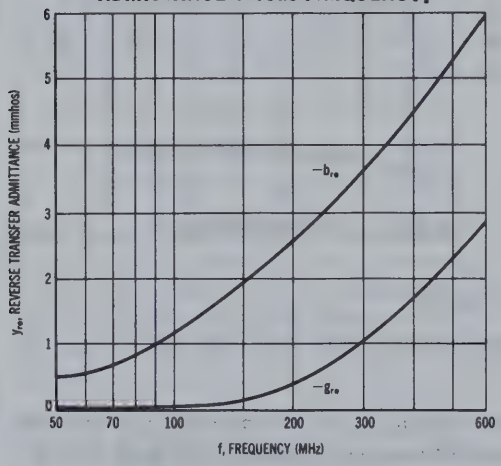
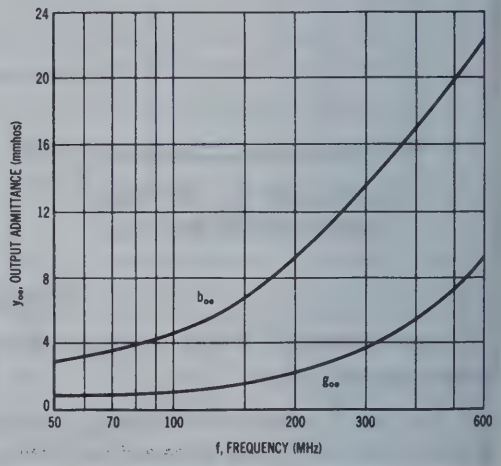


FIGURE 18 — SMALL-SIGNAL OUTPUT ADMITTANCE versus FREQUENCY



2N3883 (GERMANIUM)



Medium-current, germanium PNP high-speed switching transistor.

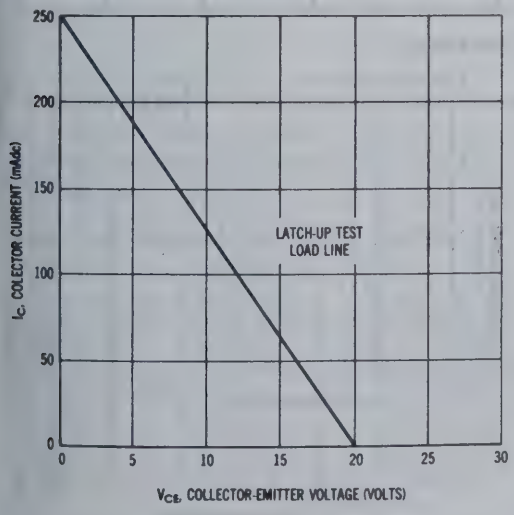
CASE 31
(TO-5)

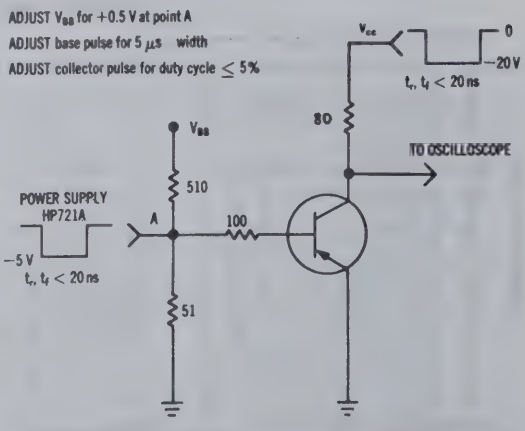
Collector connected to case

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Units
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	3	Vdc
Collector Current (Continuous)	I_C	300	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Device Dissipation @ 25°C Case Temperature (Derate 10 mW/°C above 25°C)	P_D	750	mW
Device Dissipation @ 25°C Ambient (Derate 4 mW/°C)	P_D	300	mW

COLLECTOR LATCH-UP VOLTAGE AND TEST CIRCUIT

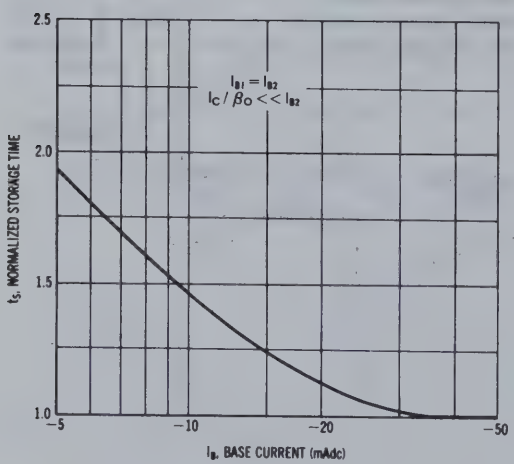


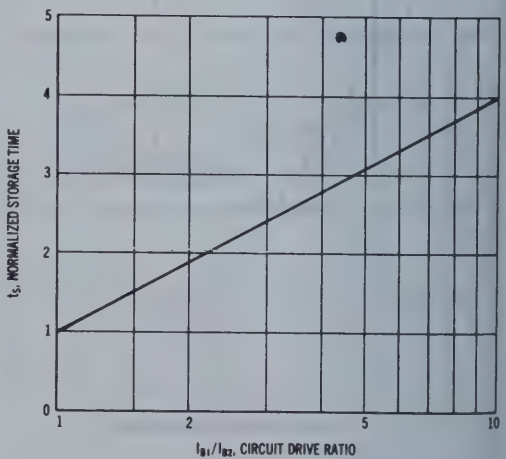


ELECTRICAL CHARACTERISTICS (At 25°C Ambient unless otherwise noted)

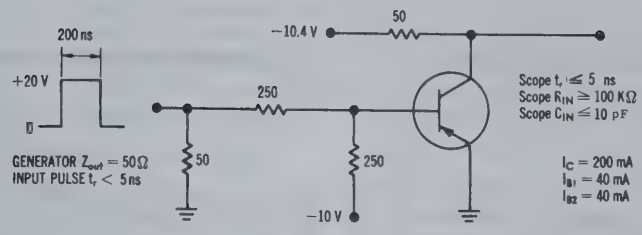
Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100μAdc, I_E = 0)	BV_{CBO}	25	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10mAdc, I_B = 0)	BV_{CEO}	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100μAdc, I_C = 0)	BV_{EBO}	3	—	—	Vdc
Latch-Up Voltage	LV_{CEX}	20	—	—	Vdc
Collector-Emitter Leakage Current (V_{CE} = 15 Vdc, V_{EB} = 0)	I_{CES}	—	—	100	μAdc
Base Cutoff Current (V_{CE} = 15 Vdc, V_{EB} = 0)	I_B	—	—	100	μAdc
DC Current Gain (I_C = 200 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	—	—	—
Collector-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 40 mAdc	$V_{CE(sat)}$	—	0.35	0.5	Vdc
Base-Emitter Voltage (I_C = 200 mAdc, I_B = 40 mAdc)	V_{BE}	0.4	0.65	0.9	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	4.5	8	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	10	25	pF
Current-Gain — Bandwidth Product (V_{CE} = 10 Vdc, I_C = 40 mAdc, f = 100 MHz)	f_T	100	300	—	MHz
Delay Time	t_d	—	8	15	ns
Rise Time	t_r	—	28	40	ns
Storage Time	t_s	—	40	70	ns
Fall Time	t_f	—	28	40	ns

STORAGE TIME VARIATIONS

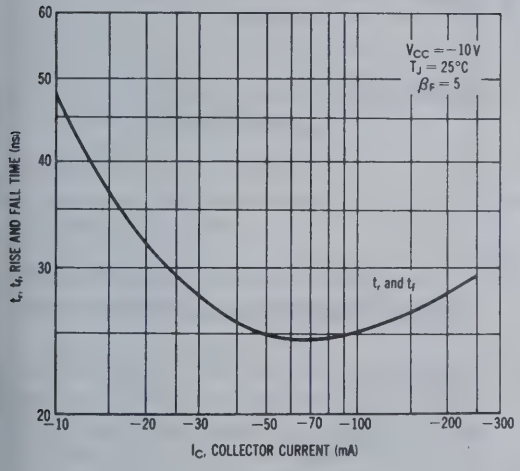




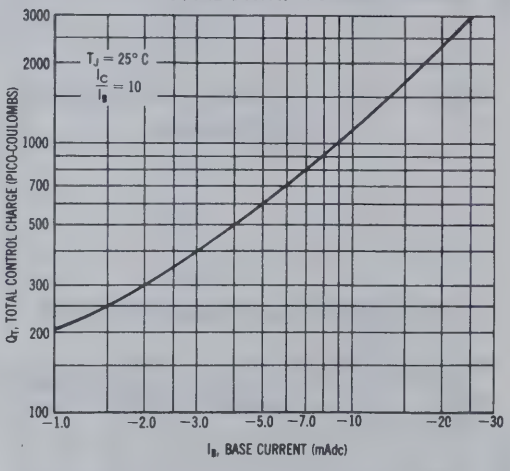
SWITCHING TIME TEST CIRCUIT



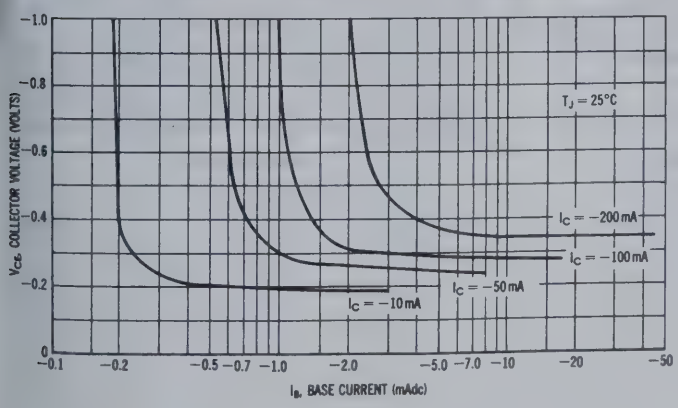
TYPICAL RISE AND FALL TIME BEHAVIOR



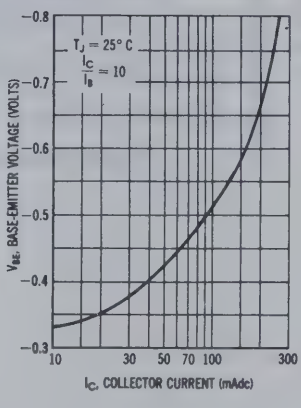
TOTAL CONTROL CHARGE



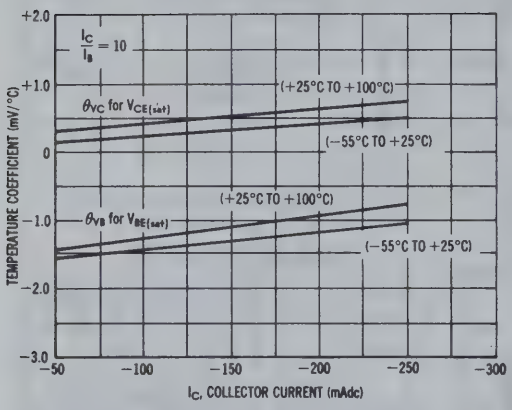
COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT



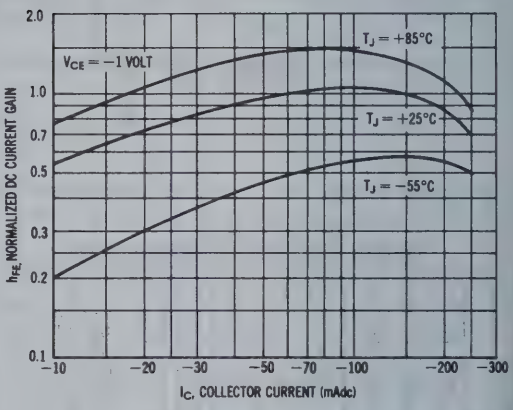
BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT



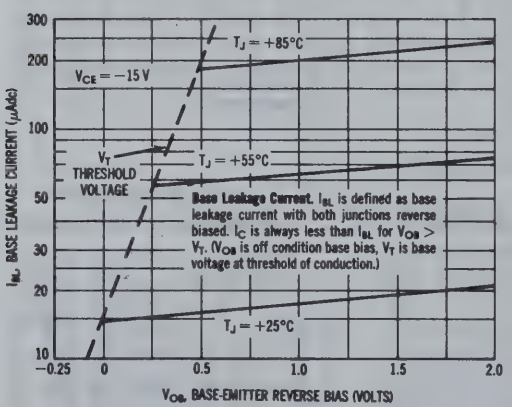
TEMPERATURE COEFFICIENTS



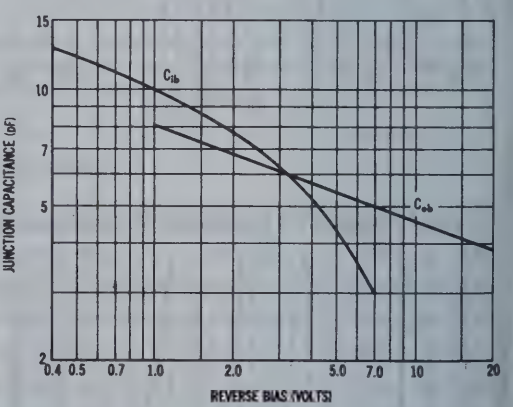
NORMALIZED CURRENT GAIN CHARACTERISTICS



LEAKAGE CHARACTERISTICS COMMON EMITTER



JUNCTION CAPACITANCE versus REVERSE VOLTAGE



2N3903 (SILICON)
2N3904



CASE 29(1)
(TO-92)

NPN silicon annular transistors, designed for general-purpose switching and amplifier applications, features one-piece, injection-molded plastic package for high reliability. The 2N3903 and 2N3904 are complementary with PNP types 2N3905 and 2N3906, respectively.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	310	mW
T_A = 60°C		210	mW
Derate above 25°C		2.81	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0)			BV_{CEO}*	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)			I_{CEX}	-	50	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)			I_{BL}	-	50	nAdc
ON CHARACTERISTICS						
DC Current Gain*		15	h_{FE}*			-
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3903			20	-	
	2N3904			40	-	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3903			35	-	
	2N3904			70	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3903			50	150	
	2N3904			100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3903			30	-	
	2N3904			60	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3903			15	-	
	2N3904			30	-	
Collector-Emitter Saturation Voltage*		16, 17	$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)				-	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.3	
Base-Emitter Saturation Voltage*		17	$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)				0.65	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.95	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3903		f_T	250	-	MHz
	2N3904			300	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		3	C_{ob}	-	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		3	C_{ib}	-	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903	13	h_{ie}	0.5	8.0	k ohms
	2N3904			1.0	10	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903	14	h_{re}	0.1	5.0	X 10-4
	2N3904			0.5	8.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903	11	h_{fe}	50	200	-
	2N3904			100	400	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		12	h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 10 Hz to 15.7 kHz)	2N3903	9, 10	NF	-	6.0	dB
	2N3904			-	5.0	
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	1, 5	t_d	-	35	ns
Rise Time		1, 5, 6	t_r	-	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) 2N3903	2, 7	t_s	-	175	ns
	2N3904			-	200	
Fall Time		2, 8	t_f	-	50	ns

* Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

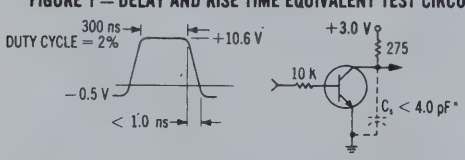
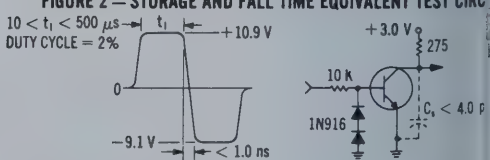


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRC



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS

— $T_J = 25°C$ ---$T_J = 125°C$

FIGURE 3 — CAPACITANCE

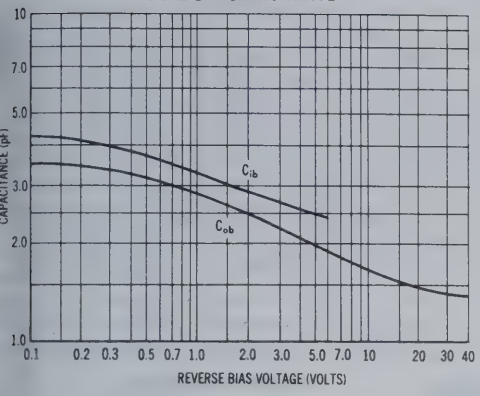


FIGURE 4 — CHARGE DATA

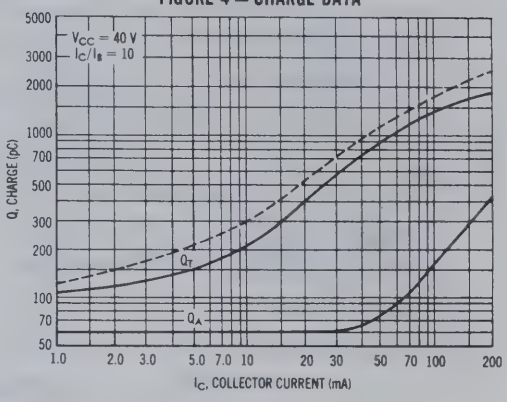


FIGURE 5 — TURN-ON TIME

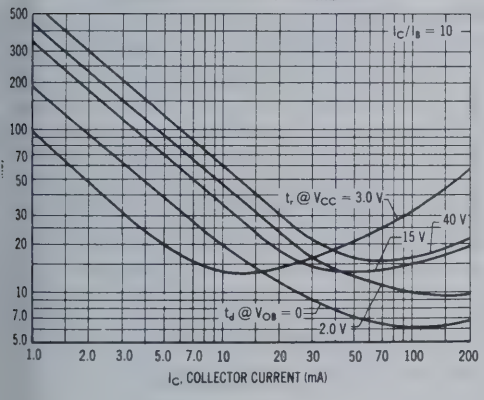


FIGURE 6 — RISE TIME

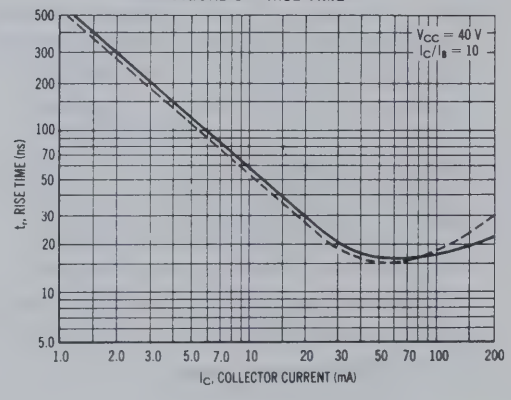


FIGURE 7 — STORAGE TIME

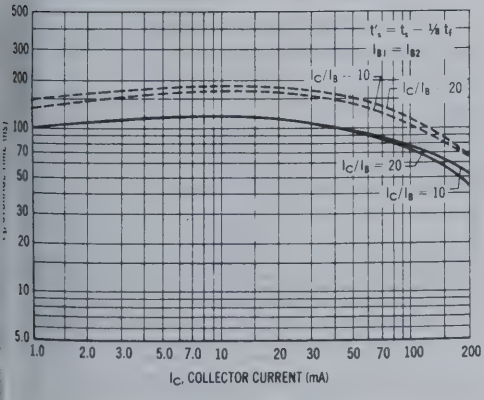
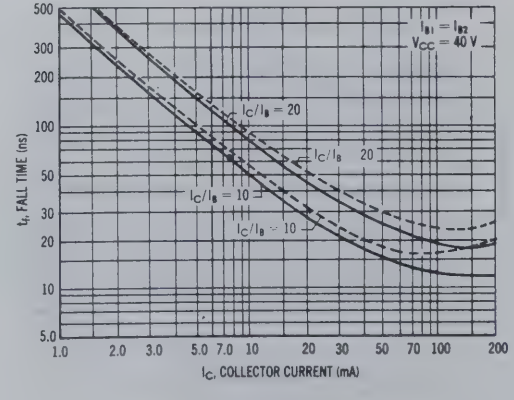


FIGURE 8 — FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS
V_{CE} = 5.0 Vdc, T_A = 25°C

FIGURE 9

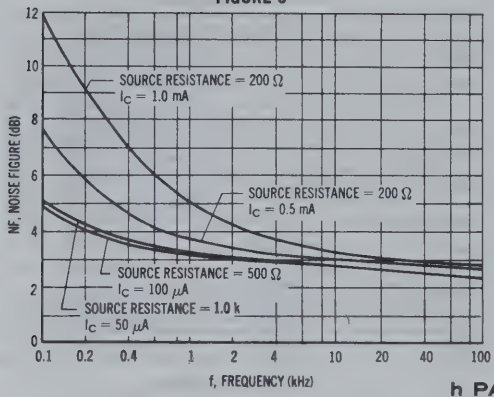
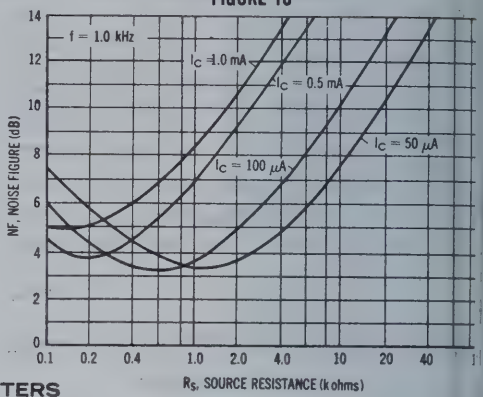


FIGURE 10



h PARAMETERS
(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 11 — CURRENT GAIN

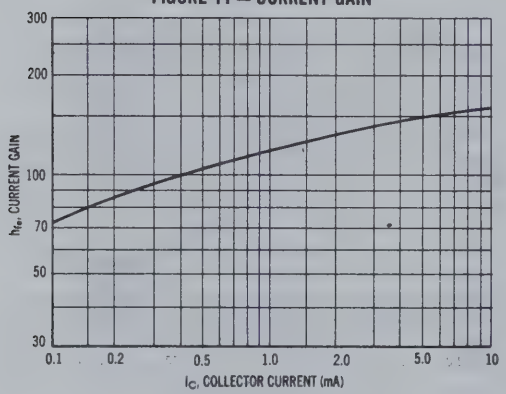


FIGURE 12 — OUTPUT ADMITTANCE

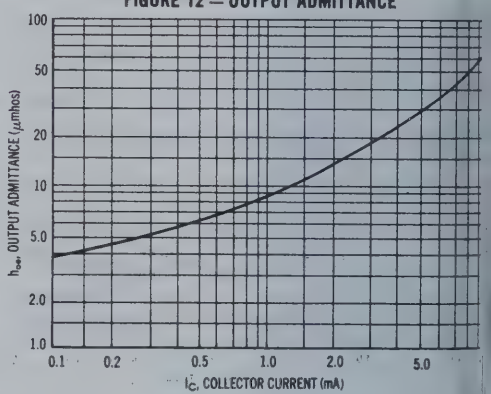


FIGURE 13 — INPUT IMPEDANCE

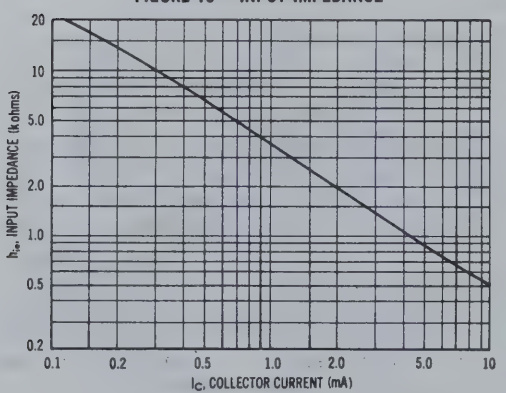
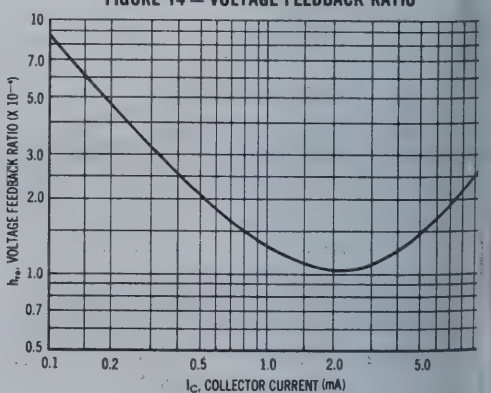


FIGURE 14 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 15 — NORMALIZED CURRENT GAIN

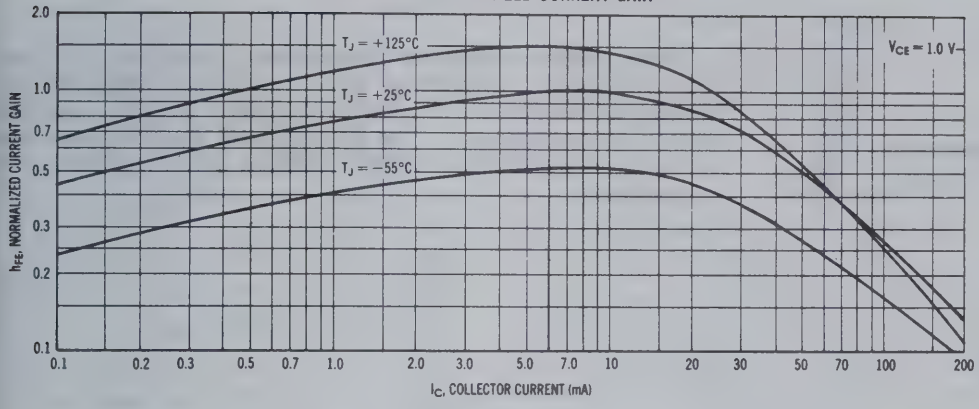


FIGURE 16 — COLLECTOR SATURATION REGION

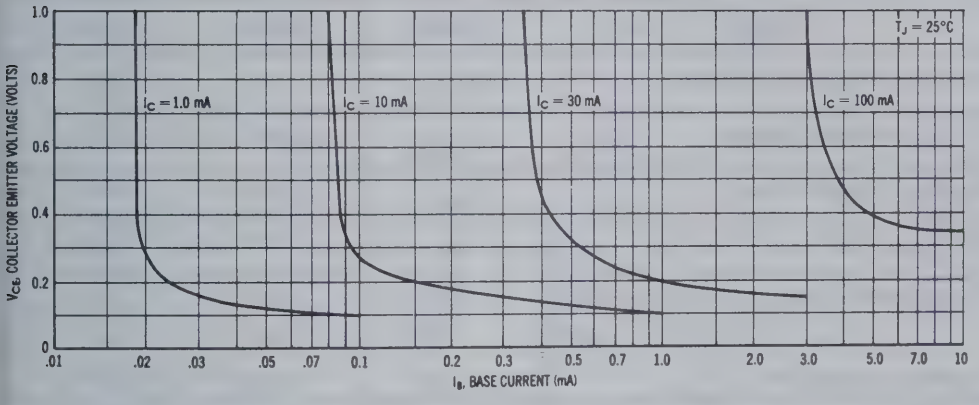


FIGURE 17 — "ON" VOLTAGES

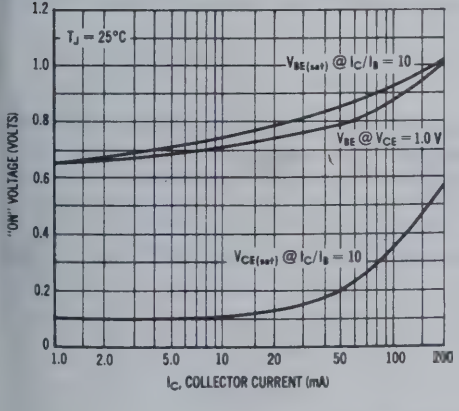
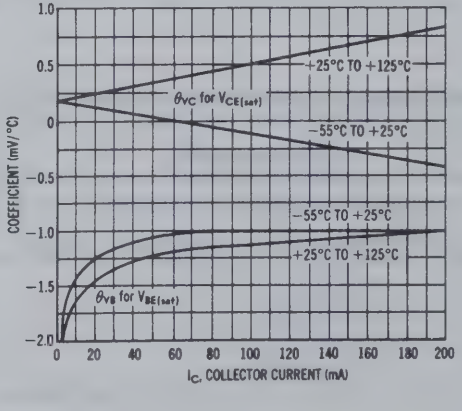
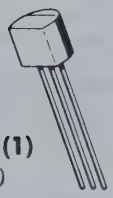


FIGURE 18 — TEMPERATURE COEFFICIENTS



2N3905 (SILICON)
2N3906



CASE 29(1)
(TO-92)

PNP silicon annular **transistors,** designed for general purpose switching and amplifier applications, features one-piece, injection-molded plastic package for high reliability. The 2N3905 and 2N3906 are complementary with NPN types 2N3903 and 2N3904, respectively.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	310	mW
T_A = 60°C		210	mW
Derate above 25°C		2.81	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	40	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0)			BV_{CEO}*	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)			I_{CEX}	-	50	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)			I_{BL}	-	50	nAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3905	15	h_{FE}*	30	-	-
	2N3906			60	-	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3905			40	-	
	2N3906			80	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3905			50	150	
	2N3906			100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3905			30	-	
	2N3906			60	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3905			15	-	
	2N3906			30	-	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		16, 17	$V_{CE(sat)}$*	-	0.25	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.4	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		17	$V_{BE(sat)}$*	0.65	0.85	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.95	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3905		f_T	200	-	MHz
	2N3906			250	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		3	C_{ob}	-	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		3	C_{ib}	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905	13	h_{ie}	0.5	8.0	k ohms
	2N3906			2.0	12	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905	14	h_{re}	0.1	5.0	X 10^{-4}
	2N3906			1.0	10	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905	11	h_{fe}	50	200	-
	2N3906			100	400	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3905	12	h_{oe}	1.0	40	μmhos
	2N3906			3.0	60	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz)	2N3905	9, 10	NF	-	5.0	dB
	2N3906			-	4.0	
SWITCHING CHARACTERISTICS						
Delay Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		1, 5	t_d	-	35	ns
Rise Time		1, 5, 6	t_r	-	35	ns
Storage Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	2N3905	2, 7	t_s	-	200	ns
	2N3906			-	225	
Fall Time	2N3905	2, 8	t_f	-	60	ns
	2N3906			-	75	

* Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

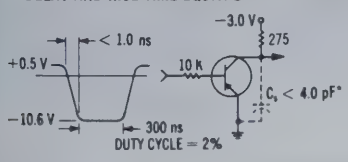
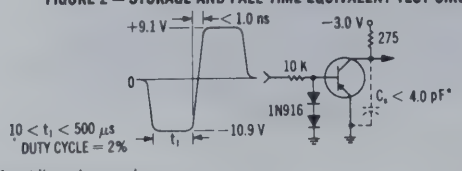


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS
— T_J = 25°C --- T_J = 125°C

FIGURE 3 — CAPACITANCE

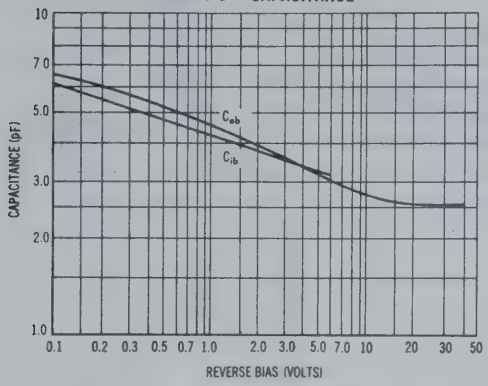


FIGURE 4 — CHARGE DATA

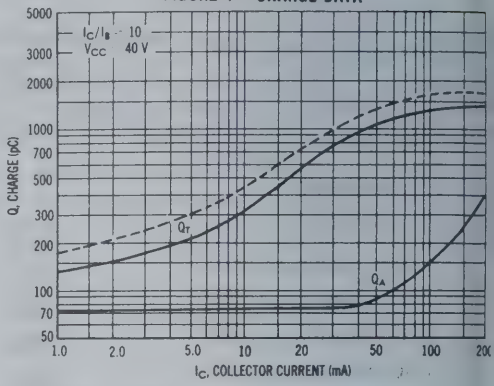


FIGURE 5 — TURN-ON TIME

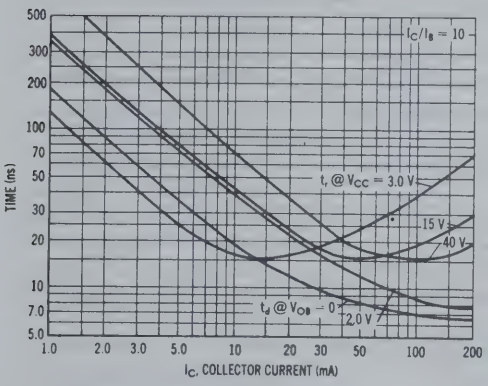


FIGURE 6 — RISE TIME

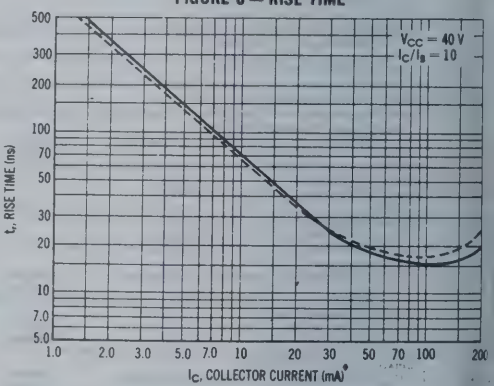


FIGURE 7 — STORAGE TIME

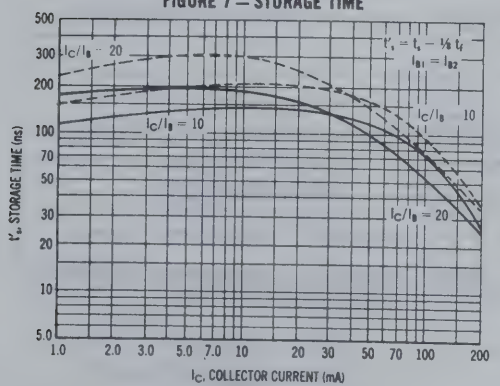
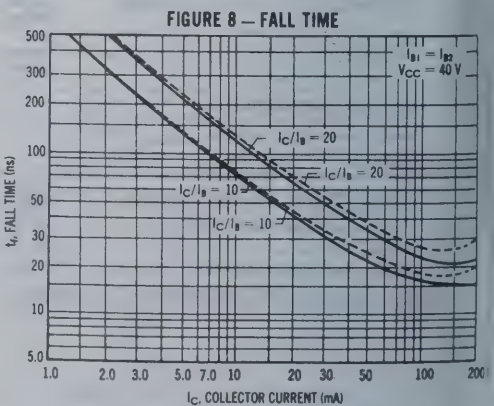


FIGURE 8 — FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS
$V_{CE} = 5.0$ Vdc, $T_A = 25°C$

FIGURE 9

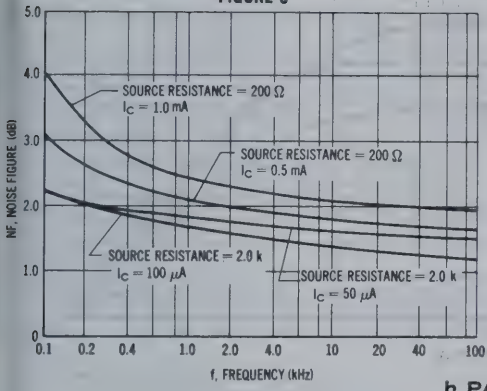
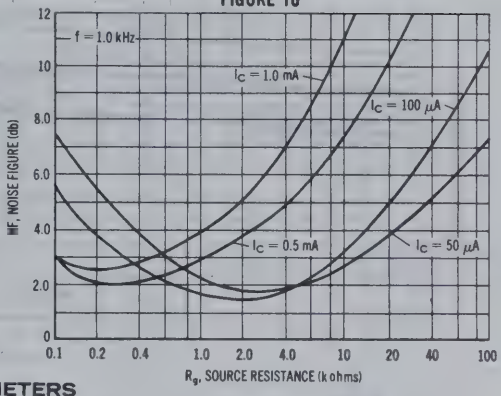


FIGURE 10



h PARAMETERS
($V_{CE} = 10$ Vdc, f = 1.0 kHz, $T_A = 25°C$)

FIGURE 11 — CURRENT GAIN

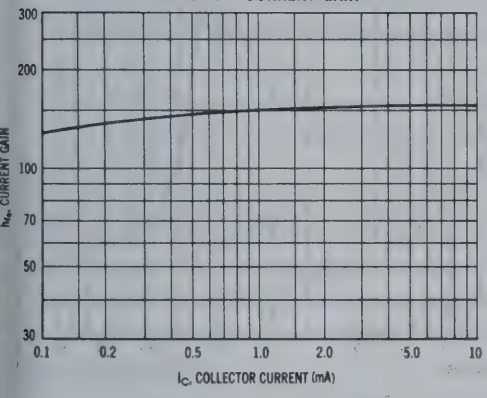


FIGURE 12 — OUTPUT ADMITTANCE

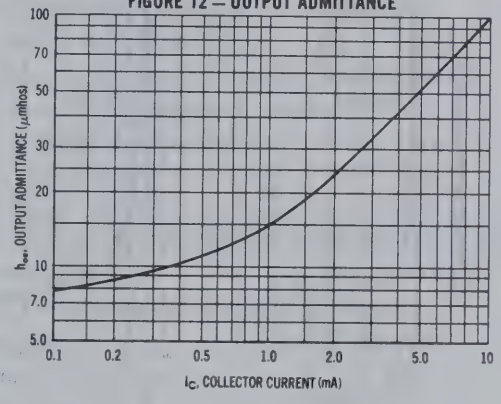


FIGURE 13 — INPUT IMPEDANCE

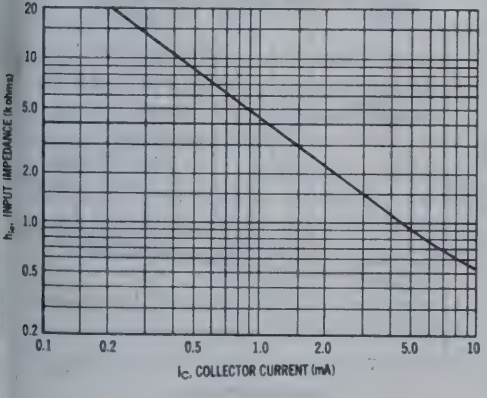
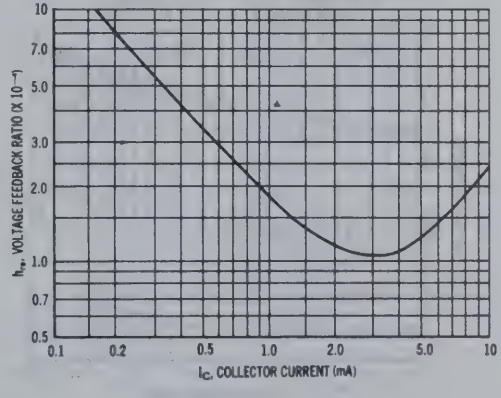


FIGURE 14 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 15 — NORMALIZED CURRENT GAIN

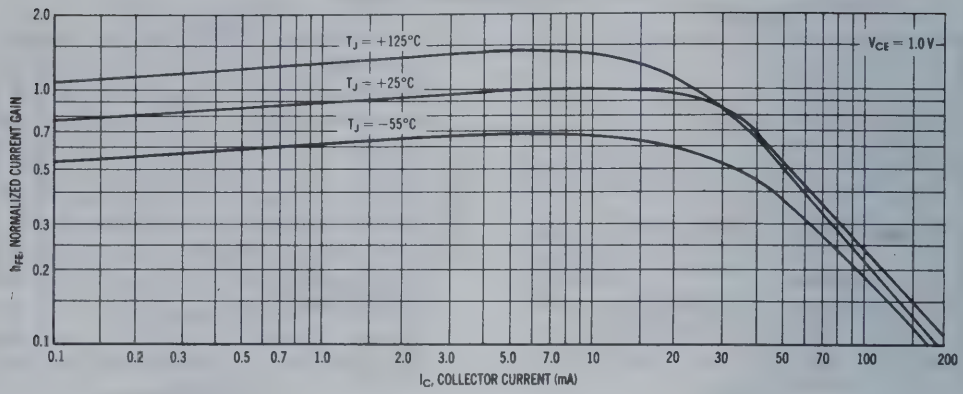


FIGURE 16 — COLLECTOR SATURATION REGION

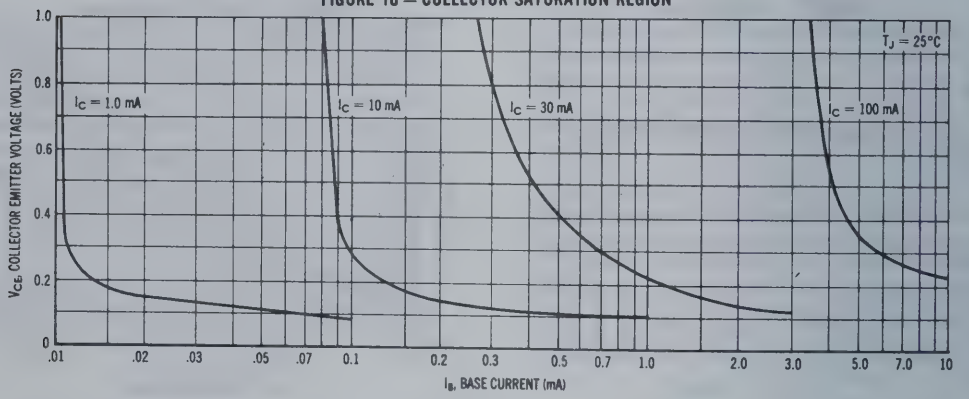


FIGURE 17 — "ON" VOLTAGES

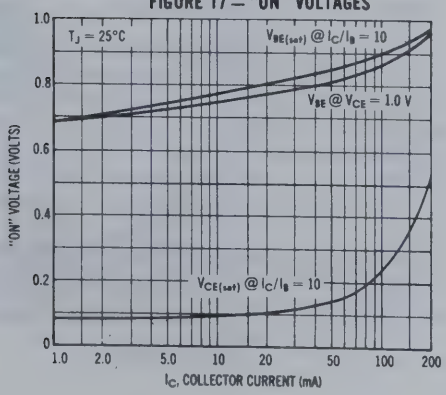
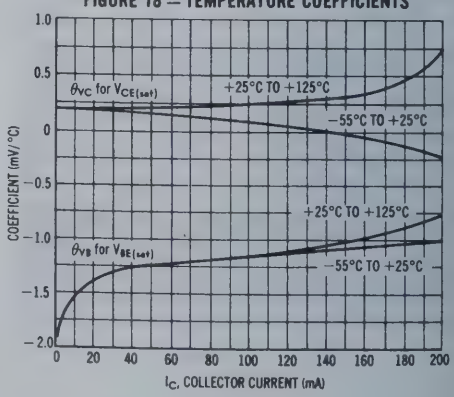


FIGURE 18 — TEMPERATURE COEFFICIENTS



2N3909 (SILICON)
2N3909A

SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for low-power audio amplifier applications.

- High AC Input Resistance — Typically > 30 Megohms @ f = 1.0 kHz
- Drain and Source Interchangeable
- Active Elements Isolated from Case

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

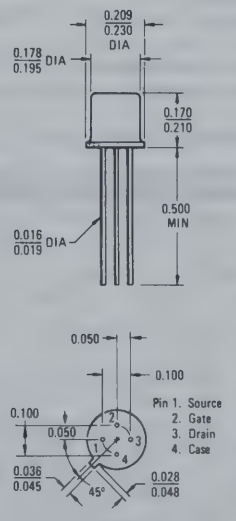
(Type A)



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-20	Vdc
Drain-Gate Voltage	V_{DG}	-20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Forward Gate-Source Voltage	V_{GSF}	20	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	300 2.0	mW $mW/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.



TO-72
CASE 20 (5)

Case Connected to Source

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) (Note 1)

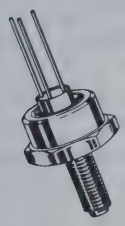
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	20	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 10 μAdc)	2N3909	$V_{GS(off)}$	–	8.0	Vdc
	2N3909A		–	8.0	
Gate Reverse Current (V_{GS} = 10 Vdc, V_{DS} = 0)		I_{GSS}	–	10	nAdc
(V_{GS} = 10 Vdc, V_{DS} = 0, T_A = 100°C)			–	1.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 2) (V_{DS} = -10 Vdc, V_{GS} = 0)	2N3909	I_{DSS}	0.3	15	mAdc
	2N3909A		1.0	15	
Gate-Source Voltage (V_{DS} = -10 Vdc, I_D = 30 μAdc)		V_{GS}	0.3	7.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (Note 2) (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N3909	$\|y_{fs}\|$	1000	5000	μmhos
	2N3909A		2200	5000	
(V_{DS} = -10 Vdc, V_{GS} = 0, f = 10 MHz)	2N3909		900	–	
	2N3909A		2000	–	
Output Admittance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	–	100	μmhos
Input Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	2N3909	C_{iss}	–	32	pF
	2N3909A		–	9.0	
Reverse Transfer Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	2N3909	C_{rss}	–	16	pF
	2N3909A		–	3.0	

*Indicates JEDEC Registered Data.

Note 1: The fourth lead (case) is connected to the source for all measurements.
Note 2: Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

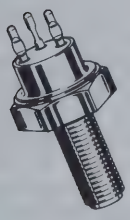
2N3924 (SILICON) thru 2N3927

NPN silicon annular RF power transistors, optimized for large-signal power-amplifier and driver applications to 300 MHz.



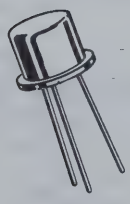
Collector electrically connected to case; stud electrically isolated from case

CASE 24
2N3925
(TO-102)



CASE 36
2N3926
2N3927
(TO-60)

Stud and case electrically connected to emitter



CASE 79
2N3924
(TO-39)

Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

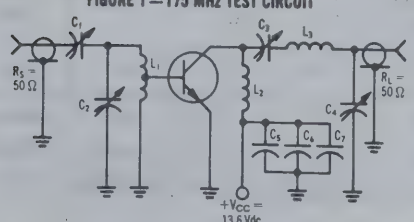
Rating	Symbol	2N3924	2N3925	2N3926	2N3927	Unit
Collector-Emitter Voltage	V_{CEO}	18	18	18	18	Vdc
Collector-Base Voltage	V_{CB}	36	36	36	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	4.0	4.0	Vdc
Collector Current	I_C	0.5	1.0	1.5	3.0	Adc
Power Dissipation @ T_C = 25°C	P_D	7.0	10	11.6	23.2	Watts
Derate above 25°C		40	57.1	66.3	132.5	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage	I_C = 200 mAdc	$BV_{CEO(sus)}$*	18	-	-	Vdc
Collector-Base Breakdown Voltage	I_C = 0.25 mAdc, I_E = 0 — 2N3924 thru 2N3926	BV_{CBO}	36	-	-	Vdc
	I_C = 0.50 mAdc, I_E = 0 — 2N3927		36	-	-	
Emitter-Base Breakdown Voltage	I_E = 1.0 mAdc, I_C = 0 — 2N3924 thru 2N3926	BV_{EBO}	4.0	-	-	Vdc
	I_E = 2.0 mAdc, I_C = 0 — 2N3927		4.0	-	-	
Collector Cutoff Current	V_{CB} = 15 Vdc, I_E = 0 — 2N3924 thru 2N3926	I_{CBO}	-	-	0.1	mAdc
	2N3927		-	-	0.25	
	V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C — 2N3924 thru 2N3926		-	-	5.0	
	2N3927		-	-	10	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product	I_C = 100 mAdc, V_{CE} = 13.6 Vdc, f = 100 MHz — 2N3924 thru 2N3926	f_T	-	350	-	MHz
	I_C = 200 mAdc, V_{CE} = 13.6 Vdc, f = 100 MHz — 2N3927		-	350	-	
Output Capacitance	V_{CB} = 13.6 Vdc, I_E = 0, f = 100 kHz — 2N3924 thru 2N3926	C_{ob}	-	12.5	20	pF
	2N3927		-	25	45	
FUNCTIONAL TESTS 2N3924						
Power Input	Test Circuit Figure 1	P_{in}	-	-	1.0	Watt
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 MHz	G_{pe}	6.0	7.3	-	dB
Collector Efficiency	P_{out} = 4.0 Watts	η	70	-	-	%
2N3925						
Power Input	Test Circuit Figure 1	P_{in}	-	-	1.3	Watts
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 MHz	G_{pe}	5.84	6.5	-	dB
Collector Efficiency	P_{out} = 5.0 Watts	η	70	-	-	%
2N3926						
Power Input	Test Circuit Figure 1	P_{in}	-	-	2.0	Watts
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 MHz	G_{pe}	5.44	6.0	-	dB
Collector Efficiency	P_{out} = 7.0 Watts	η	70	-	-	%
2N3927						
Power Input	Test Circuit Figure 1	P_{in}	-	-	4.0	Watts
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 MHz	G_{pe}	4.77	5.0	-	dB
Collector Efficiency	P_{out} = 12 Watts	η	80	-	-	%

* Pulsed thru a 25-mH inductor (See Figure 2)

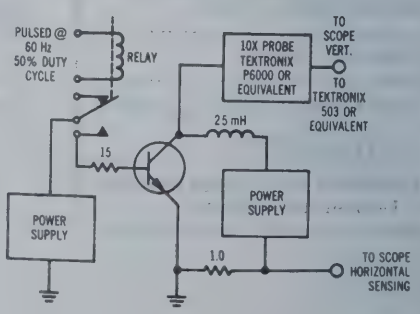
FIGURE 1 — 175 MHz TEST CIRCUIT



C_1, C_2, C_4 ..... 5-50 pF (Air variable)
C_3 ..... 7-100 pF (Air variable)
C_5 ..... 470 pF (Disc ceramic)
C_6 ..... 0.01 μF (Disc ceramic)
C_7 ..... 0.001 μF (Disc ceramic)

L_1 — 1 1/2 turns #14 AWG tinned wire; 3/8" ID Air wound; winding length 3/16"; base tapped 1 turn from ground
L_2 — RFC
L_3 — 2 turns #14 AWG tinned wire; 1/4" ID Air wound; winding length 3/16"

FIGURE 2 — PULSE TEST CIRCUIT



CLASS C DESIGN DATA FOR $V_{CE} = 13.6$ Vdc, $T_C = 25°C$

(Emitter Grounded Directly to the Chassis — No Tuned-Emitter Techniques Used)

2N3924

FIGURE 3 — POWER OUTPUT vs FREQUENCY

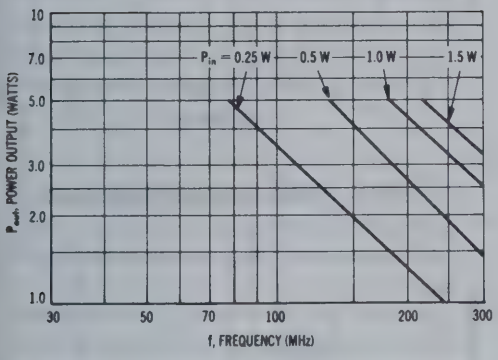


FIGURE 4 — POWER OUTPUT vs POWER INPUT

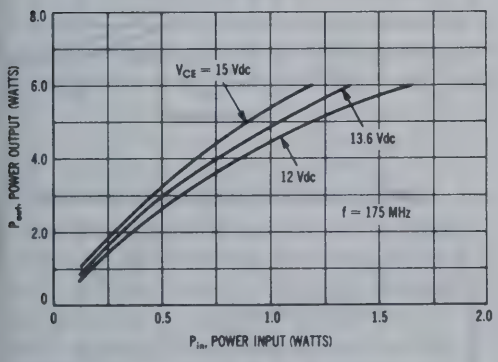


FIGURE 5 — PARALLEL EQUIVALENT INPUT RESISTANCE

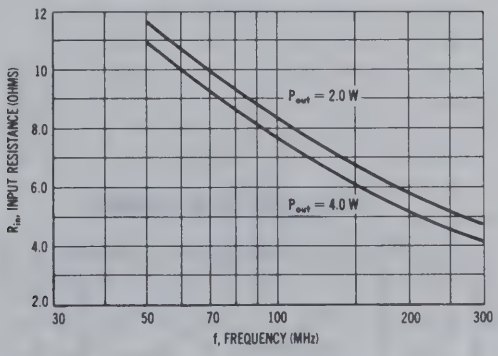


FIGURE 6 — PARALLEL EQUIVALENT INPUT CAPACITANCE

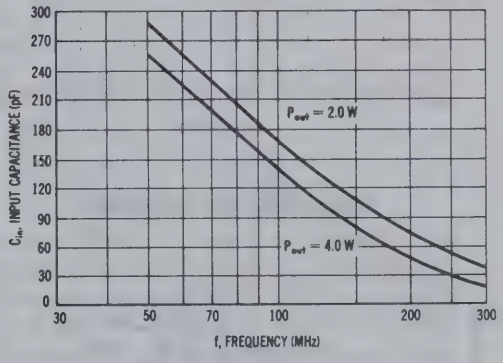
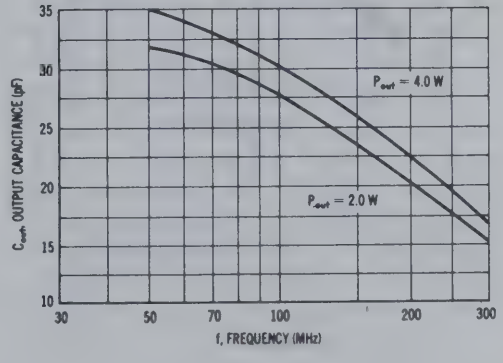


FIGURE 7 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3925

FIGURE 8 — POWER OUTPUT vs FREQUENCY

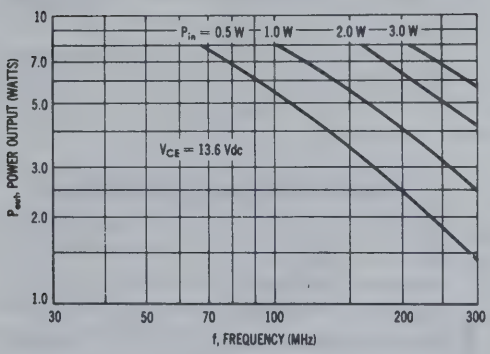


FIGURE 9 — POWER OUTPUT vs POWER INPUT

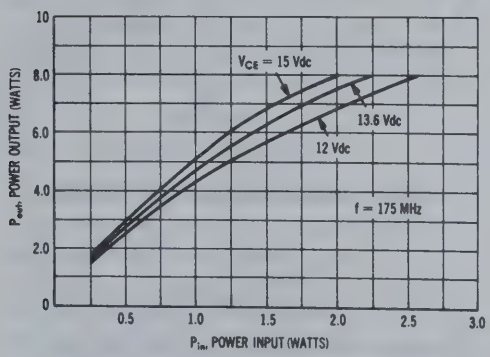


FIGURE 10 — PARALLEL EQUIVALENT INPUT RESISTANCE

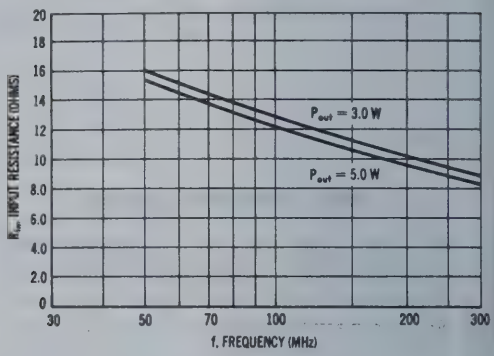


FIGURE 11 — PARALLEL EQUIVALENT INPUT CAPACITANCE

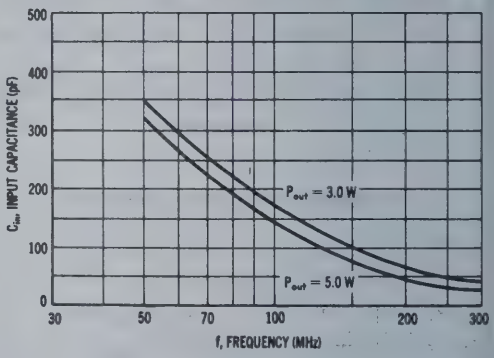
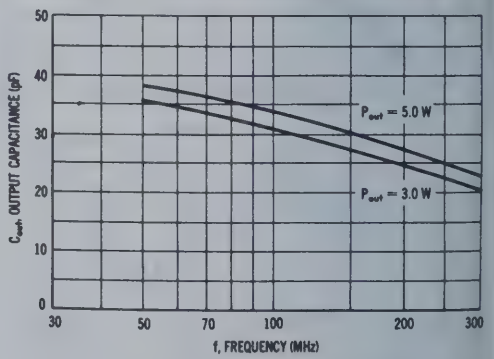


FIGURE 12 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3926

FIGURE 13 — POWER OUTPUT vs FREQUENCY

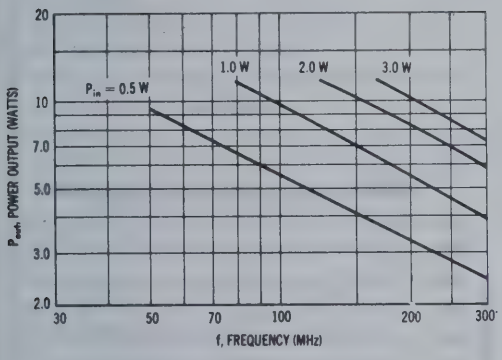


FIGURE 14 — POWER OUTPUT vs POWER INPUT

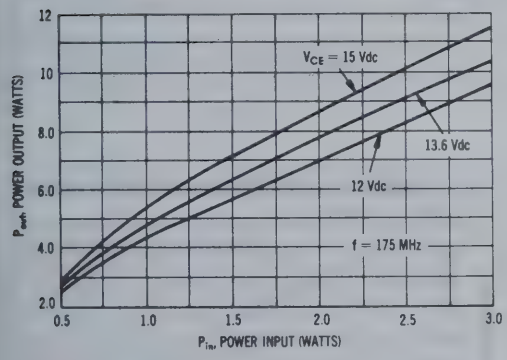


FIGURE 15 — PARALLEL EQUIVALENT INPUT RESISTANCE

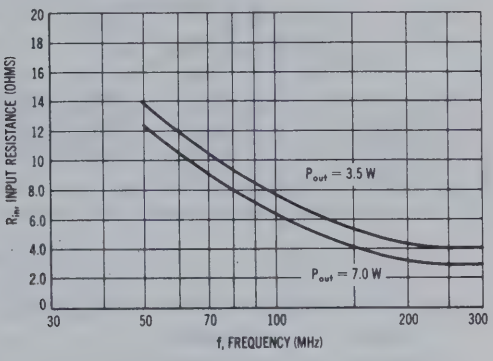


FIGURE 16 — PARALLEL EQUIVALENT INPUT CAPACITANCE

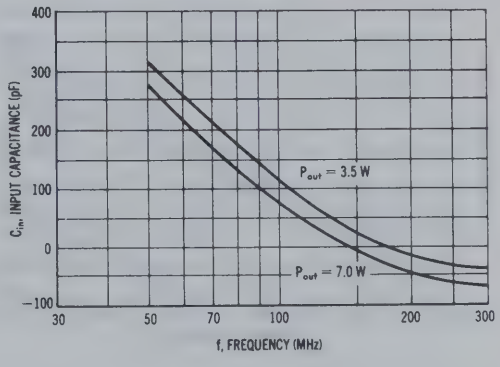
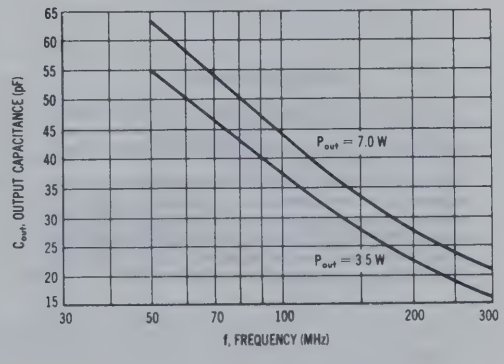


FIGURE 17 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3927

FIGURE 18 — POWER INPUT vs FREQUENCY

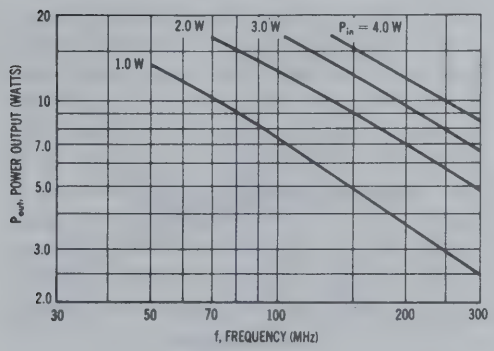
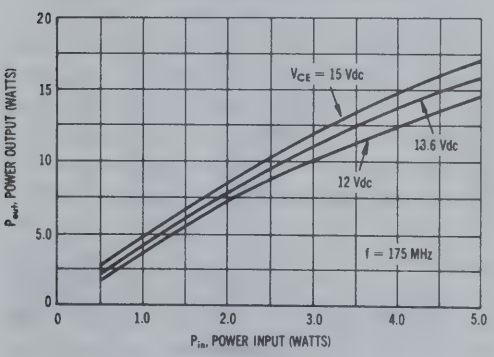


FIGURE 19 — POWER OUTPUT vs POWER INPUT



DESIGN NOTE

For Class C power-amplifier designs, small-signal parameters are not applicable. The parallel equivalent output capacitance and input resistance and capacitance for Class C power-amplifier design are used.

The parallel resistive portion of the collector load impedance for a power amplifier, R_L', may be computed by assuming a peak voltage swing equal to V_{CC}, and using the expression $R_L' = V_{CC}^2/2P$ where P = RF power output. The computed R_L' may then be combined with the data for Class C design to complete device impedance data.

FIGURE 20 — PARALLEL EQUIVALENT INPUT RESISTANCE

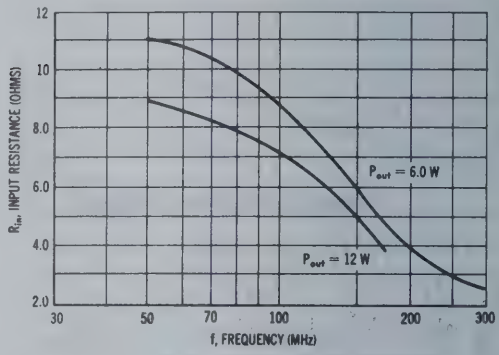


FIGURE 21 — PARALLEL EQUIVALENT INPUT CAPACITANCE

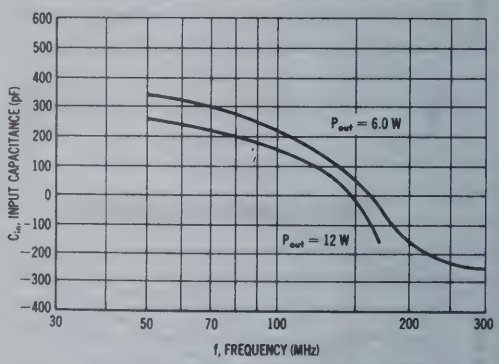
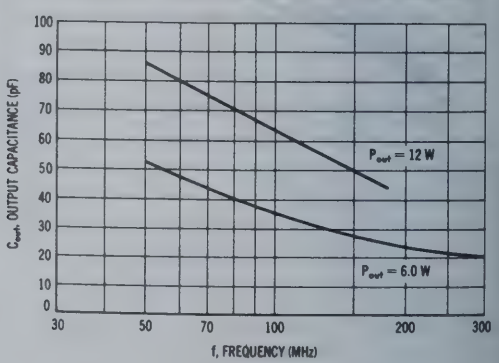


FIGURE 22 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3946 (SILICON)
2N3947



CASE 22
(TO-18)

NPN silicon annular transistors, designed for general purpose switching and amplifier applications. The 2N3946 and 2N3947 are complementary with PNP types 2N3250 and 2N3251, respectively.

Collector connected to case

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	6	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_C = 25°C$	P_D	1.2	Watts
Derating Factor Above 25°C		6.9	mW/°C
Total Device Dissipation @ $T_A = 25°C$	P_D	0.36	Watt
Derating Factor Above 25°C		2.06	mW/°C
Thermal Resistance			
Junction to Ambient	θJA	0.49	°C/mW
Junction to Case	θJC	0.15	°C/mW
Junction Operating Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc)	BV_{CEO}*	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6	—	Vdc
Collector-Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3 Vdc)	I_{CEX}	—	.010	μAdc
(V_{CE} = 40 Vdc, V_{OB} = 3 Vdc, T_A = 150°C)		—	15	
Base Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3 Vdc)	I_{BL}	—	.025	μAdc

*Pulse Test: PW ≤ 300 μs , Duty Cycle ≤ 2% V_{OB} = Base-Emitter Reverse Bias

ELECTRICAL CHARACTERISTICS (continued)

(T_A = 25°C unless otherwise noted)

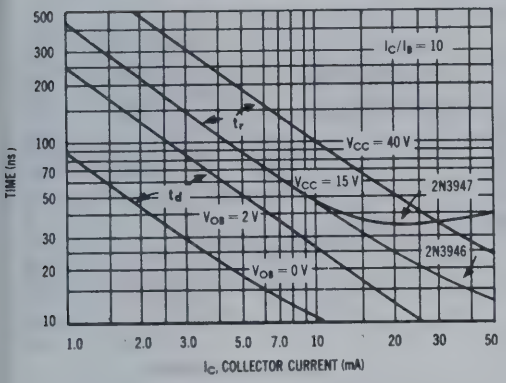
Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			—
(I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N3946		30	—	
	2N3947		60	—	
(I_C = 1.0 mAdc, V_{CE} = 1 Vdc)	2N3946		45	—	
	2N3947		90	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N3946		50	150	
	2N3947		100	300	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N3946		20	—	
	2N3947		40	—	
Collector Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			—	0.2	
(I_C = 50 mAdc, I_B = 5 mAdc)			—	0.3	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			0.6	0.9	
(I_C = 50 mAdc, I_B = 5 mAdc)			—	1.0	
TRANSIENT CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	4	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	8	pF
Current-Gain - Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3946	f_T	250	—	MHz
	2N3947		300	—	
Delay Time	V_{CC} = 3 Vdc, V_{OB} = 0.5 Vdc	t_d	—	35	ns
Rise Time	I_C = 10 mAdc, I_{B1} = 1 mA	t_r	—	35	ns
Storage Time	V_{CC} = 3 V, I_C = 10 mA, 2N3946	t_s	—	300	ns
	V_{CC} = 3 V, I_C = 10 mA, 2N3947		—	375	
Fall Time	I_{B1} = $-I_{B2}$ = 1 mAdc	t_f	—	75	ns
SMALL SIGNAL CHARACTERISTICS					
Small-Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3946	h_{fe}	50	250	—
	2N3947		100	700	
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3946	h_{re}	—	10	X10-4
	2N3947		—	20	
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3946	h_{ie}	0.5	6	kohms
	2N3947		2	12	
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3946	h_{oe}	1	30	μmhos
	2N3947		5	50	
Collector-Base Time Constant (I_C = 10 mA, V_{CE} = 20 V, f = 31.8 MHz)		r'_bC_C	—	200	ps
Wide Band Noise Figure (I_C = 100 μA, V_{CE} = 5 V, R_g = 1 kΩ, f = 10 Hz to 15.7 kHz)		NF	—	5	dB

*Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2% V_{OB} = Base-Emitter Reverse Bias

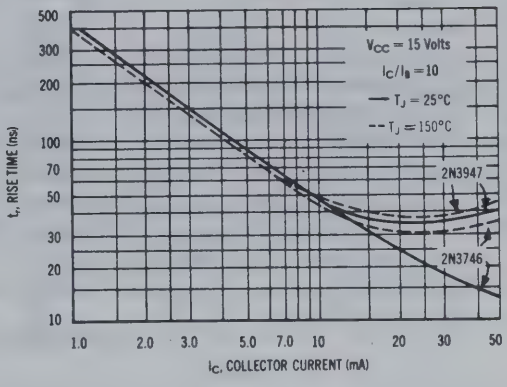
TYPICAL SWITCHING CHARACTERISTICS

($T_J = 25°C$ unless otherwise noted)

DELAY AND RISE TIME

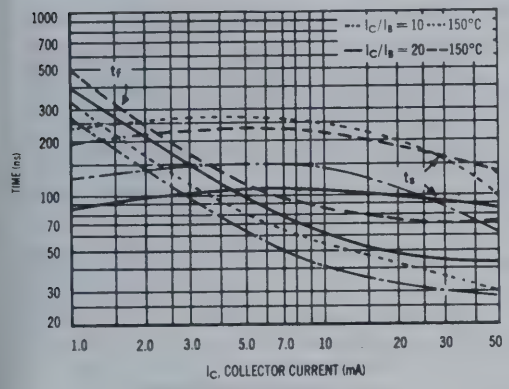


RISE TIME

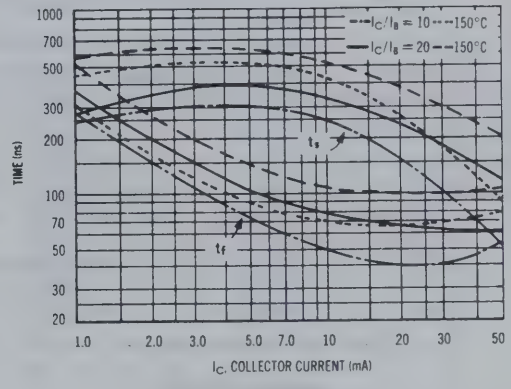


STORAGE AND FALL TIMES

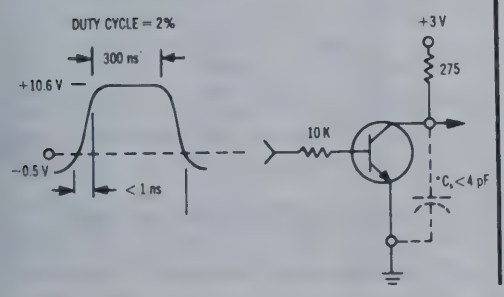
2N3946



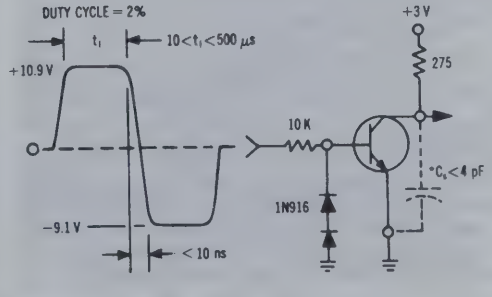
2N3947



TURN-ON TIME EQUIVALENT TEST CIRCUIT



TURN-OFF TIME EQUIVALENT TEST CIRCUIT

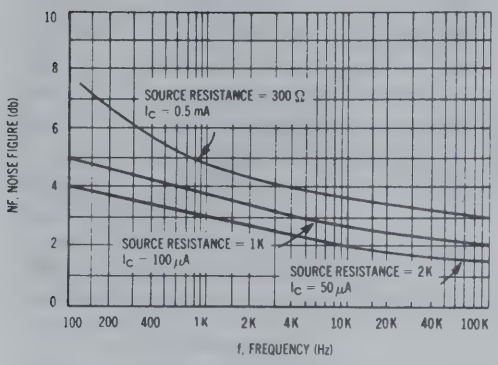


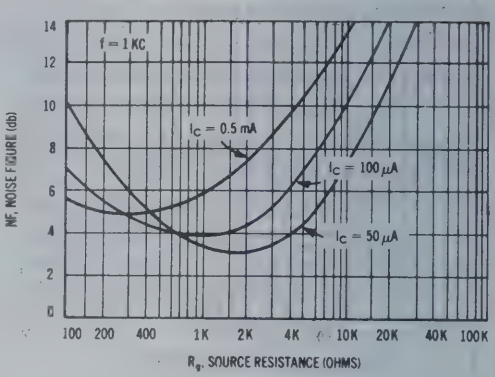
*TOTAL SHUNT CAPACITANCE OF TEST JIG AND CONNECTORS

AUDIO SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5 V, T_A = 25°C

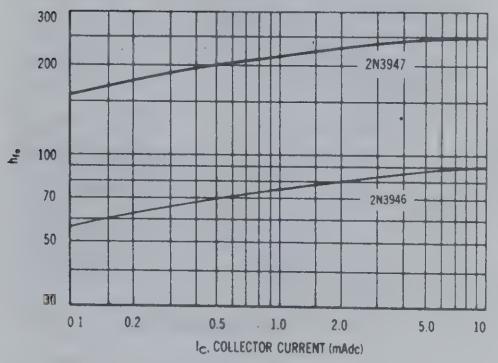




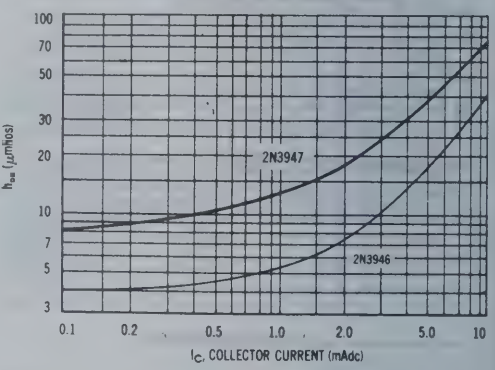
h PARAMETERS

V_{CE} = 10 V, T_A = 25°C, f = 1 Kc

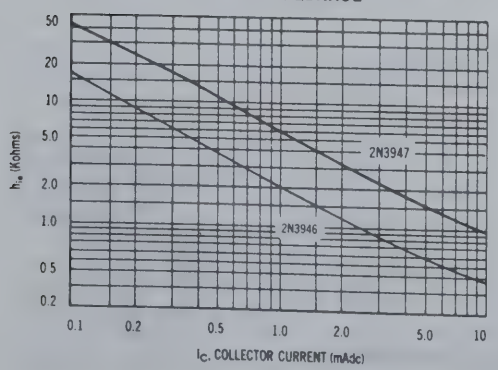
CURRENT GAIN



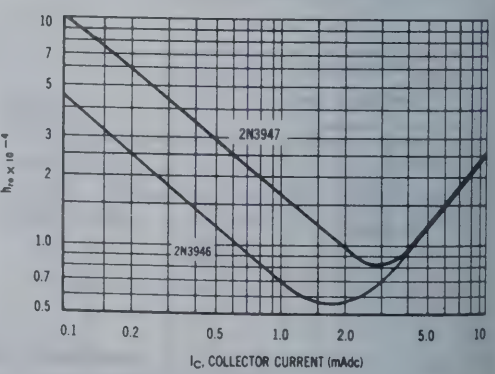
OUTPUT ADMITTANCE



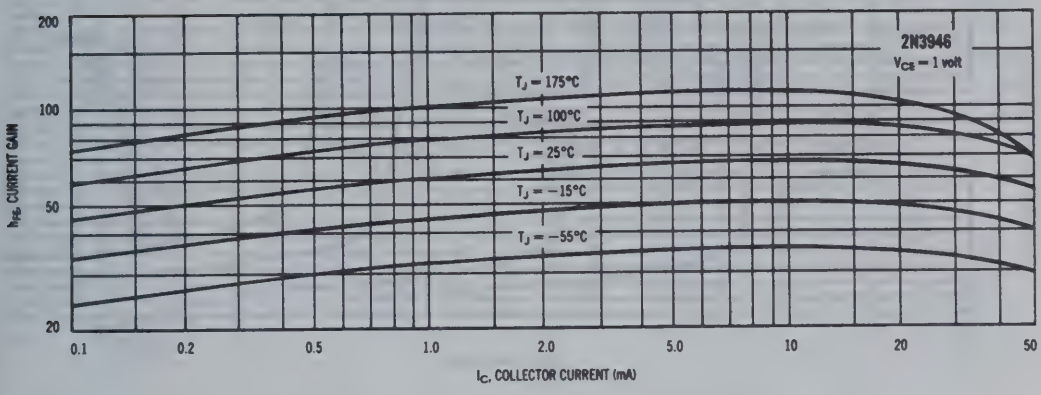
INPUT IMPEDANCE

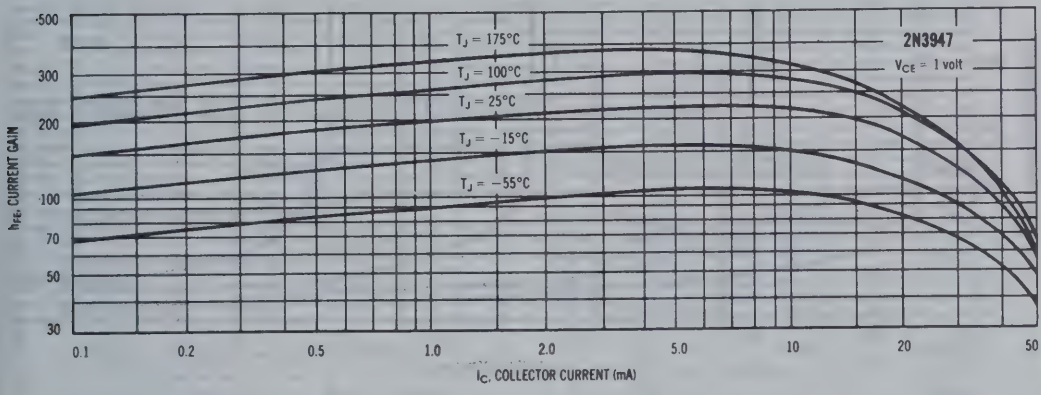


VOLTAGE FEEDBACK RATIO

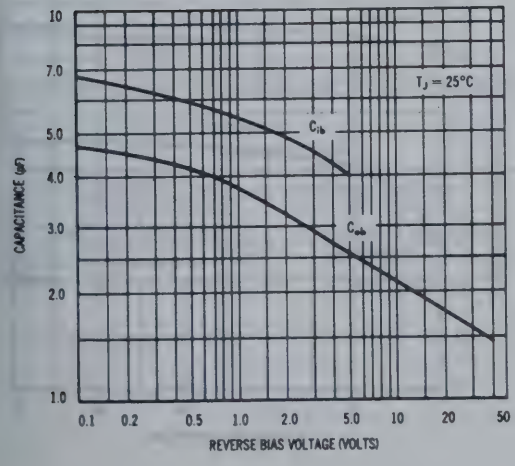


CURRENT GAIN CHARACTERISTICS

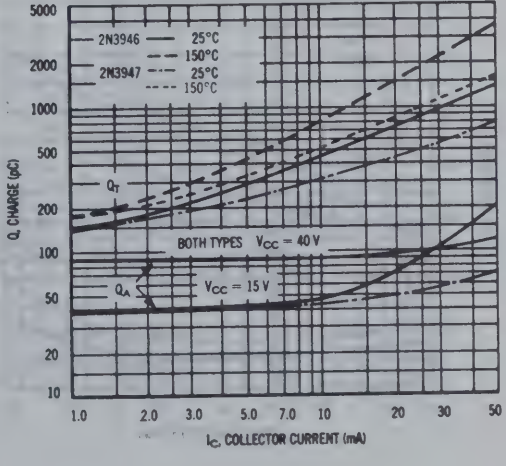




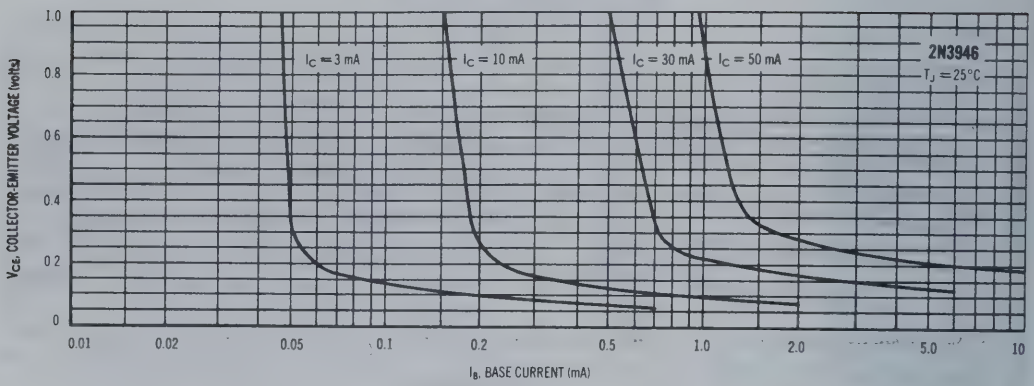
CAPACITANCE

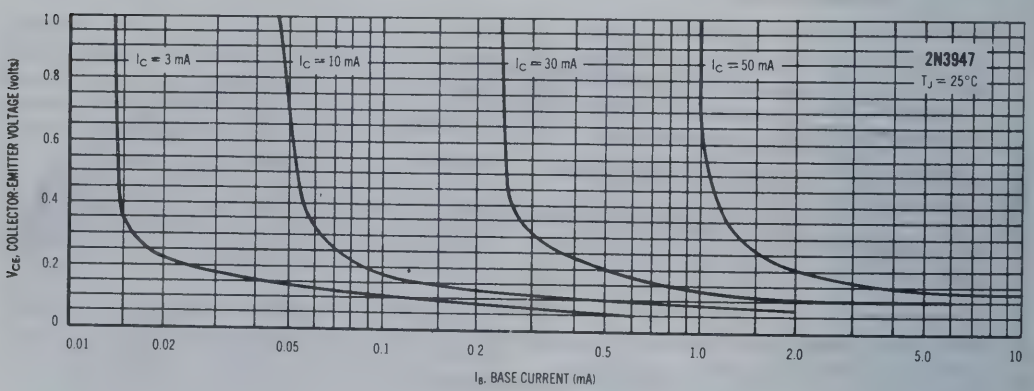


CHARGE DATA

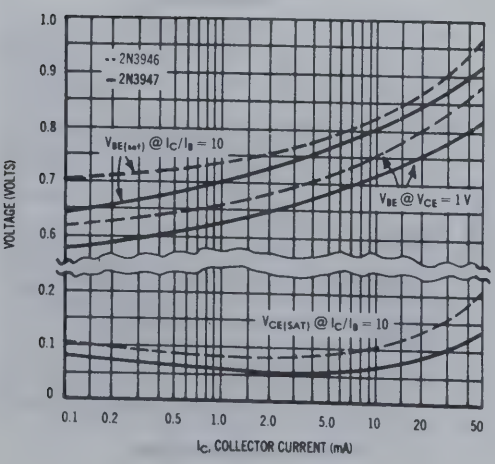


COLLECTOR SATURATION REGION

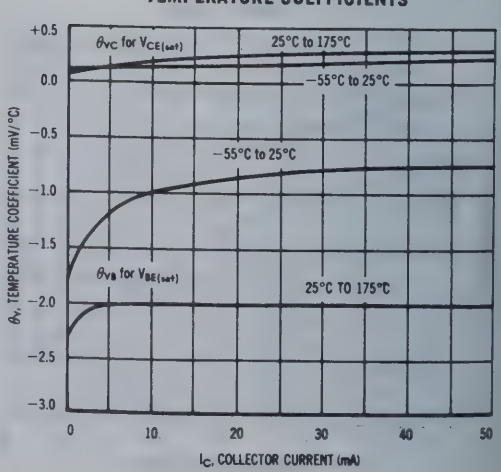




"ON" VOLTAGES



TEMPERATURE COEFFICIENTS



2N3948 (SILICON)



CASE 79
(TO-39)

NPN silicon RF power transistor designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output, driver, or pre-driver stages in VHF and UHF equipment. Ideal for CATV applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1 5.71	Watt mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	35	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 5 mAdc, I_B = 0)		$BV_{CEO(sus)}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		BV_{CBO}	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	3.5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	0.1	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)			—	100	
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5 Vdc)		h_{FE}	15	—	—
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_E = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		f_T	700	—	MHz
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	—	4.5	pF
FUNCTIONAL TEST					
Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms,	G_{PE}	6	—	dB
Power Output	R_L = 50 ohms, f = 400 MHz,	P_{out}	1	—	Watt
Collector Efficiency	P_{in} = 0.25 W	η	45	—	%

SMALL-SIGNAL ADMITTANCE PARAMETERS VERSUS FREQUENCY

(I_C = 80 mAdc, V_{CE} = 15 Vdc, T_A = 25°C)

FIGURE 1 — y_{ie}

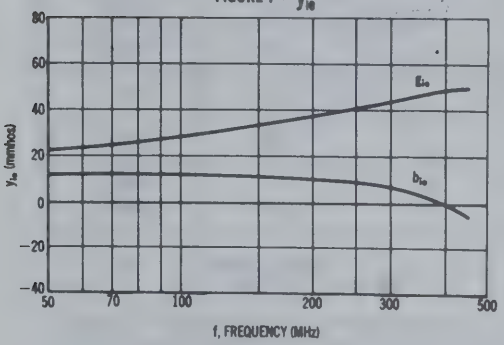


FIGURE 2 — y_{re}

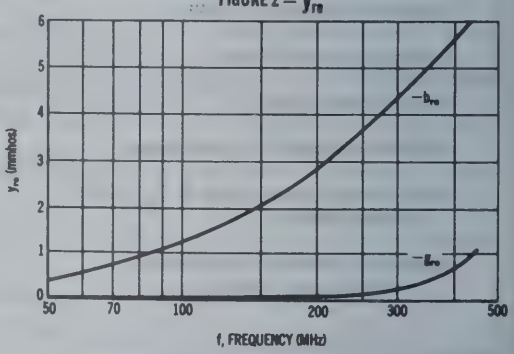


FIGURE 3 — y_{fe}

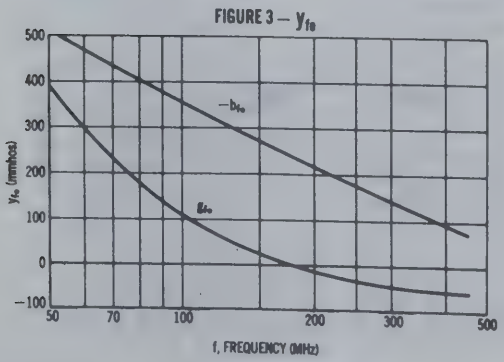


FIGURE 4 — y_{oe}

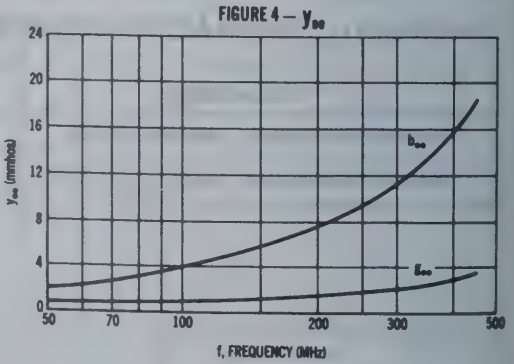


FIGURE 5 — SMALL-SIGNAL CURRENT GAIN

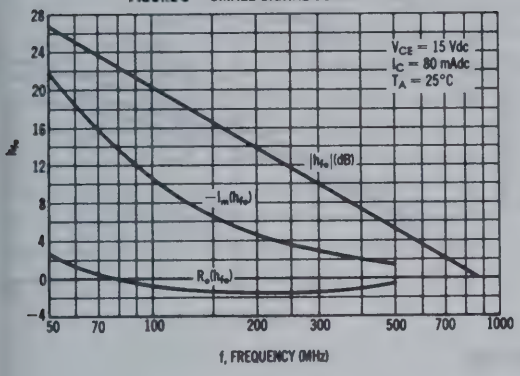
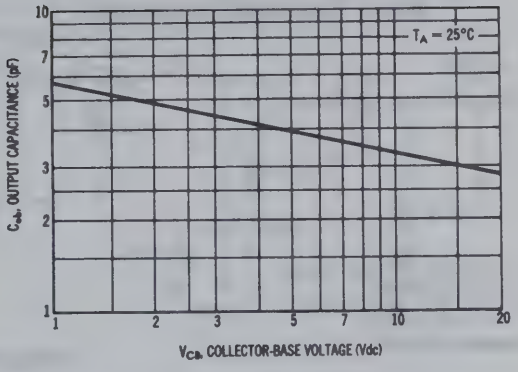


FIGURE 6 — OUTPUT CAPACITANCE



SMALL-SIGNAL ADMITTANCE PARAMETERS VERSUS COLLECTOR CURRENT

(f = 200 MHz, T_A = 25°C)

— V_{CE} = 10 V — V_{CE} = 15 V

FIGURE 7 — y_{ie}

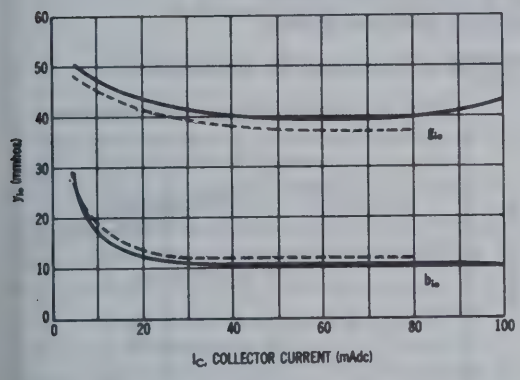


FIGURE 8 — y_{re}

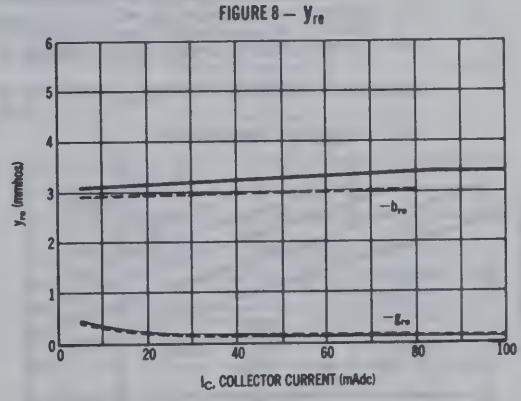


FIGURE 9 — y_{fe}

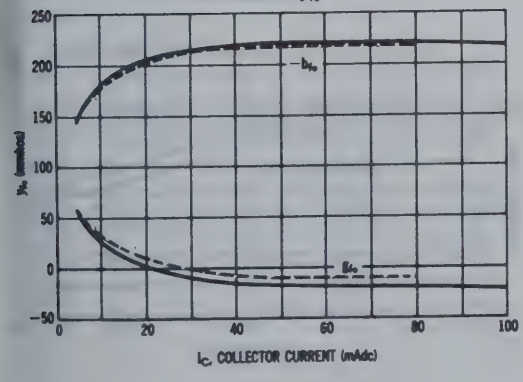


FIGURE 10 — y_{oe}

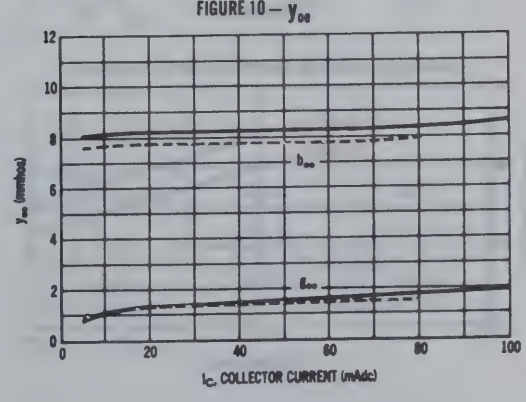
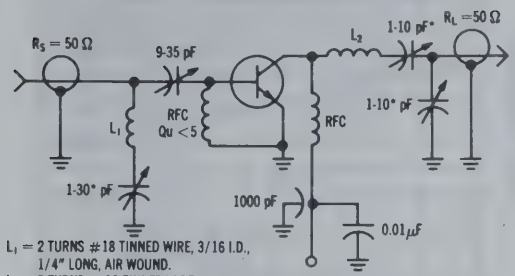
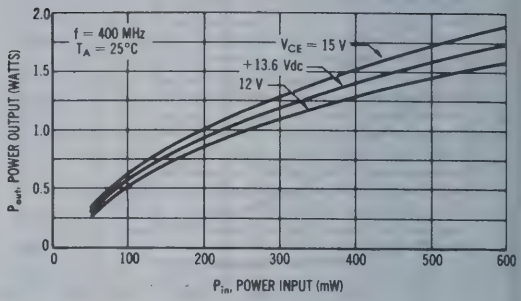


FIGURE 11 — 400 MHz RF AMPLIFIER TEST CIRCUIT



L_1 = 2 TURNS #18 TINNED WIRE, 3/16 I.D., 1/4" LONG, AIR WOUND.
L_2 = 2 TURNS, #18 TINNED WIRE, 1/2 I.D., 3/16" LONG, AIR WOUND.
*AIR VARIABLE CAPACITORS

FIGURE 12 — POWER GAIN



DESIGN NOTE

Figures 1 through 4 and 7 through 10 show small-signal admittance-parameter data. This data can be used for Class A amplifier designs.

For Class C power-amplifier designs, the small-signal parameters are not applicable. The parallel equivalent output capacitance and input resistance and capacitance for Class C power-amplifier operation are used

The parallel resistive portion of the collector load impedance for a power amplifier, R_L', may be computed by assuming a peak voltage swing equal to V_{CC}, and using the expression $R_L' = V_{CC}^2/2P$ where P = RF power output. The computed R_L' may then be combined with the data in Figures 14, 15 and 16 to comprise complete device impedance data for Class C power amplifier design.

CLASS C DESIGN DATA (EMITTER GROUNDED DIRECTLY TO CHASSIS)

(V_{CE} = 13.6 V, T_A = 25°C)

FIGURE 13 — POWER OUTPUT

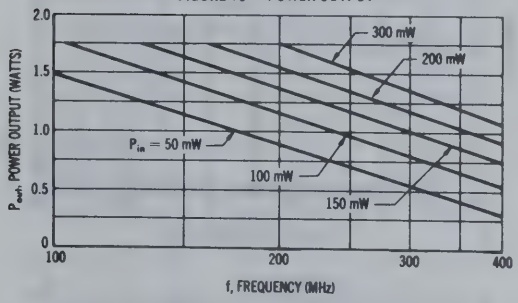


FIGURE 14 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE

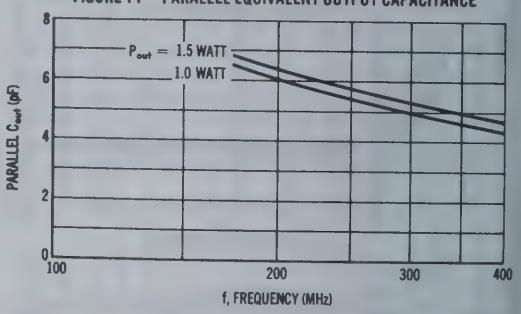


FIGURE 15 — PARALLEL EQUIVALENT INPUT RESISTANCE

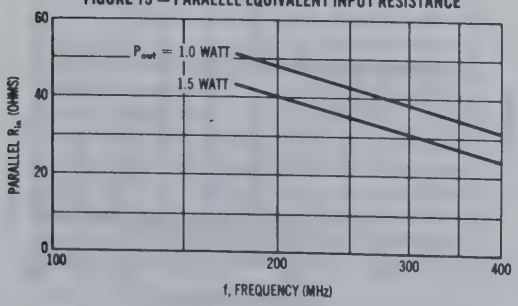
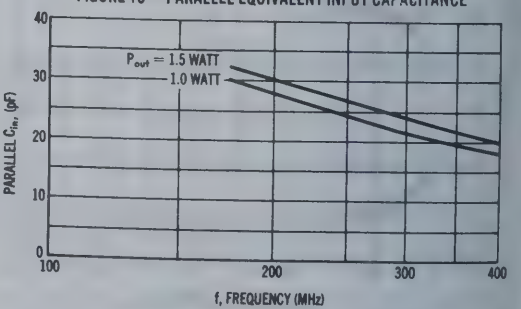


FIGURE 16 — PARALLEL EQUIVALENT INPUT CAPACITANCE



2N3950 (SILICON)



NPN silicon RF power transistor designed for high-power RF amplifier applications in military and industrial equipment.

CASE 36
(TO-60)

Emitter common to stud and case

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector-Current — Continuous	I_C	3.3	Amp
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	2.8 16	Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	70 0.4	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

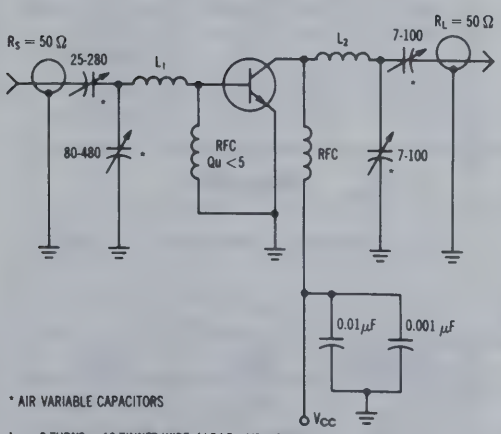
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	62.5	°C/W
Thermal Resistance, Junction to Case	θ_{JC}	2.5	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	35	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)	BV_{CES}	65	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	BV_{EBO}	4	—	—	Vdc
Collector Cutoff Current (V_{CB} = 65 Vdc, I_E = 0)	I_{CBO}	—	—	10	mAdc
(V_{CB} = 28 Vdc, I_E = 0, T_A = 150°C)		—	—	10	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_E = 500 mAdc, V_{CE} = 28 Vdc, f = 50 MHz)	f_T	—	150	—	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	80	120	pF
FUNCTIONAL TEST					
Power Gain	Test Circuit — Figure 1, P_{out} = 50 W, V_{CC} = 28 Vdc, R_S = 50 ohms, f = 50 MHz	G_{PE}	8	—	—	dB
Collector-Efficiency		η	60	—	—	%

*Pulsed through a 25 mH inductor; Duty factor = 50%, Rep. Rate ≤ 80 Hz.

FIGURE 1 — 50 MHz TEST CIRCUIT

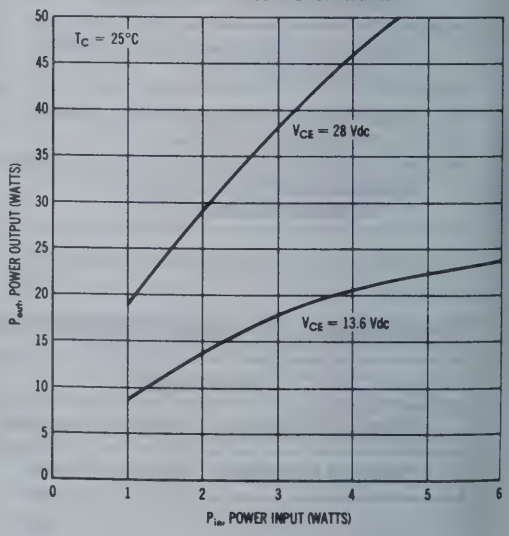


* AIR VARIABLE CAPACITORS

L_1 = 2 TURNS #18 TINNED WIRE, ¼" I.D., AIR WOUND, WINDING LENGTH ⅛".

L_2 = 5 TURNS #16 TINNED WIRE, ⅜" I.D., AIR WOUND, WINDING LENGTH ¾".

FIGURE 2 — 50 MHz POWER GAIN



CLASS C DESIGN DATA FOR V_{CE} = 28 Vdc, T_C = 25°C

(EMITTER GROUNDED DIRECTLY TO THE CHASSIS — NO TUNED-EMITTER TECHNIQUES USED)

FIGURE 3 — POWER OUTPUT

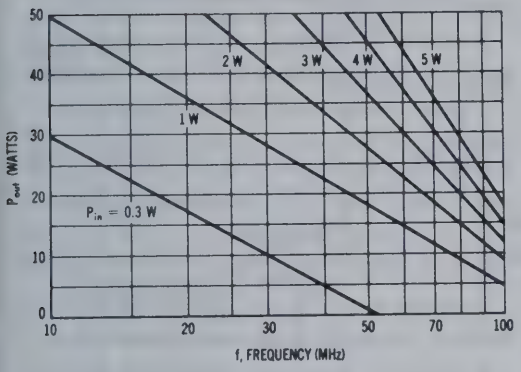


FIGURE 4 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE

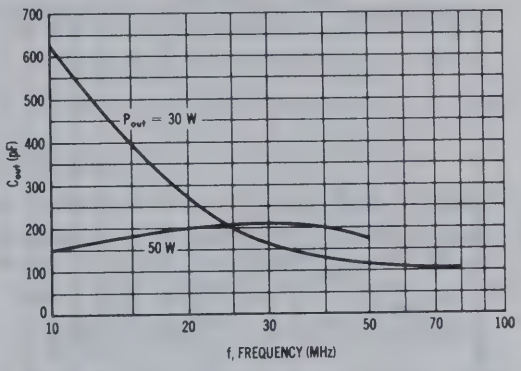


FIGURE 5 — PARALLEL EQUIVALENT INPUT RESTISTANCE

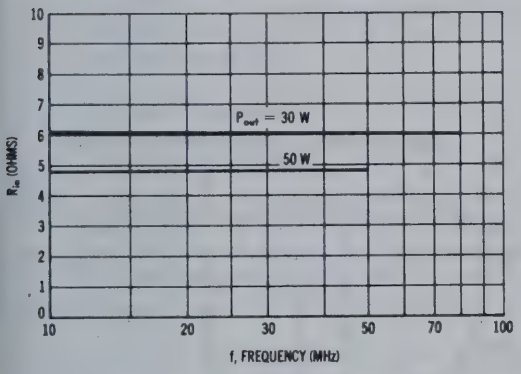
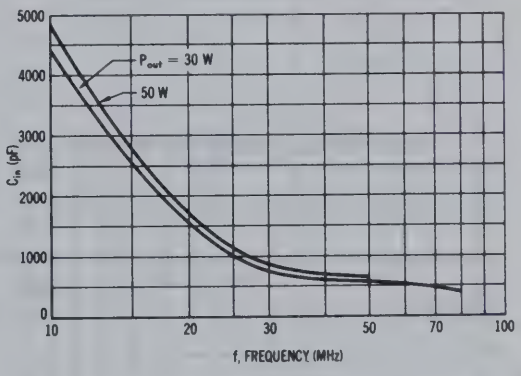


FIGURE 6 — PARALLEL EQUIVALENT INPUT CAPACITANCE



DESIGN NOTES

For Class-C power-amplifier designs, the small-signal parameters are not applicable. Figures 4 thru 6 and 8 thru 10 give the parallel equivalent output capacitance and input capacitance and resistance for Class-C power-amplifier operation.

The parallel resistive portion of the collector load impedance for a power amplifier, R_L' may be computed by assuming a peak voltage swing equal to V_{CC}, and using the expression $R_L' = V_{CC}^2/2P$ where P = RF power output. The computed R_L' may then be combined with the data in Figures 4 through 10 to comprise complete device impedance data for Class-C power-amplifier design.

Due to the high performance capabilities of the 2N3950, care should be exercised during initial tuning of prototype circuits.

Input power should be increased gradually, while stopping at intermediate levels to tune. If tuning difficulties are experienced, or if the power or collector current are abnormal at any intermediate power input level, the difficulties should be resolved before increasing power levels further.

The 2N3950 is designed to provide maximum ruggedness commensurate with its high performance. Operation at loads with high SWR may produce dangerous voltage and current excursions, a condition which should be avoided. In addition, disconnecting the load at full power output could increase device dissipation to over 70 watts which could result in device failure due to dissipation beyond safe limits set by the junction to ambient thermal resistance, regardless of the internal construction and safe area of the device.

CLASS C DESIGN DATA FOR $V_{CE} = 13.6$ Vdc, $T_C = 25°C$

(EMITTER GROUNDED DIRECTLY TO THE CHASSIS — NO TUNED-EMITTER TECHNIQUES USED)

FIGURE 7 — POWER OUTPUT

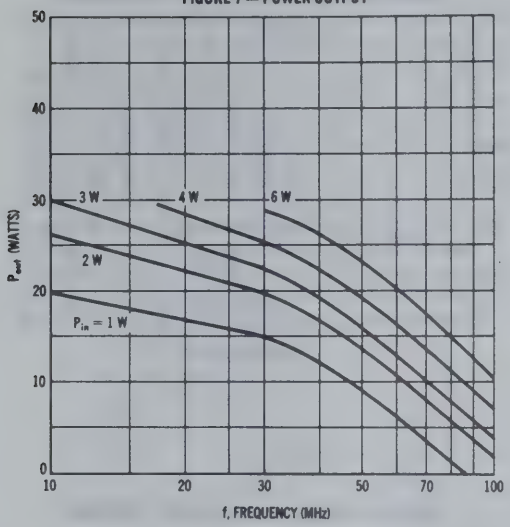


FIGURE 8 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE

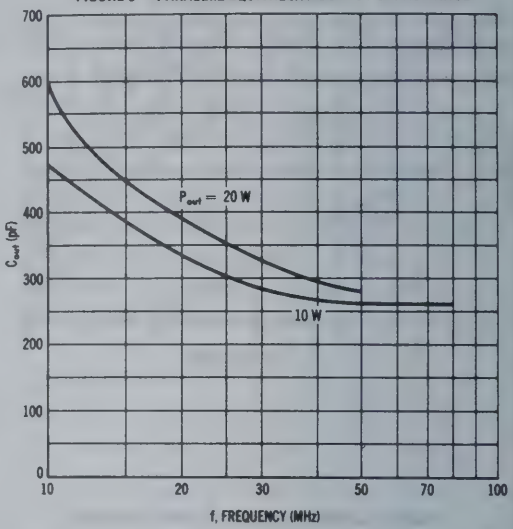


FIGURE 9 — PARALLEL EQUIVALENT INPUT RESISTANCE

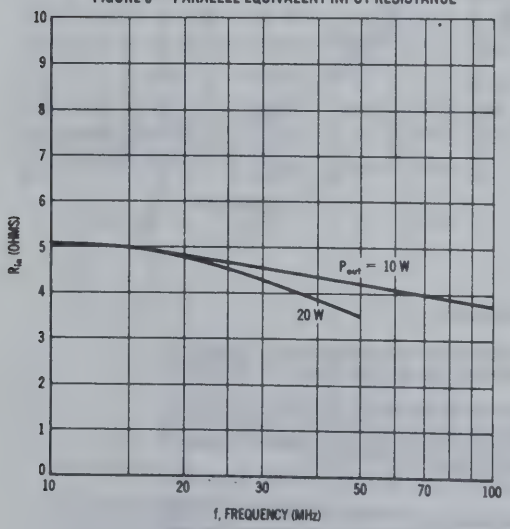
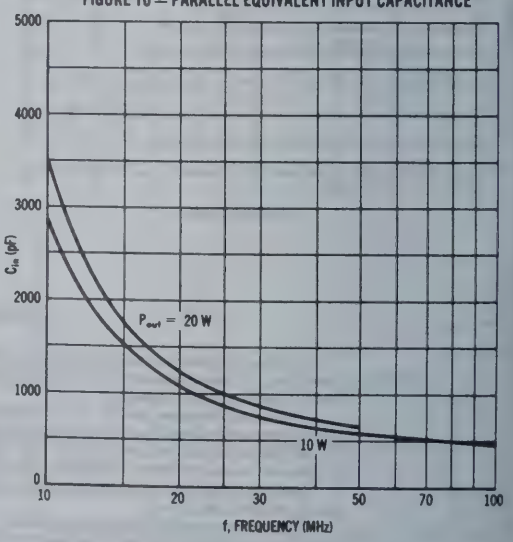


FIGURE 10 — PARALLEL EQUIVALENT INPUT CAPACITANCE



2N3959 (SILICON)
2N3960



CASE 22
(TO-18)

NPN silicon annular transistors particularly well suited for high-speed current-mode logic switching applications.

Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	20	Vdc
Collector-Emitter Voltage (1 to 30 mA)	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	750 4.3	mW mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.3	mW mW/°C
Thermal Resistance Junction to Case Junction to Ambient	 θ_{JC} θ_{JA}	 0.233 0.436	°C/mW
Junction Operating Temperature Range	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	20	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.5	—	Vdc
Collector Reverse Current (V_{CE} = 10 Vdc, V_{EB} = 2 Vdc) (V_{CE} = 10 Vdc, V_{EB} = 2 Vdc, T_A = 150°C)	9	I_{CEX}	— —	.005 5	μAdc
Base Cutoff Current (V_{CE} = 10 Vdc, V_{EB} = 2 Vdc)	9	I_{BL}	—	.005	μAdc
Collector Forward Current (V_{CE} = 5 Vdc, V_{BE} = 0.4 Vdc)	9	I_{CEX}	—	0.10	μAdc

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain	1	h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 1 Vdc)			25	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)			40	200	
(I_C = 30 mAdc, V_{CE} = 1 Vdc)			25	—	
Collector-Emitter Saturation Voltage	2, 3, 4	$V_{CE(sat)}$			Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)			—	0.2	
(I_C = 30 mAdc, I_B = 3 mAdc)			—	0.3	
Base-Emitter "ON" Voltage	3,4	$V_{BE(ON)}$			Vdc
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)			—	0.8	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)			—	1.0	
TRANSIENT CHARACTERISTICS					
Output Capacitance	8	C_{ob}			pF
(V_{CB} = 4 Vdc, I_E = 0, f = 1 kHz)			—	2.5	
Input Capacitance	8	C_{ib}			pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)			—	2.5	
High-Frequency Current Gain		$\lvert h_{fe} \rvert$			—
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N3959			13	—	
2N3960			16	—	
Current-Gain - Bandwidth Product	5	f_T			MHz
(I_C = 5 mAdc, V_{CE} = 4 Vdc, f = 100 MHz) 2N3959			1000	—	
2N3960			1300	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N3959			1300	—	
2N3960			1600	—	
(I_C = 30 mAdc, V_{CE} = 4 Vdc, f = 100 MHz) 2N3959			1000	—	
2N3960			1200	—	
Collector-Base Time Constant	6	$r'_b C_c$			ps
(I_C = 5 mAdc, V_{CE} = 4 Vdc) 2N3959			—	30	
2N3960			—	50	
(I_C = 10 mAdc, V_{CE} = 10 Vdc) 2N3959			—	25	
2N3960			—	40	
(I_C = 30 mAdc, V_{CE} = 4 Vdc) 2N3959			—	30	
2N3960			—	50	

TYPICAL SWITCHING TIMES			Typical Performance (v_{out} = 1 V) @ 10 mA	@ 30 mA	
Turn-On Delay Time	7	$t_{on(delay)}$	2.4	2	ns
Rise Time 2N3959		t_r	3	2.2	ns
2N3960			3	1.7	ns
Turn-Off Delay Time	7	$t_{off(delay)}$	1.6	1.6	ns
Fall-Time 2N3959		t_f	3.3	2.3	ns
2N3960			3.3	1.9	ns

FIGURE 1

MINIMUM DC CURRENT GAIN

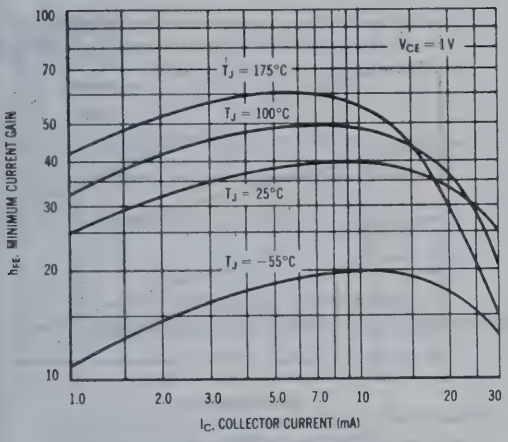


FIGURE 2

COLLECTOR SATURATION REGION

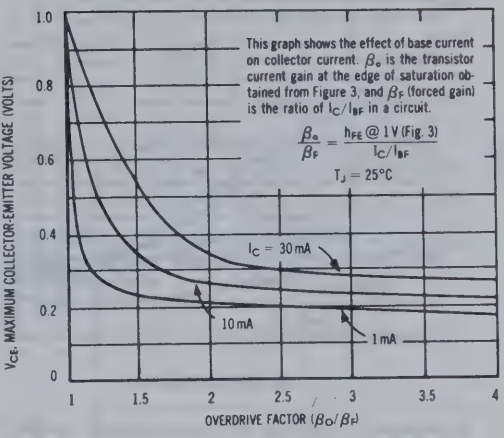


FIGURE 3

"ON" VOLTAGE LIMITS

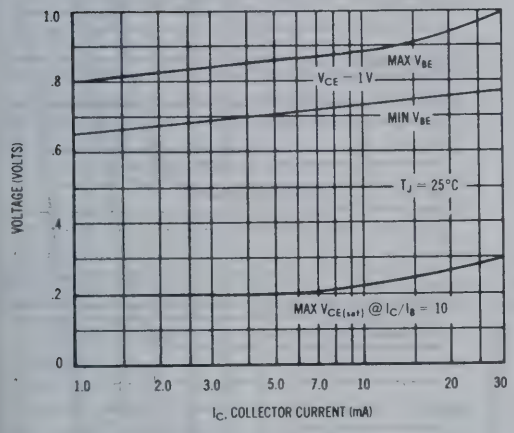


FIGURE 4

MAXIMUM COLLECTOR-BASE TIME CONSTANT

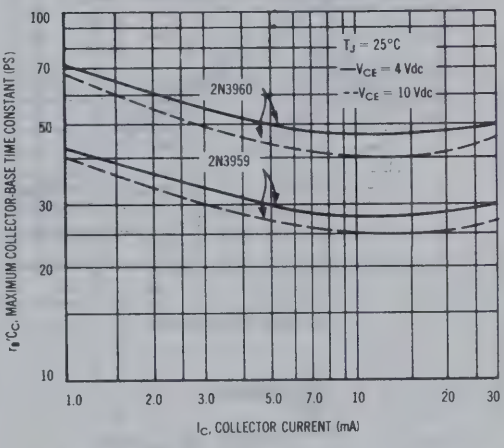


FIGURE 5

TYPICAL TEMPERATURE COEFFICIENTS

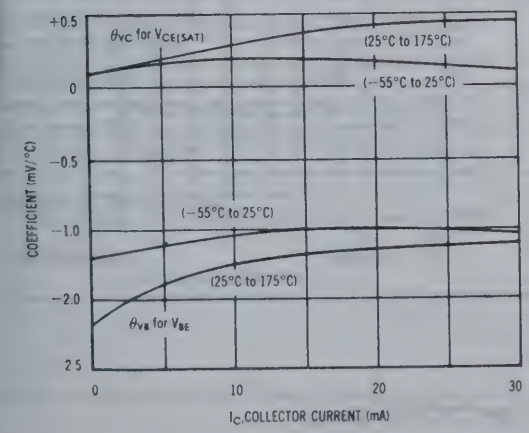
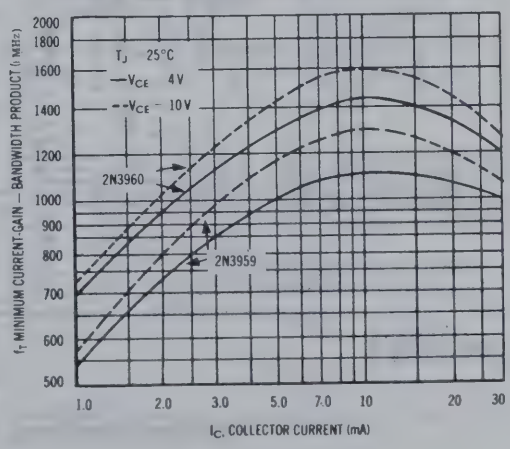


FIGURE 6

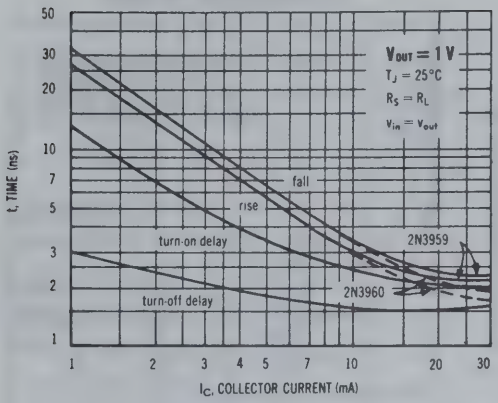
MINIMUM CURRENT GAIN-BANDWIDTH PRODUCT

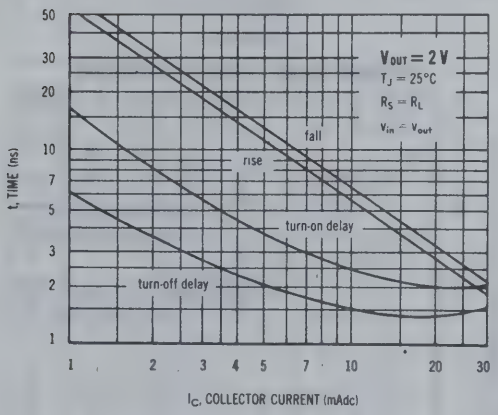


2N3959, 2N3960 (continued)

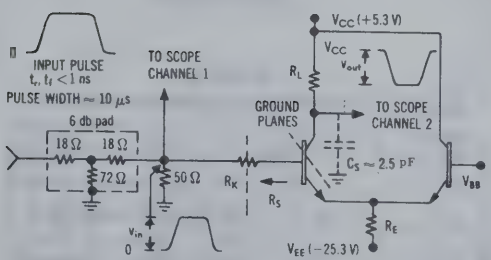
FIGURE 7

TYPICAL SWITCHING TIMES





TEST CIRCUIT



THIS TEST SET UP IS DESIGNED TO SIMULATE A CASCADE OF IDENTICAL STAGES. THE SOURCE RESISTANCE (R_S) EQUALS THE LOAD RESISTANCE (R_L). VALUES USED IN THE TEST ARE SHOWN IN THE TABLE.

FOR $V_{in} = V_{out} = 1$ V, $V_{BB} = +0.5$ V, R_L & R_K VALUES APPROPRIATELY REDUCED

$V_{in} = V_{out} = 2$ volts, $V_{BB} = +1.0$ V			
I_C (mA)	R_E (KΩ)	R_L (Ω)	R_K (Ω)
1.0	24.0	2 K	2 K
3.0	8.2	680	680
10	2.4	200	180
30	0.8	68	36

FIGURE 8

JUNCTION CAPACITANCE

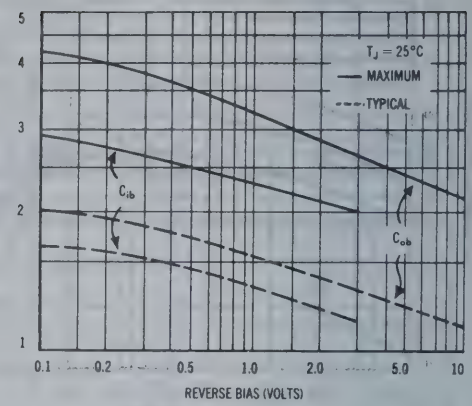
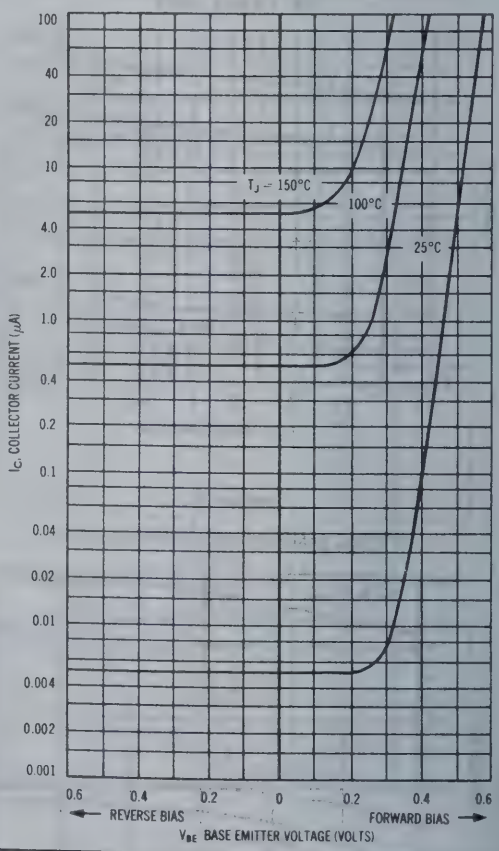


FIGURE 9

MAXIMUM CUT-OFF CHARACTERISTICS



2N3961

For Specifications, See 2N3375 Data.

2N3970 (SILICON)
2N3971
2N3972

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for chopper and high-speed switching applications.

- High Input Impedance —
  I_{GSS} = 250 pAdc (Max) @ V_{GS} = 20 Vdc
- Low Drain-Source "ON" Resistance —
  $r_{ds(on)}$ = 30 Ohms (Max) @ f = 1.0 kHz (2N3970)
- Guaranteed Switching Characteristics

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

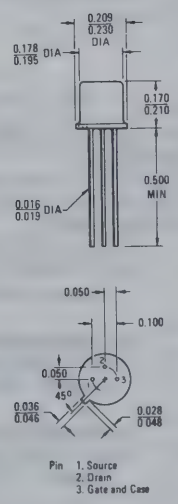
(Type A)



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



Pin 1. Source
2. Drain
3. Gate and Case

CASE 22 (4)
TO-18

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{GS} = 0)		$V_{(BR)GSS}$	40	–	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	–	250	pAdc
Drain Reverse Current		I_{DGO}			
(V_{DG} = 20 Vdc, I_S = 0)			–	250	pAdc
(V_{DG} = 20 Vdc, I_S = 0, T_A = 150°C)			–	500	nAdc
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = 20 Vdc, V_{GS} = – 12 Vdc)			–	250	pAdc
(V_{DS} = 20 Vdc, V_{GS} = – 12 Vdc, T_A = 150°C)			–	500	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1)		I_{DSS}			mAdc
(V_{DS} = 20 Vdc, V_{GS} = 0)	2N3970		50	150	
	2N3971		25	75	
	2N3972		5.0	30	
Gate-Source Voltage		V_{GS}			Vdc
(V_{DS} = 20 Vdc, I_D = 1.0 nAdc)	2N3970		4.0	10	
	2N3971		2.0	5.0	
	2N3972		0.5	3.0	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 20 mAdc, V_{GS} = 0)	2N3970		–	1.0	
(I_D = 10 mAdc, V_{GS} = 0)	2N3971		–	1.5	
(I_D = 5.0 mAdc, V_{GS} = 0)	2N3972		–	2.0	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$			Ohms
(I_D = 1.0 mAdc, V_{GS} = 0)	2N3970		–	30	
	2N3971		–	60	
	2N3972		–	100	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N3970		–	30	
	2N3971		–	60	
	2N3972		–	100	
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	25	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = – 12 Vdc, f = 1.0 MHz)		C_{rss}	–	6.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay Time	Test Condition for 2N3970:				
(V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 20 mAdc, $V_{GS(off)}$ = 10 Vdc)	2N3970	$t_{d(on)}$	–	10	ns
	2N3971		–	15	
	2N3972		–	40	
Rise Time	Test Condition for 2N3971:				
(V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 5.0 Vdc)	2N3970	t_r	–	10	ns
	2N3971		–	15	
	2N3972		–	40	
Turn-Off Time	Test Condition for 2N3972:				
(V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 5.0 mAdc, $V_{GS(off)}$ = 3.0 Vdc)	2N3970	t_{off}	–	30	ns
	2N3971		–	60	
	2N3972		–	100	

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle = 3.0%.

2N3980 (SILICON)



CASE 22 A
(TO-18 Modified)
(Lead 3 connected to case)

Silicon annular PN unijunction transistor designed for military and industrial use in pulse, timing, sensing, and oscillator circuits.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D	360*	mW
RMS Emitter Current	I_e	50	mA
Peak Pulse Emitter Current**	i_e	1.0**	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage	V_{B2B1}	35	Volts
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Derate 2.4 mW/°C increase in ambient temperature. Total power dissipation (available power to Emitter and Base-Two) must be limited by external circuitry.

**Capacitance discharge current must fall to 0.37 Amp within 3.0 ms and PRR ≤ 10 PPS.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (V_{B2B1} = 10 V) Note 1	η	0.68	—	0.82	—
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)	R_{BB}	4.0	6.0	8.0	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65°C to +100°C)	αR_{BB}	0.4	—	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA) Note 2	$V_{EB1(sat)}$	—	2.5	3.0	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)	$I_{B2(mod)}$	12	15	—	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)	I_{EO}	—	5.0	10	nA
(V_{B2E} = 30 V, I_{B1} = 0, T_A = 125°C)		—	—	1.0	μA
Peak Point Emitter Current (V_{B2B1} = 25 V)	I_P	—	0.6	2.0	μA
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms) Note 2	I_V	1.0	4.0	10	mA
Base-One Peak Pulse Voltage (Note 3, Figure 3)	V_{OB1}	6.0	8.0	—	Volts
Maximum Oscillation Frequency (Figure 4)	f(max)	1.0	1.25	—	MHz

NOTES

1. Intrinsic standoff ratio, η, is defined by equation:

$$\eta = \frac{V_P - V_{(EB1)}}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage
V_{B2B1} = Interbase Voltage
$V_{(EB1)}$ = Emitter to Base-One Junction Diode Drop (~0.5 V @ 10 μA)

2. Use pulse techniques: PW ~ 300 μs duty cycle ≤2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

3. Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

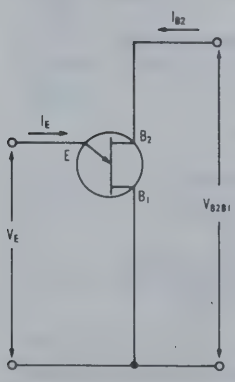


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES

(Exaggerated to Show Details)

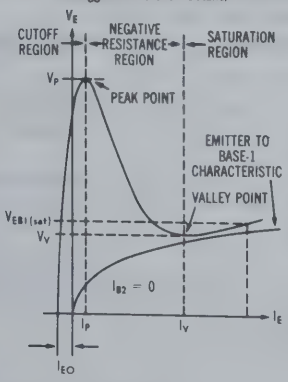


FIGURE 3 — V_{OB1} TEST CIRCUIT

(Typical Relaxation Oscillator)

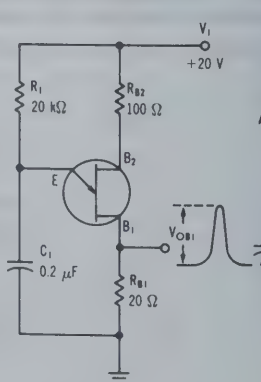
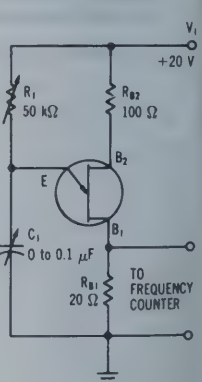


FIGURE 4 — F(max) MAXIMUM FREQUENCY TEST CIRCUIT



2N3993, 2N3994 (SILICON)
2N3994A

SILICON P-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for chopper and high-speed switching applications.

- Low Leakage Current –
  I_{DGO} = 1.2 nAdc (Max) @ V_{DG} = 15 Vdc
- Low Reverse Transfer Capacitance –
  C_{rss} = 4.5 pF (Max) @ V_{GS} = 10 Vdc (2N3993)
- Low Drain-Source "ON" Resistance –
  $r_{ds(on)}$ = 150 Ohms (Max) @ f = 1.0 kHz (2N3993)

P-CHANNEL
JUNCTION FIELD-EFFECT
TRANSISTORS

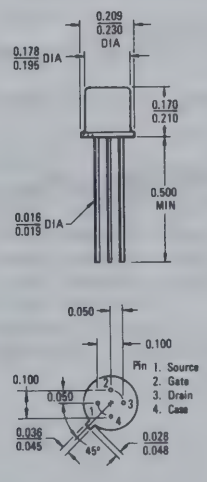
(Type A)



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



TO-72
CASE 20 (5)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	–	Vdc
Drain Reverse Current		I_{DGO}			
(V_{DG} = -15 Vdc, I_S = 0)			–	1.2	nAdc
(V_{DG} = -15 Vdc, I_S = 0, T_A = 150°C)			–	1.2	μAdc
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = -10 Vdc, V_{GS} = 10 Vdc)	2N3993		–	1.2	nAdc
(V_{DS} = -10 Vdc, V_{GS} = 6.0 Vdc)	2N3994, 2N3994A		–	1.2	
(V_{DS} = -10 Vdc, V_{GS} = 10 Vdc, T_A = 150°)	2N3993, 2N3993A		–	1.0	μAdc
(V_{DS} = -10 Vdc, V_{GS} = 6.0 Vdc, T_A = 150°)	2N3994, 2N3994A		–	1.0	
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1)		I_{DSS}			mAdc
(V_{DS} = -10 Vdc, V_{GS} = 0)	2N3993		10		
	2N3994, 2N3994A		2.0	–	
Gate-Source Voltage		V_{GS}			Vdc
(V_{DS} = -10 Vdc, I_D = -1.0 μAdc)	2N3993		4.0	9.5	
	2N3994, 2N3994A		1.0	5.5	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N3993		–	150	
	2N3994, 2N3994A		–	300	
Forward Transadmittance (Note 1)		$\|Y_{fs}\|$			mmhos
(V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N3993		6.0	12	
	2N3994		4.0	10	
	2N3994A		5.0	10	
Input Capacitance		C_{iss}			pF
(V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	2N3993, 2N3994		–	16	
	2N3994A		–	12	
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	2N3993		–	4.5	
(V_{DS} = 0, V_{GS} = 6.0 Vdc, f = 1.0 MHz)	2N3994		–	5.0	
	2N3994A		–	3.5	

*Indicates JEDEC Registered Data.
Note 1: Pulse Test: Pulse With = 100 ms, Duty Cycle ≤ 10%

2N4012 (SILICON)



stud isolated from case

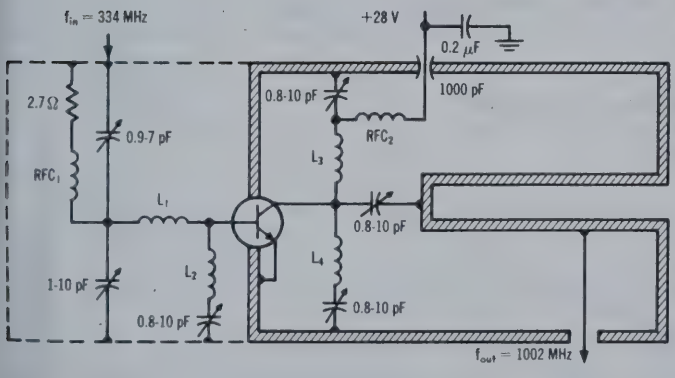
CASE 36
(TO-60)

NPN silicon annular transistor, designed for frequency – multiplication applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage ($V_{EB(off)} = 1.5$ Vdc)	V_{CEV}	65	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current	I_C	1.5	Amps
Total Device Dissipation @ $T_A = 25°C$ Derate Above 25°C	P_D	11.6 66.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 – TRIPLER TEST CIRCUIT



RFC_1 = 0.22 μH
RFC_2 = 0.33 OHMS, W.W. RESISTOR
L_1 = 2 TURNS, ⅜" DIAMETER, NO. 16 WIRE
L_2 = 1/16" WIDTH COPPER STRIP, ⅜" LONG
L_3 = 2 TURNS, ⅜" DIAMETER, NO. 18 WIRE
L_4 = 1½ TURNS, ⅜" DIAMETER, 1/16" COPPER STRIP
OUTPUT CAVITY = 1¼" X 1¼" X 2¼"
CENTER CONDUCTOR = ¼" OD TUBE
OUTPUT DIRECT COUPLE = 1" FROM SHORTED END

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 0 to 200 mAdc, I_B = 0)	BV_{CEO}*	40	-	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 0 to 200 mAdc, $V_{EB(off)}$ = 1.5 Vdc)	BV_{CEV}*	65	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	65	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	4	-	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	-	-	0.1	mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 100 mAdc)	$V_{CE(sat)}$	-	-	1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 150 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	-	500	-	MHz
Collector-Base Cutoff Frequency † (V_{CE} = 28 Vdc, I_C = 0)	f_c	-	25	-	GHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0)	C_{ob}	-	-	10	pF
Base-Spreading Resistance (I_C = 250 mAdc, V_{CE} = 28 Vdc, f = 400 MHz)*	$r_{bb'}$	-	10	-	Ohms
FUNCTIONAL TEST					
Power Output	Tripler (Test Circuit Figure 1) V_{CE} = 28 Vdc, P_{in} = 1 W, f_{in} = 334 MHz, f_{out} = 1002 MHz	P_{out}	2.5	-	-	Watts
Efficiency		η	25	-	-	%
Power Output	Doubler V_{CE} = 28 Vdc, P_{in} = 1 W, f_{in} = 400 MHz, f_{out} = 800 MHz	P_{out}	-	3.0	-	Watts
Efficiency		η	-	35	-	%

*Pulsed through a 25 mH inductor; duty cycle = 50%

†f_c is determined from Q measured at 210 MHz. f_c = Q x 210 MHz.

2N4048 thru 2N4053 (GERMANIUM)

CASE 7



PNP germanium power transistors designed for high-current applications requiring high gain and extremely low saturation voltage.

Collector connected to case

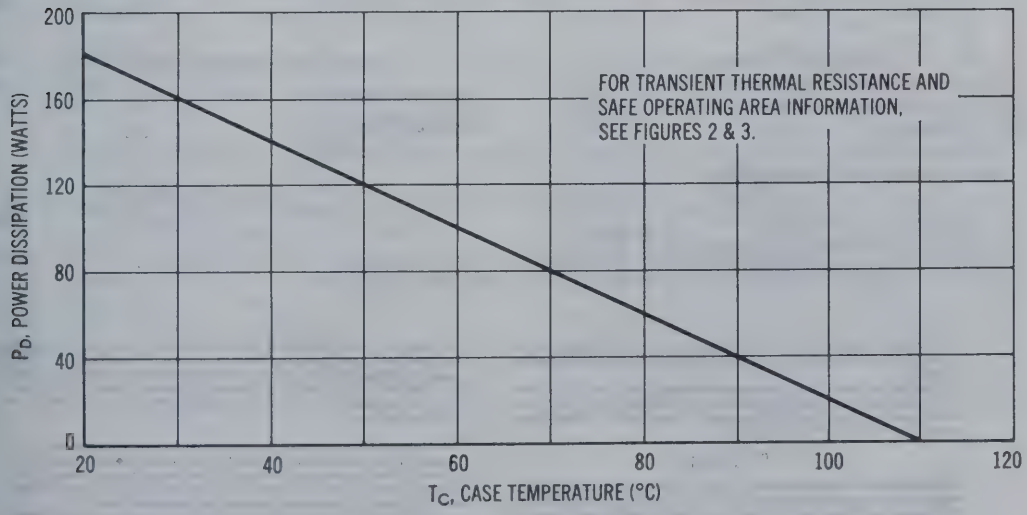
MAXIMUM RATINGS

Rating	Symbol	2N4048 2N4051	2N4049 2N4052	2N4050 2N4053	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	30	40	Vdc
Collector Current — Continuous	I_C*	← 60 →			Adc
Total Device Dissipation @ T_C = 25°C	P_D	← 170 →			Watts
Derate above 25°C		← 2.0 →			W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +110 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	← 0.5 →	°C/W

FIGURE 1 — AVERAGE POWER-TEMPERATURE DERATING CURVE



* JEDEC Registered Values, For True Capability See Figure 3

2N4048 thru 2N4053 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage† (I_C = 1.0 Adc, I_B = 0)	2N4048, 2N4051	BV_{CEO}†	30	-	Vdc
	2N4049, 2N4052		45	-	
	2N4050, 2N4053		60	-	
Collector-Emitter Breakdown Voltage (I_C = 300 mAdc, V_{BE} = 0)	2N4048, 2N4051	BV_{CES}	45	-	Vdc
	2N4049, 2N4052		60	-	
	2N4050, 2N4053		75	-	
Floating Potential (V_{CB} = 45 Vdc, I_E = 0)	2N4048, 2N4051	V_{EBF}	-	0.5	Vdc
(V_{CB} = 60 Vdc, I_E = 0)	2N4049, 2N4052		-	0.5	
(V_{CB} = 75 Vdc, I_E = 0)	2N4050, 2N4053		-	0.5	
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4048, 2N4051	I_{CEX}	-	15	mAdc
(V_{CE} = 45 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4049, 2N4052		-	15	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4050, 2N4053		-	15	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	0.2	mAdc
(V_{CB} = 45 Vdc, I_E = 0)	2N4048, 2N4051		-	4.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N4049, 2N4052		-	4.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N4050, 2N4053		-	4.0	
Emitter Cutoff Current (V_{BE} = 25 Vdc, I_C = 0)	2N4048, 2N4051	I_{EBO}	-	4.0	mAdc
(V_{BE} = 25 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 30 Vdc, I_C = 0)	2N4049, 2N4052		-	4.0	
(V_{BE} = 30 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 40 Vdc, I_C = 0)	2N4050, 2N4053		-	4.0	
(V_{BE} = 40 Vdc, I_C = 0, T_C = +71°C)			-	15	
ON CHARACTERISTICS					
DC Current Gain† (I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N4048, 2N4049, 2N4050	h_{FE}†	60	120	-
	2N4051, 2N4052, 2N4053		80	180	
(I_C = 60 Adc, V_{CE} = 2.0 Vdc)			15	-	
Collector-Emitter Saturation Voltage† (I_C = 15 Adc, I_B = 1.0 Adc)		$V_{CE(sat)}$†	-	0.15	Vdc
(I_C = 60 Adc, I_B = 6.0 Adc)			-	0.3	
Base-Emitter Saturation Voltage† (I_C = 15 Adc, I_B = 1.0 Adc)		$V_{BE(sat)}$†	-	0.6	Vdc
(I_C = 60 Adc, I_B = 6.0 Adc)			-	1.0	
SMALL SIGNAL CHARACTERISTICS					
Common-Emitter Cutoff Frequency (I_C = 15 Adc, V_{CE} = 2.0 Vdc)		$f_{\alpha e}$	2.0	-	kHz

† To avoid excessive heating of the collector junction, perform test with pulse method.

The switching performance of this transistor is determined primarily by the gain-bandwidth product, f_T*, and the behavior of the base-spreading resistance, $r_{b'}$

In the case of rise time, the base-spreading resistance plays a small part, and the test circuit delivers a constant current step of turn-on current to the transistor (I_{B1}). Therefore, the curve of t, on Figure 6 follows theory closely, i.e.:

$$t_r = 0.8 \frac{I_C}{I_{B1}} \cdot \frac{1}{2\pi f_T}$$

From the curve, it can be seen that f_T is roughly constant with current; using the equation, its large signal value can be calculated to be approximately 120 kHz at the 20-Amp level. A lower supply voltage will increase rise time slightly.

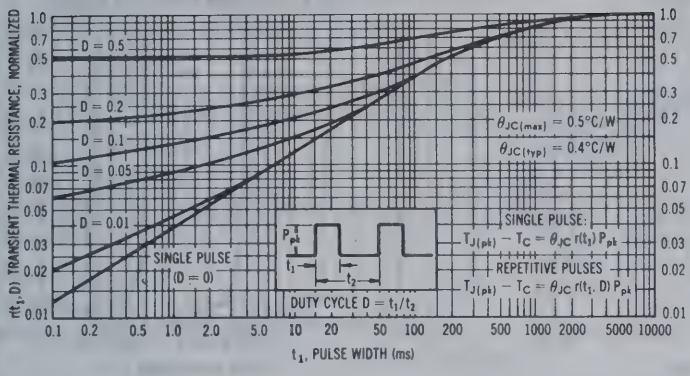
Turn-off time is slow because of conductivity modulation which occurs in the base region. When the transistor is held "on" in saturation, the base region becomes filled with excess charge; i.e., charge in excess of that necessary to sustain the circuit limited value of I_C. As a result, the base resistivity and consequently $r_{b'}$ become very low. During turn off, as the excess charge is reduced, the accompanying increase in resistivity causes a marked reduction in the turn-off current, i_{B2}, as can be seen from the waveforms of Figure 5. During fall time, the i_{B2} current is very low causing an extended fall time.

Only a slight improvement in turn-off performance is achieved with a "speed-up" capacitor placed across R_B. This unusual behavior occurs because $r_{b'}$ limits the amount of reverse current which can be achieved. Also, it seems evident that $r_{b'}$ increases with applied reverse current, so that efforts to speed up the turn-off behavior are somewhat futile.

In most applications, switching time will be close to the values shown on Figure 6. Delay time is not shown as it is negligible in comparison to the other times.

* $f_T \simeq f_{\alpha e} \times h_{fe}$

FIGURE 2 — TRANSIENT THERMAL RESISTANCE



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e. the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 110°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 110°C$. $T_{J(pk)}$ may be calculated from the data in Figure 2. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 3 — ACTIVE REGION SAFE-OPERATING AREA

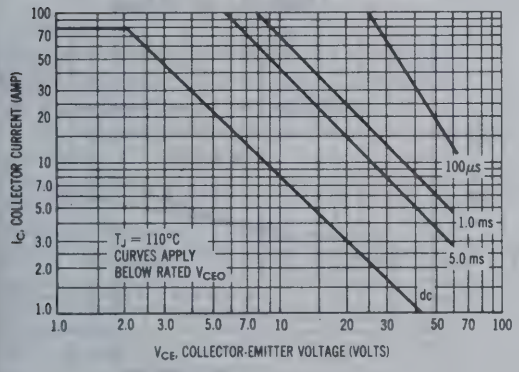
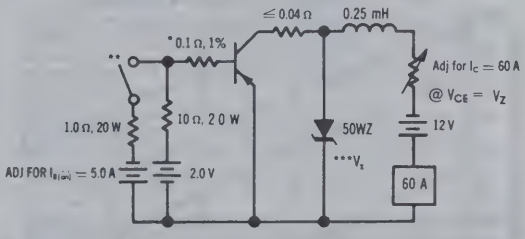


FIGURE 4 — SAFE OPERATING AREA TEST CIRCUIT



*NOT REQUIRED IF CURRENT PROBE USED TO READ I_{b1}

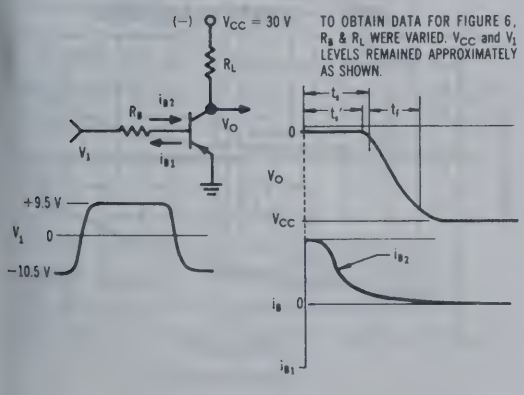
**PRF ≈ 60 Hz

SERIES IMPEDANCE & INDUCTANCE MUST BE KEPT TO A MINIMUM.

***ZENER SELECTED TO ESTABLISH SAFE OPERATING AREA VOLTAGE.

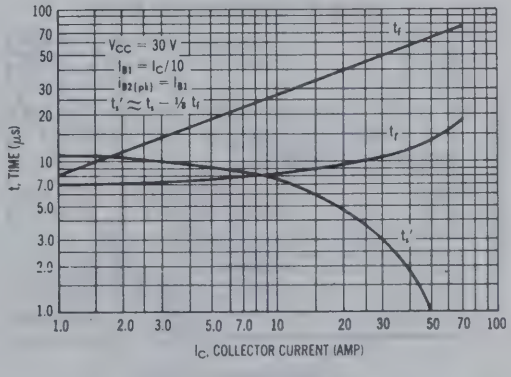
@ I_C = 60 Adc:
2N4048, 2N4051 = 35 Vdc
2N4049, 2N4052 = 40 Vdc
2N4050, 2N4053 = 45 Vdc

FIGURE 5 — SWITCHING TEST CIRCUIT



TO OBTAIN DATA FOR FIGURE 6, R_B & R_L WERE VARIED. V_{CC} and V_1 LEVELS REMAINED APPROXIMATELY AS SHOWN.

FIGURE 6 — SWITCHING TIMES



TYPICAL DC CHARACTERISTICS

FIGURE 7 — DC CURRENT GAIN

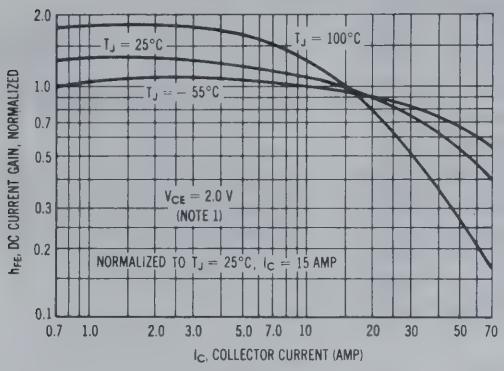


FIGURE 8 — COLLECTOR SATURATION REGION

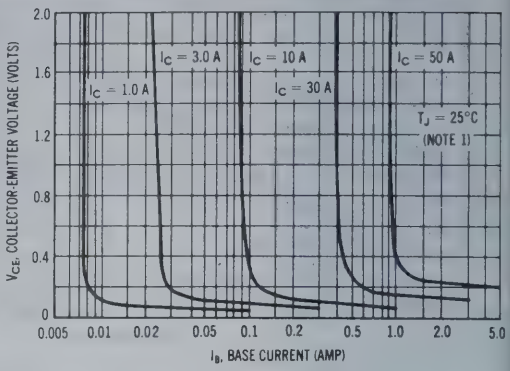


FIGURE 9 — EFFECTS OF BASE-EMITTER RESISTANCE

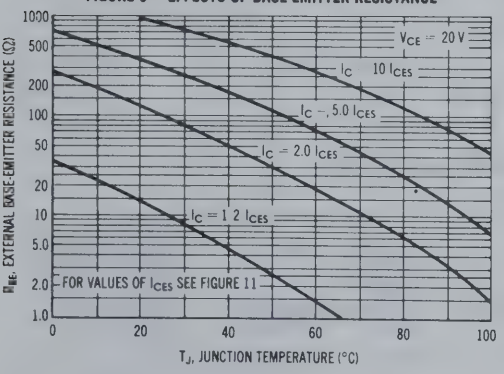


FIGURE 10 — "ON" VOLTAGES

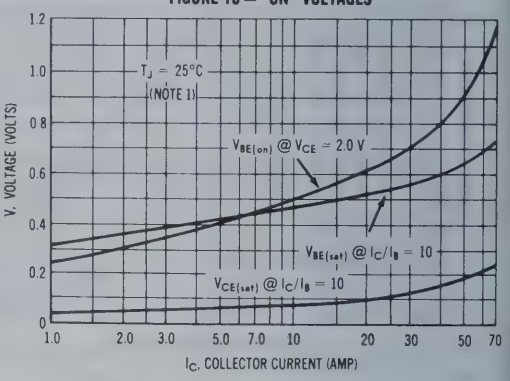
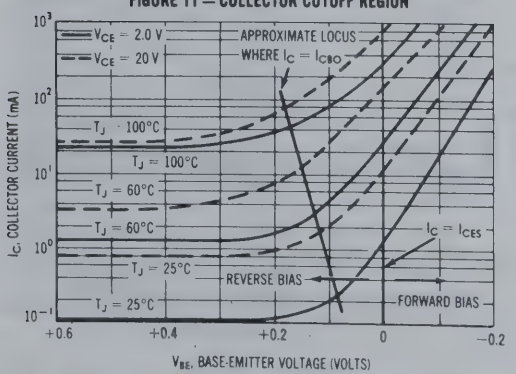
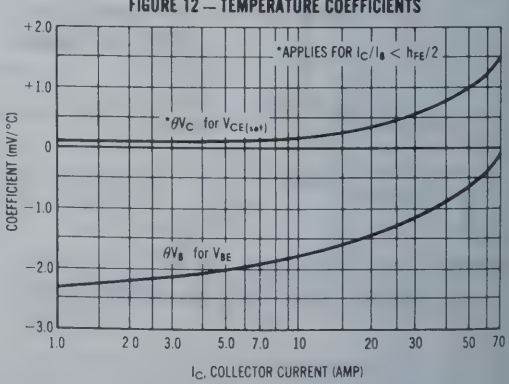


FIGURE 11 — COLLECTOR CUTOFF REGION



NOTE 1: Data is obtained from pulse tests and adjusted to nullify the effect of I_{CBO}.

FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4066 (SILICON)
2N4067

DUAL P-CHANNEL MOS FIELD-EFFECT TRANSISTORS

Enhancement Mode (Type C) MOS Field-Effect Transistors designed primarily for low-power, chopper or switching applications.

- High Forward Transadmittance — $|y_{fs}|$ = 2.5 mmhos (Min) @ V_{DS} = -15 Vdc (2N4067)
- Low Forward Gate Current — I_{GF} = 2.5 pAdc (Max) @ V_{GS} = -25 Vdc
- Low Drain-Source "ON" Resistance — $r_{ds(on)}$ = 250 Ohms (Max) @ V_{GS} = -15 Vdc (2N4067)

DUAL P-CHANNEL MOS FIELD-EFFECT TRANSISTORS

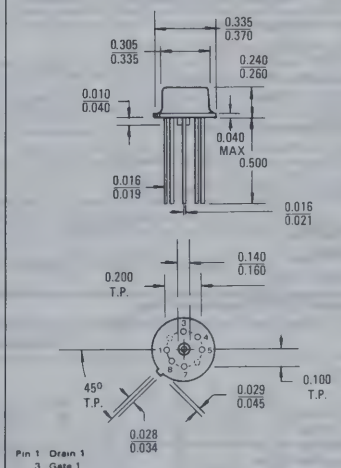
(Type C)



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-30	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	+25	Vdc
Forward Gate-Source Voltage	V_{GSF}	-25	Vdc
Drain Current	I_D	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.7 11.3	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C

*Indicates JEDEC Registered Data.



Pin 1. Drain 1
3. Gate 1
4. Substrate
5. Gate 2
7. Drain 2
8. Source 1 and 2

CASE 196(1)
TO-76

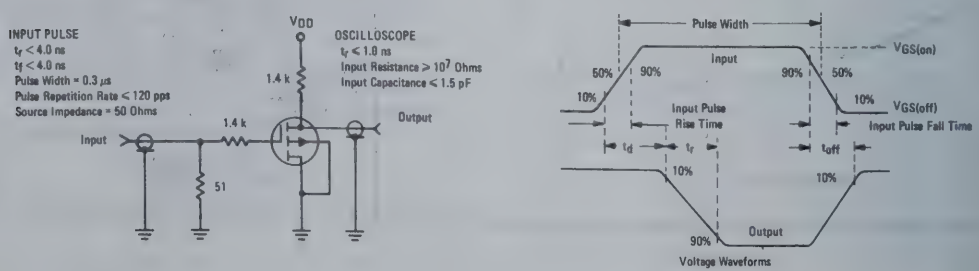
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_{GS} = 0)		$V_{(BR)DSS}$	-30	–	Vdc
Source-Drain Breakdown Voltage (I_S = 10 μAdc, V_{GD} = 0)		$V_{(BR)SDS}$	-30	–	Vdc
Zero-Gate Voltage Source Current		I_{SDS}			
(V_{SD} = -15 Vdc, V_{GD} = 0)			–	1.0	nAdc
(V_{SD} = -15 Vdc, V_{GD} = 0, T_A = 150°C)			–	2.0	μAdc
Zero-Gate Voltage Drain Current (Note 1)		I_{DSS}			
(V_{DS} = -15 Vdc, V_{GS} = 0)			–	1.0	nAdc
(V_{DS} = -15 Vdc, V_{GS} = 0, T_A = 150°C)			–	2.0	μAdc
ON CHARACTERISTICS					
Gate-Source Threshold Voltage (V_{DS} = -15 Vdc, I_D = 10 μAdc)		$V_{GS(TH)}$	-3.0	-6.0	Vdc
Forward Gate Current (V_{GS} = -25 Vdc, V_{DS} = 0)		I_{GF}	–	2.5	pAdc
"ON" Drain Current (V_{DS} = -15 Vdc, V_{GS} = -15 Vdc)		$I_{D(on)}$	10	50	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = -15 Vdc, I_D = 0, f = 1.0 kHz)	2N4066	$r_{ds(on)}$	–	500	Ohms
	2N4067		–	250	
Forward Transadmittance (Note 1)		$\lvert y_{fs} \rvert$			mmhos
(V_{DS} = -15 Vdc, V_{GS} = -15 Vdc, f = 1.0 kHz)	2N4066		1.5	–	
	2N4067		2.5	–	
(V_{DS} = -15 Vdc, V_{GS} = -15 Vdc, f = 1.0 kHz, T_A = 100°C)	2N4066		1.0	–	
	2N4067		1.75	–	
Output Admittance (V_{DS} = -15 Vdc, V_{GS} = -15 Vdc, f = 1.0 kHz)		$\lvert y_{os} \rvert$	–	300	μmhos
Input Capacitance (V_{DS} = -15 Vdc, V_{GS} = -15 Vdc, f = 1.0 MHz)		C_{iss}	–	7.0	pF
Reverse Transfer-Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	1.5	pF
Source-Substrate Capacitance (V_{DU} = -15 Vdc, V_{GS} = 0, I_S = 0, f = 1.0 MHz)		C_{SU}	–	5.0	pF
Drain-Substrate Capacitance (V_{SU} = -15 Vdc, V_{GS} = 0, I_S = 0, f = 1.0 MHz)		C_{DU}	–	5.0	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{DD} = -15 Vdc, $I_{D(on)}$ = 10 mAdc,	t_d	–	20	ns
Rise Time		t_r	–	30	ns
Turn-Off Time	$V_{GS(on)}$ = -15 Vdc, $V_{GS(off)}$ = 0)	t_{off}	–	50	ns

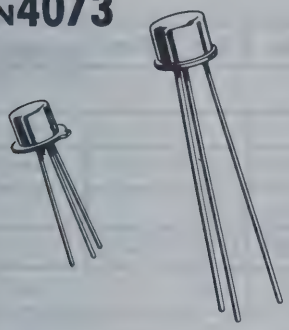
*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



2N4072 (SILICON)
2N4073



NPN silicon annular transistors designed as amplifiers and drivers for large-signal VHF and UHF applications.

Collector connected to case

CASE 22 (TO-18) 2N4072

CASE 31 (TO-5) 2N4073

MAXIMUM RATINGS

Rating	Symbol	2N4072	2N4073	Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current-Continuous	I_C	100	150	mAdc
Total Device Dissipation @ T_A = 25°C Derate Above 25°C	P_D	0.35 2.0	- -	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	- -	1.5 8.57	Watts mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
STATIC CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 15 mAdc, I_B = 0)	$BV_{CEO(sus)}$	20	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	- -	0.1 100	μAdc
DC Current Gain (I_C = 25 mAdc, V_{CE} = 2 Vdc)	h_{FE}	10	-	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 25 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	-	550	-	MHz
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	3.0	4.0	pF

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
FUNCTIONAL TEST						
Power Gain	2N4072 Test Circuit - Figure 5 P_{in} = 25 mW, V_{CE} = 13.6 Vdc, f = 175 MHz	G_{PE}	10	-	-	dB
Power Output		P_{out}	250	-	-	mW
Collector Efficency		η	50	60	-	%
Power Gain	2N4073 Test Circuit - Figure 5 P_{in} = 50 mW, V_{CE} = 13.6 Vdc, f = 175 MHz	G_{PE}	10	-	-	dB
Power Output		P_{out}	500	650	-	mW
Collector Efficiency		η	50	65	-	%

2N4072

FIGURE 1 — POWER OUTPUT versus FREQUENCY

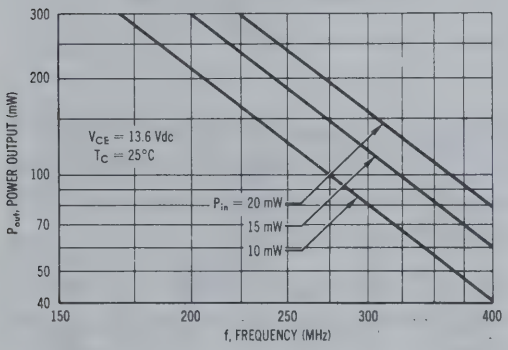
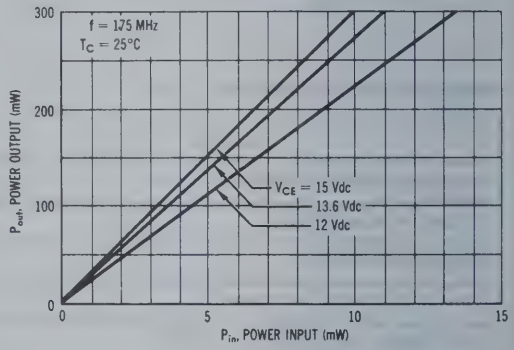


FIGURE 2 — POWER OUTPUT versus POWER INPUT



2N4073

FIGURE 3 — POWER OUTPUT versus FREQUENCY

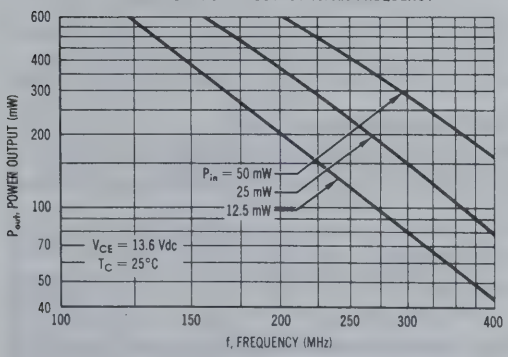


FIGURE 4 — POWER OUTPUT versus POWER INPUT

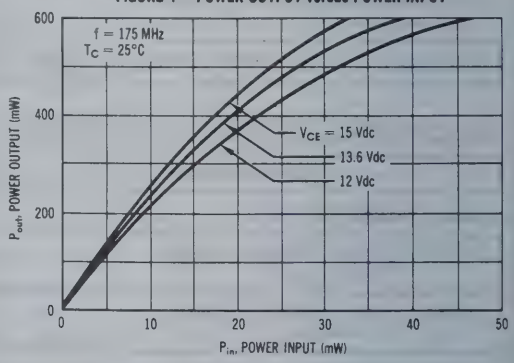
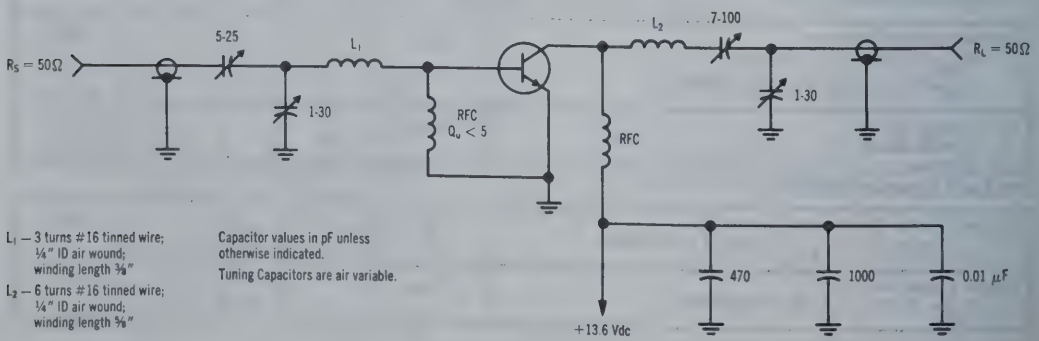


FIGURE 5 — 175 MHz TEST CIRCUIT



L_1 — 3 turns #16 tinned wire; ¼" ID air wound; winding length ⅜"

L_2 — 6 turns #16 tinned wire; ¼" ID air wound; winding length ⅝"

Capacitor values in pF unless otherwise indicated.

Tuning Capacitors are air variable.

2N4091 (SILICON)
2N4092
2N4093

SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

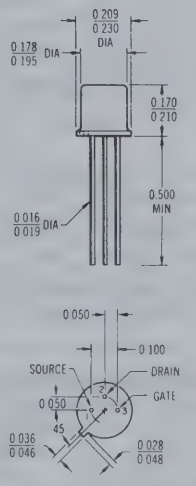
- Low Drain-Source "On" Resistance — $r_{ds(on)}$ = 30 Ohms (Max) @ f = 1.0 kHz (2N4091)
- Low Source Reverse Current — I_{SGO} = 0.2 nAdc (Max) @ V_{SG} = 20 Vdc
- Guaranteed Switching Characteristics

N-CHANNEL

JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)



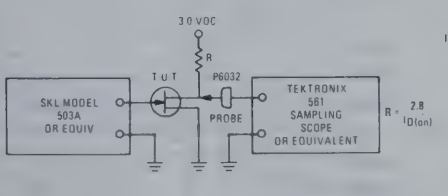


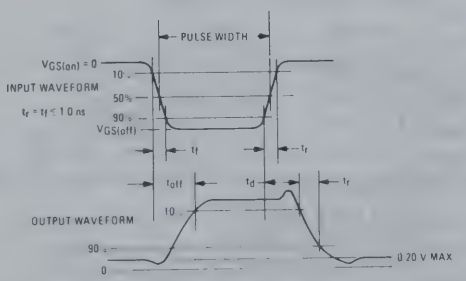
CASE 22 (3)
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT





ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	-	Vdc
Drain-Gate Breakdown Voltage (I_D = 1.0 μAdc, I_S = 0)		$V_{(BR)DGO}$	40	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 20 Vdc, I_D = 1.0 nAdc)	2N4091	$V_{GS(off)}$	5.0	10	Vdc
	2N4092		2.0	7.0	
	2N4093		1.0	5.0	
Source Reverse Current (V_{SG} = 20 Vdc, I_D = 0)		I_{SGO}	-	0.2	nAdc
Drain Reverse Current (V_{DG} = 20 Vdc, I_S = 0)		I_{DGO}	-	0.2	nAdc
(V_{DG} = 20 Vdc, I_D = 0, T_A = 150°C)			-	0.4	μAdc
Drain-Cutoff Current (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc)	2N4091	$I_{D(off)}$	-	0.2	nAdc
(V_{DS} = 20 Vdc, V_{GS} = 8.0 Vdc)	2N4092		-	0.2	
(V_{DS} = 20 Vdc, V_{GS} = 6.0 Vdc)	2N4093		-	0.2	
(V_{DS} = 20 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)	2N4091		-	0.4	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 8.0 Vdc, T_A = 150°C)	2N4092		-	0.4	
(V_{DS} = 20 Vdc, V_{GS} = 6.0 Vdc, T_A = 150°C)	2N4093		-	0.4	
ON CHARACTERISTICS					
Zero-Gate Voltate Drain Current* (V_{DS} = 20 Vdc, V_{GS} = 0)	2N4091	I_{DSS}*	30	-	mAdc
	2N4092		15	-	
	2N4093		8.0	-	
Drain-Source "ON" Voltage (I_D = 6.6 mAdc, V_{GS} = 0)	2N4091	$V_{DS(on)}$	-	0.2	Vdc
(I_D = 4.0 mAdc, V_{GS} = 0)	2N4092		-	0.2	
(I_D = 2.5 mAdc, V_{GS} = 0)	2N4093		-	0.2	
Static Drain-Source "ON" Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	2N4091	$r_{DS(on)}$	-	30	Ohms
	2N4092		-	50	
	2N4093		-	80	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N4091	$r_{ds(on)}$	-	30	Ohms
	2N4092		-	50	
	2N4093		-	80	
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	16	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 20 Vdc, f = 1.0 MHz)		C_{rss}	-	5.0	pF
SWITCHING CHARACTERISTICS					
Delay Time (See Figure 1) ($I_{D(on)}$ = 6.6 mAdc)	2N4091	t_d	-	15	ns
($I_{D(on)}$ = 4.0 mAdc)	2N4092		-	15	
($I_{D(on)}$ = 2.5 mAdc)	2N4093		-	20	
Rise Time (See Figure 1)		t_r			ns
($I_{D(on)}$ = 6.6 mAdc)	2N4091		-	10	
($I_{D(on)}$ = 4.0 mAdc)	2N4092		-	20	
($I_{D(on)}$ = 2.5 mAdc)	2N4093		-	40	
Turn-Off Time (See Figure 1)		t_{off}			ns
($V_{GS(off)}$ = 12 Vdc)	2N4091		-	40	
($V_{GS(off)}$ = 8.0 Vdc)	2N4092		-	60	
($V_{GS(off)}$ = 6.0 Vdc)	2N4093		-	80	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

2N4123 (SILICON)
2N4124



CASE 29 (1)
(TO-92)

NPN silicon transistors designed for general purpose switching and amplifier applications and for complementary circuitry with PNP types 2N4125 and 2N4126. Features one-piece, injection-molded plastic package for high reliability.

MAXIMUM RATINGS

Rating	Symbol	2N4123	2N4124	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CB}	40	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ T_A = 60°C	P_D	210		mW
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

FIGURE 1 — CAPACITANCE

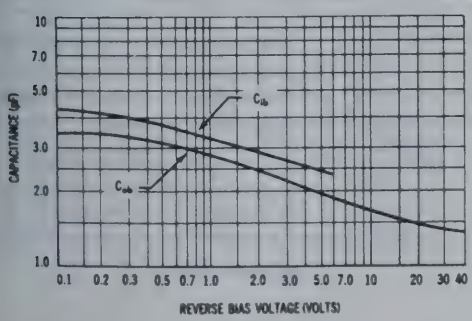
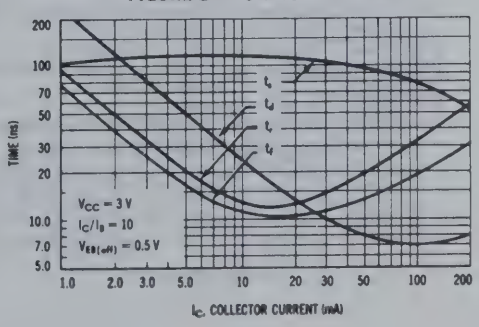


FIGURE 2 — SWITCHING TIMES



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1 mAdc, I_E = 0)	2N4123 2N4124		BV_{CEO}*	30 25	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N4123 2N4124		BV_{CBO}	40 30	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)			I_{CBO}	–	50	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)			I_{EBO}	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 2 mAdc, V_{CE} = 1 Vdc)	2N4123 2N4124	9	h_{FE}*	50 120	150 360	–
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N4123 2N4124			25 60	– –	
Collector-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)		10, 11	$V_{CE(sat)}$*	–	0.3	Vdc
Base-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)		11	$V_{BE(sat)}$*	–	0.95	Vdc
SMALL SIGNAL CHARACTERISTICS						
High-Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123 2N4124		$\lvert h_{fe} \rvert$	2.5 3.0	– –	–
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123 2N4124		f_T	250 300	– –	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)		1	C_{ob}	–	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		1	C_{ib}	–	8.0	pF
Small-Signal Current Gain (I_C = 2 mAdc, V_{CE} = 1 Vdc, f = 1 kHz)	2N4123 2N4124	5	h_{fe}	50 120	200 480	–
Noise Figure (I_C = 100 μAdc, V_{CE} = 5 Vdc, R_S = 1 k ohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	2N4123 2N4124	3, 4	NF	– –	6.0 5.0	dB

SWITCHING CHARACTERISTICS

Characteristic		Fig. No.	Symbol	Typ	Unit
Delay Time	V_{CC} = 3 Vdc, $V_{EB(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1 mAdc	2	t_d	24	ns
Rise Time		2	t_r	13	ns
Storage Time	V_{CC} = 3 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1 mAdc	2	t_s	125	ns
Fall Time		2	t_f	11	ns

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%

AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 5 Vdc, T_A = 25°C

FIGURE 3 — FREQUENCY VARIATIONS

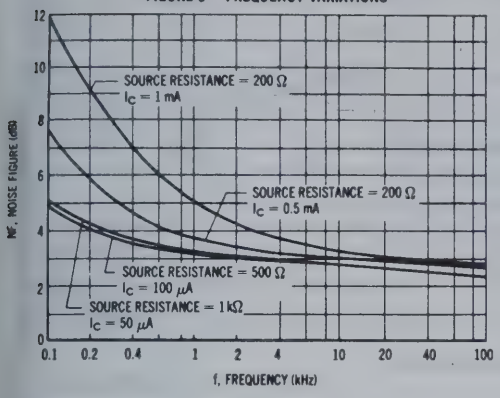
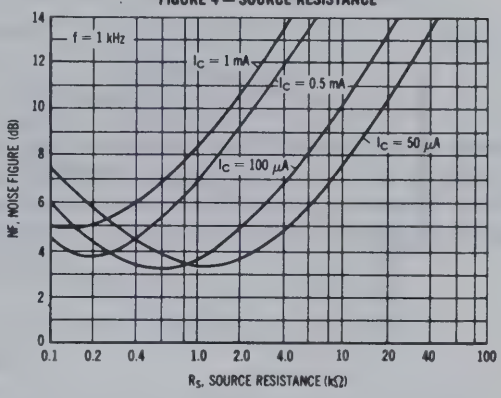


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

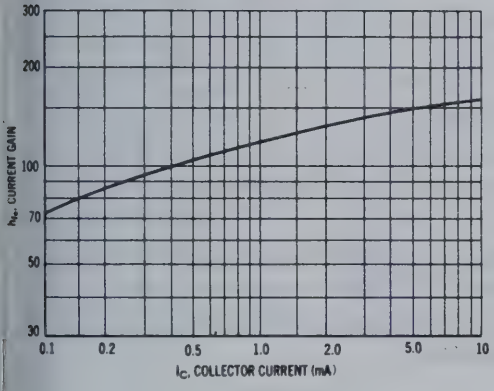


FIGURE 6 — OUTPUT ADMITTANCE

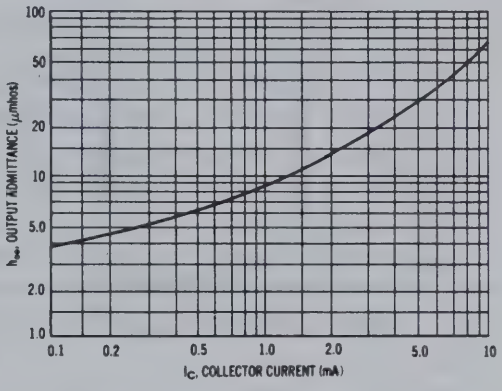


FIGURE 7 — INPUT IMPEDANCE

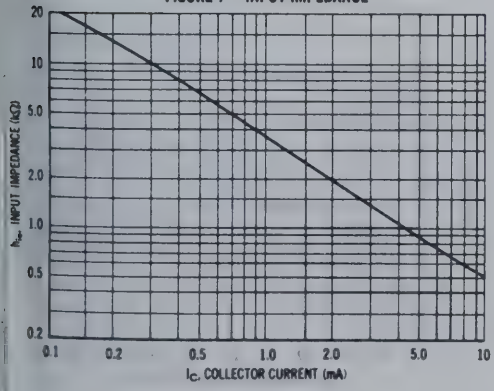
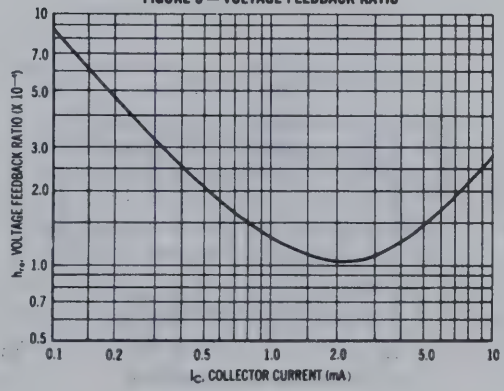


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 — NORMALIZED CURRENT GAIN

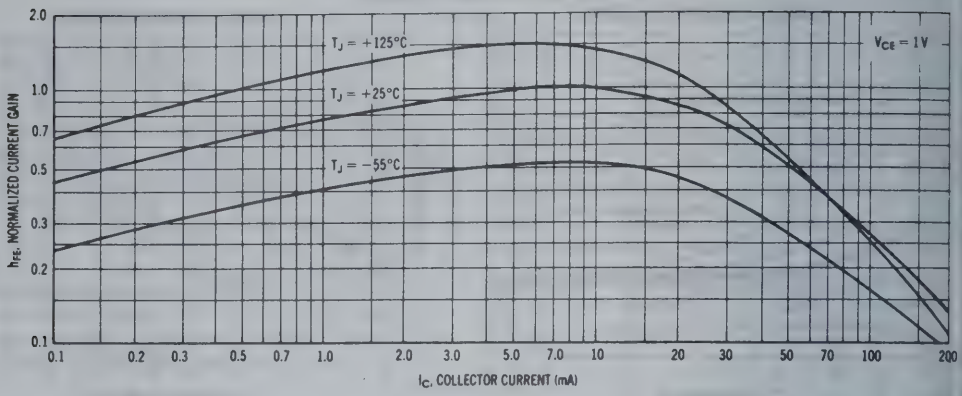


FIGURE 10 — COLLECTOR SATURATION REGION

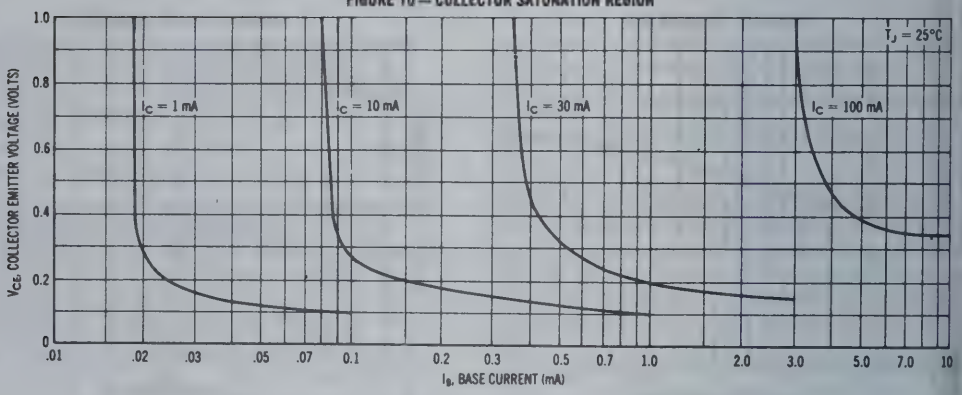


FIGURE 11 — "ON" VOLTAGES

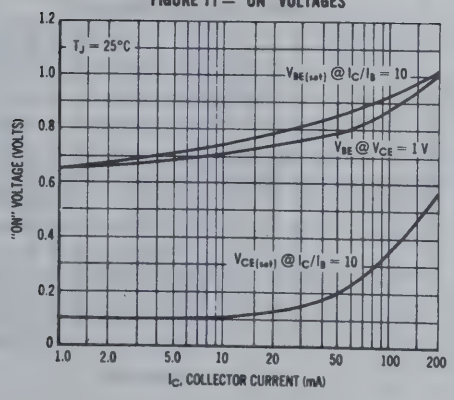
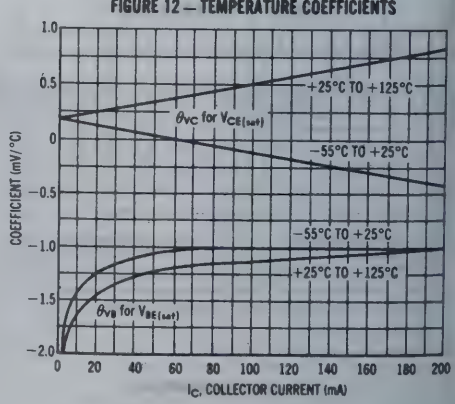


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4125 (SILICON)
2N4126



PNP silicon transistors designed for general purpose switching and amplifier applications and for complementary circuitry with NPN types 2N4123 and 2N4124 Features one-piece, injection-molded plastic package for high reliability.

CASE 29 (1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	2N4125	2N4126	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CB}	30	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ T_A = 60°C	P_D	210		mW
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

FIGURE 1 — CAPACITANCE

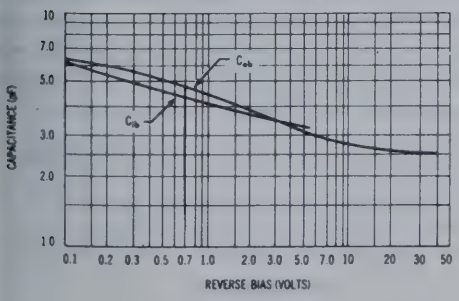
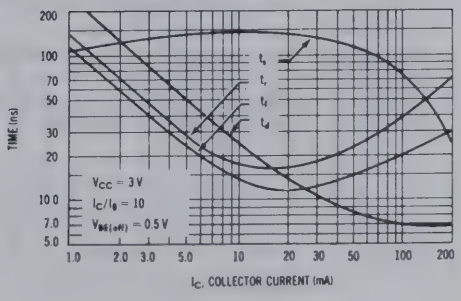


FIGURE 2 — SWITCHING TIMES



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1 mAdc, I_E = 0)	2N4125 2N4126		BV_{CEO}*	30 25	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N4125 2N4126		BV_{CBO}	30 25	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)			I_{CBO}	–	50	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)			I_{EBO}	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 2 mAdc, V_{CE} = 1 Vdc)	2N4125 2N4126	9	h_{FE}*	50 120	150 360	–
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N4125 2N4126			25 60	– –	
Collector-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)		10, 11	$V_{CE(sat)}$*	–	0.4	Vdc
Base-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)		11	$V_{BE(sat)}$*	–	0.95	Vdc
SMALL SIGNAL CHARACTERISTICS						
High-Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4125 2N4126		$\lvert h_{fe} \rvert$	2.0 2.5	– –	–
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4125 2N4126		f_T	200 250	– –	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)		1	C_{ob}	–	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		1	C_{ib}	–	10	pF
Small-Signal Current Gain (I_C = 2 mAdc, V_{CE} = 1 Vdc, f = 1 kHz)	2N4125 2N4126	5	h_{fe}	50 120	200 480	–
Noise Figure (I_C = 100 μAdc, V_{CE} = 5 Vdc, R_S = 1 k ohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	2N4125 2N4126	3, 4	NF	– –	5.0 4.0	dB

SWITCHING CHARACTERISTICS

Characteristic		Fig. No.	Symbol	Typ	Unit
Delay Time	V_{CC} = 3 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1 mAdc	2	t_d	25	ns
Rise Time		2	t_r	18	ns
Storage Time	V_{CC} = 3 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1 mAdc	2	t_s	140	ns
Fall Time		2	t_f	15	ns

*Pulse Test: Pulse Width = 300 μsec, Duty Cycle = 2%

AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 5 Vdc, T_A = 25°C

FIGURE 3 — FREQUENCY VARIATIONS

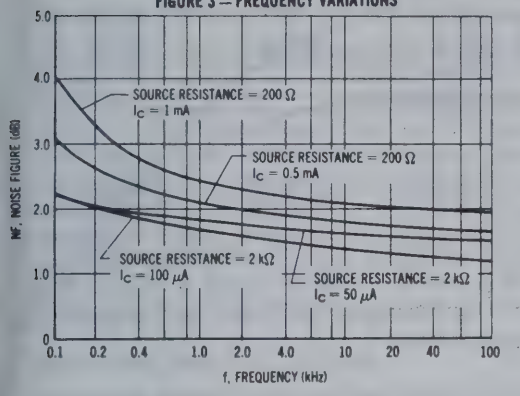
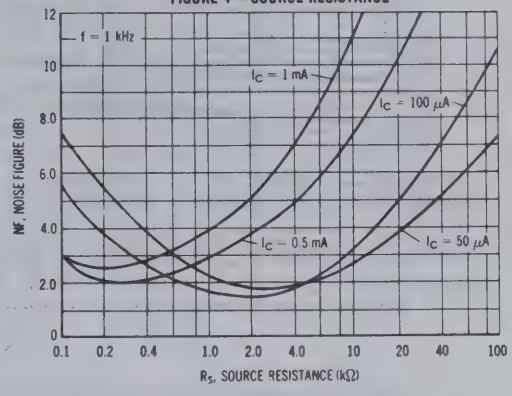


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

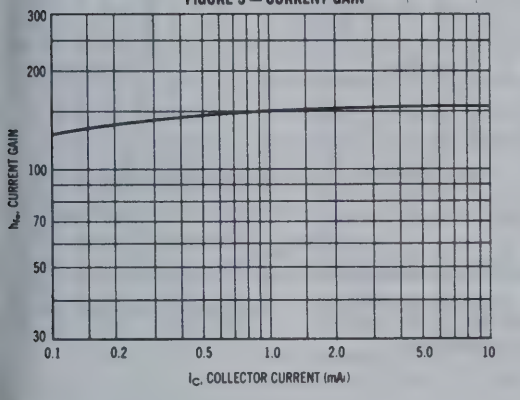


FIGURE 6 — OUTPUT ADMITTANCE

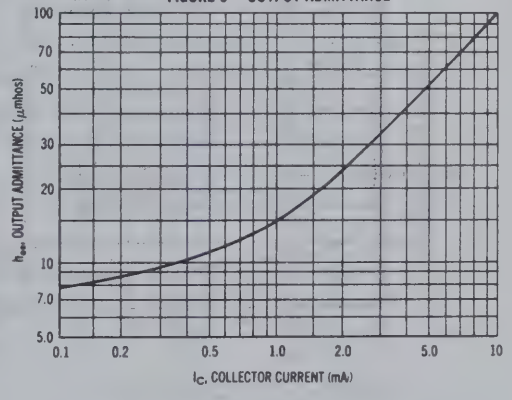


FIGURE 7 — INPUT IMPEDANCE

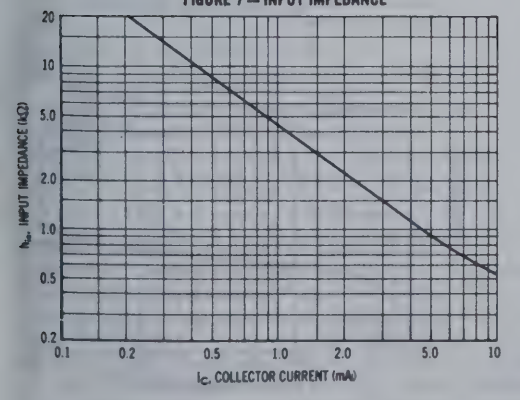
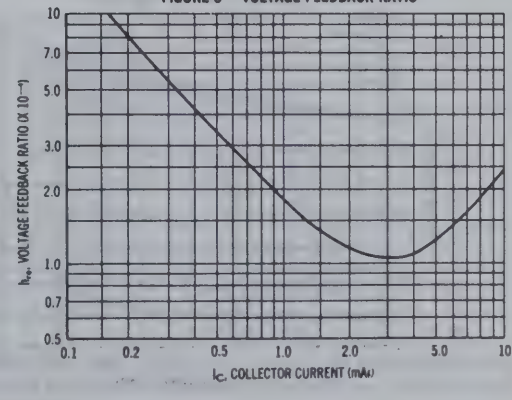


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 — NORMALIZED CURRENT GAIN

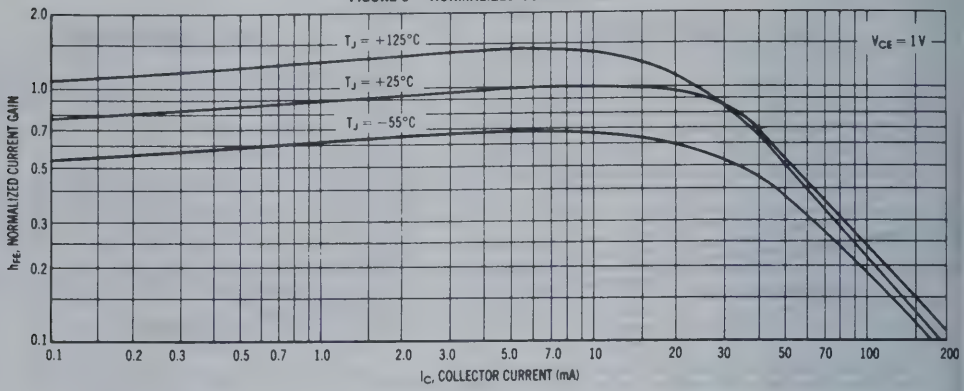


FIGURE 10 — COLLECTOR SATURATION REGION

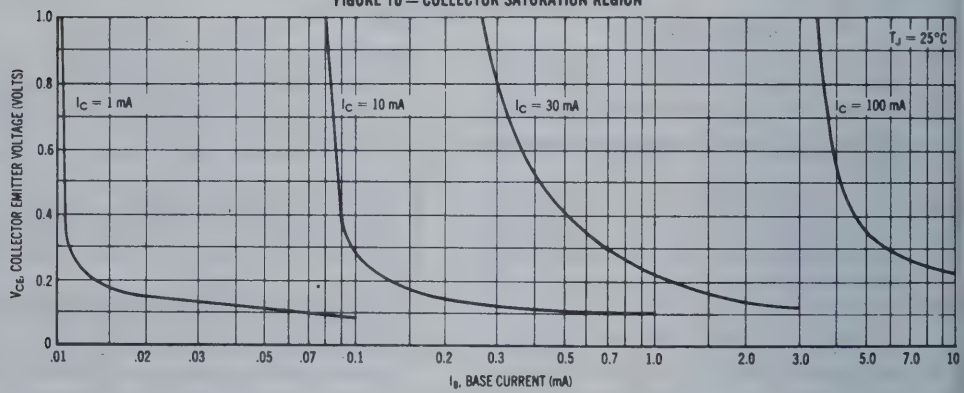


FIGURE 11 — "ON" VOLTAGES

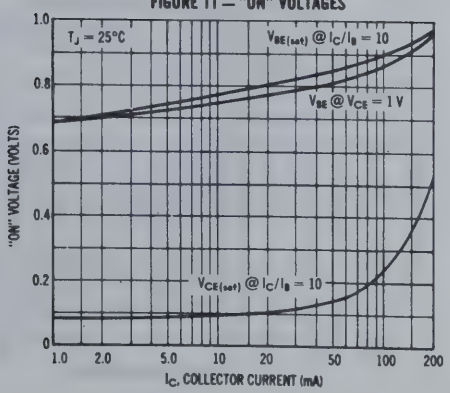
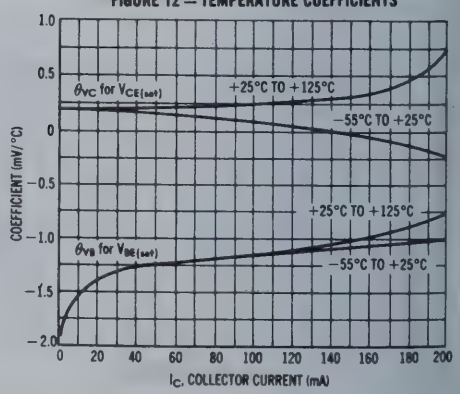
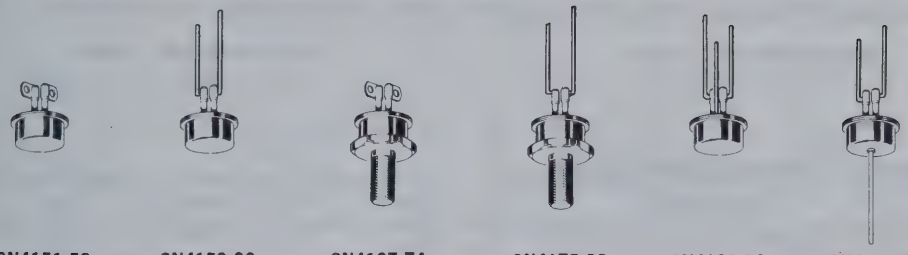


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4151 thru 2N4198 (SILICON)



2N4151-58	2N4159-66	2N4167-74	2N4175-82	2N4183-90	2N4191-98
CASE 85	**CASE 85L**	**CASE 86**	**CASE 86L**	**CASE 87L**	**CASE 88L**

Multi-purpose silicon controlled rectifiers suited for industrial, consumer, and military applications. Offered in a choice of space-saving, economical packages for mounting versatility.

MAXIMUM RATINGS

(Apply over operating temperature range and for all case types unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*†	$V_{ROM(rep)}$*†		Volts
2N4151, 59, 67, 75, 83, 91		25	
2N4152, 60, 68, 76, 84, 92		50	
2N4153, 61, 69, 77, 85, 93		100	
2N4154, 62, 70, 78, 86, 94		200	
2N4155, 63, 71, 79, 87, 95		300	
2N4156, 64, 72, 80, 88, 96		400	
2N4157, 65, 73, 81, 89, 97		500	
2N4158, 66, 74, 82, 90, 98		600	
Non-repetitive Peak Reverse Blocking Voltage	$V_{ROM(non-rep)}$		Volts
2N4151, 59, 67, 75, 83, 91		75	
2N4152, 60, 68, 76, 84, 92		100	
2N4153, 61, 69, 77, 85, 93		150	
2N4154, 62, 70, 78, 86, 94		300	
2N4155, 63, 71, 79, 87, 95		400	
2N4156, 64, 72, 80, 88, 96		500	
2N4157, 65, 73, 81, 89, 97		600	
2N4158, 66, 74, 82, 90, 98		700	
Forward Current RMS	I_f	8.0	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C; t ≤ 8.3 ms)	I^2t	40	A^2s
Peak Forward Surge Current† (One cycle, 60 Hz, T_J = -40 to +100°C)	$I_{FM(surge)}$†	100	Amp
Peak Forward Gate Power†	P_{GFM}†	5.0	Watt
Average Forward Gate Power†	$P_{GF(AV)}$†	0.5	Watt
Peak Forward Gate Current†	I_{GFM}†	2.0	Amp
Peak Gate Voltage — Forward**	V_{GFM}**	10	Volts
Reverse	V_{GRM}	10	
Operating Temperature Range†	T_J†	-40 to +100	°C
Storage Temperature Range†	T_{stg}†	-40 to +150	°C
Stud Torque 2N4167-2N4182		15	in. lb.

*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage applied exceeds the rated blocking voltage.

**Devices should not be operated with a positive bias applied to the gate concurrently with a negative potential applied to the anode.

†JEDEC Registered Values

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.5	2.5†	°C/W
Thermal Resistance, Case to Ambient (See Fig. 11) 2N4151-66, 2N4183-98	θ_{CA}	50	—	°C/W

†JEDEC Registered Values

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage*† (T_J = 100°C)	2N4151, 59, 67, 75, 83, 91	V_{FOM}*†	25	—	Volts
	2N4152, 60, 68, 76, 84, 92		50	—	
	2N4153, 61, 69, 77, 85, 93		100	—	
	2N4154, 62, 70, 78, 86, 94		200	—	
	2N4155, 63, 71, 79, 87, 95		300	—	
	2N4156, 64, 72, 80, 88, 96		400	—	
	2N4157, 65, 73, 81, 89, 97		500	—	
	2N4158, 66, 74, 82, 90, 98		600	—	
Peak Forward Blocking Current† (Rated V_{FOM} @ T_J = 100°C, gate open)		I_{FOM}†	—	2.0	mA
Peak Reverse Blocking Current† (Rated V_{ROM} @ T_J = 100°C, gate open)		I_{ROM}†	—	2.0	mA
Gate Trigger Current (Continuous dc)** (Anode Voltage = 7.0 Vdc, R_L = 100 Ω)		I_{GT}**	—	20	mA
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω T_C = -40°C)†			—	50†	
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ω)		V_{GT}	—	1.5	Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_C = -40°C)†			—	2.5†	
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_J = 100°C)†			0.2†	—	
Forward "On" Voltage (pulsed, 1.0 ms max, duty cycle ≤ 1%) (I_F = 5.0 A)		v_F	—	1.3	Volts
(I_F = 15.7 A)†			—	2.0†	
Holding Current (Anode Voltage = 7.0 Vdc, gate open)		I_{HO}	—	25	mA
(Anode Voltage = 7.0 Vdc, gate open, T_C = -40°C)†			—	60†	
Turn-On Time (t_d + t_r) (I_G = 20 mAdc, I_F = 5.0 Adc)		t_{on}	Typical		μs
			1.0		
Turn-Off Time (I_F = 5.0 Adc, I_R = 5.0 Adc)		t_{off}	15		μs
(I_F = 5.0 Adc, I_R = 5.0 Adc, T_J = 100°C) (V_{FXM} = rated voltage) (dv/dt = 30 V/μs)			25		
Forward Voltage Application Rate (Gate open, T_J = 100°C)		dv/dt	50		V/μs

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. These devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.
**For optimum operation, i.e. faster turn-on, lower switching losses, best di/dt capability, recommended I_{GT} = 200 mA.
†JEDEC Registered Values

EFFECT OF TEMPERATURE UPON TYPICAL TRIGGER CHARACTERISTICS

FIGURE 1 — GATE TRIGGER CURRENT

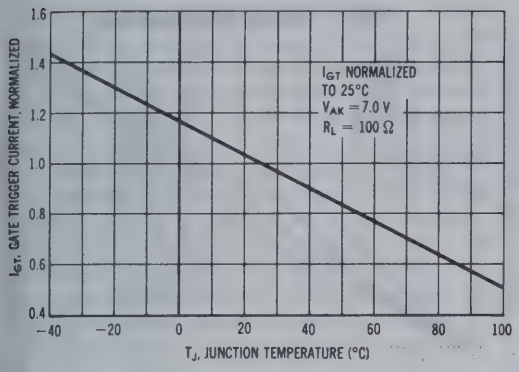
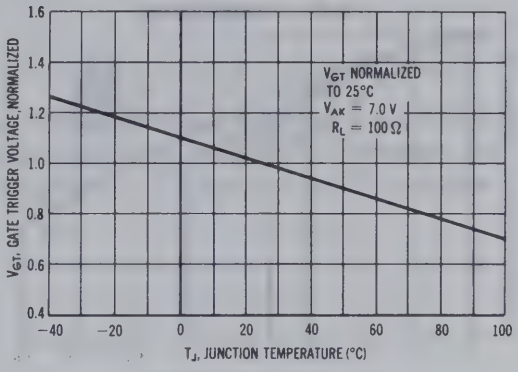


FIGURE 2 — GATE TRIGGER VOLTAGE



MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT

FIGURE 3 — 60 Hz SURGES

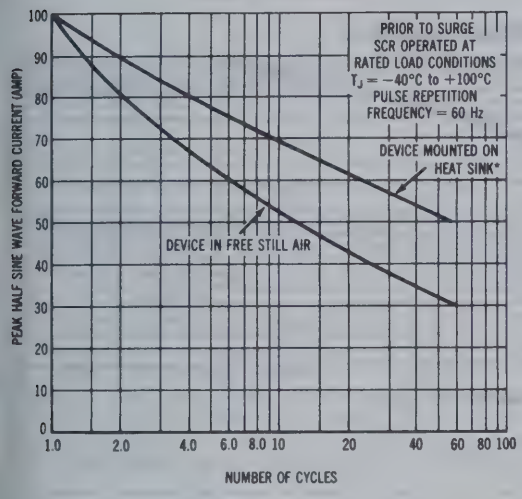


FIGURE 4 — SUB-CYCLE SURGES

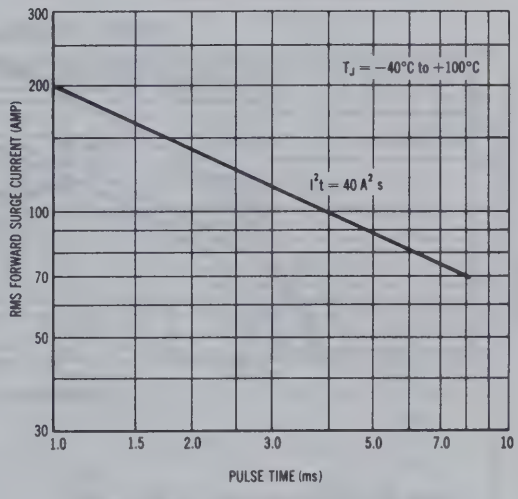


FIGURE 5 — GATE TRIGGER CHARACTERISTICS

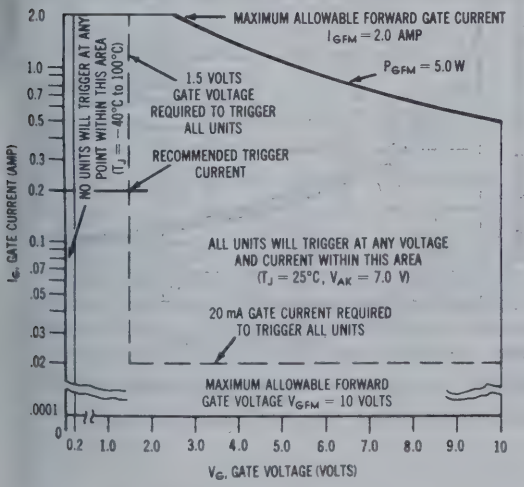
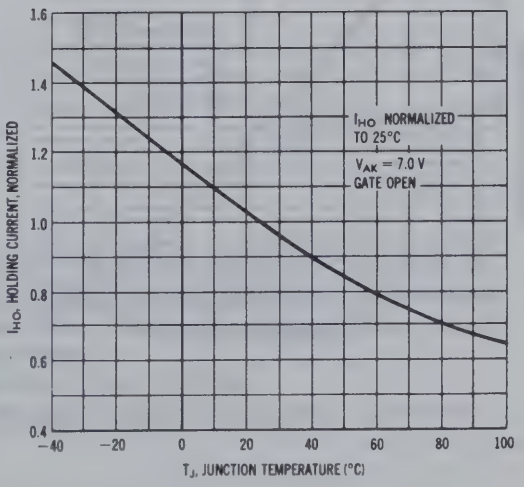


FIGURE 6 — TYPICAL HOLDING CURRENT



*Heat sink sufficient to maintain allowable case temperature for 180 degree conduction angle during normal operation, see Figure 7.

DERATING AND DISSIPATION FOR RESISTIVE AND INDUCTIVE LOADS (f = 60 to 400 Hz, SINE WAVE)

FIGURE 7 — CURRENT DERATING

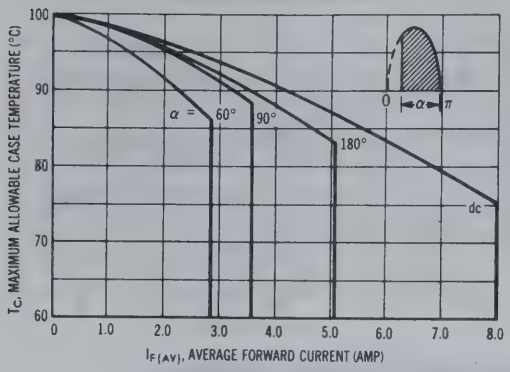


FIGURE 8 — FORWARD POWER DISSIPATION

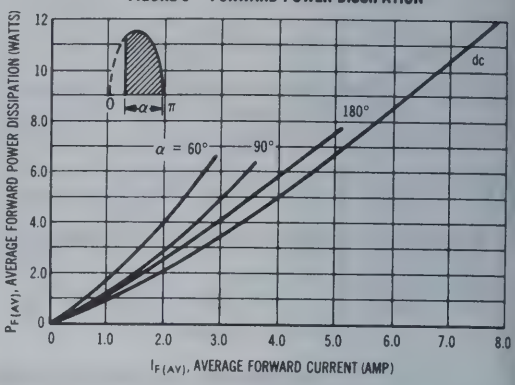


FIGURE 9 — FORWARD CONDUCTION CHARACTERISTICS

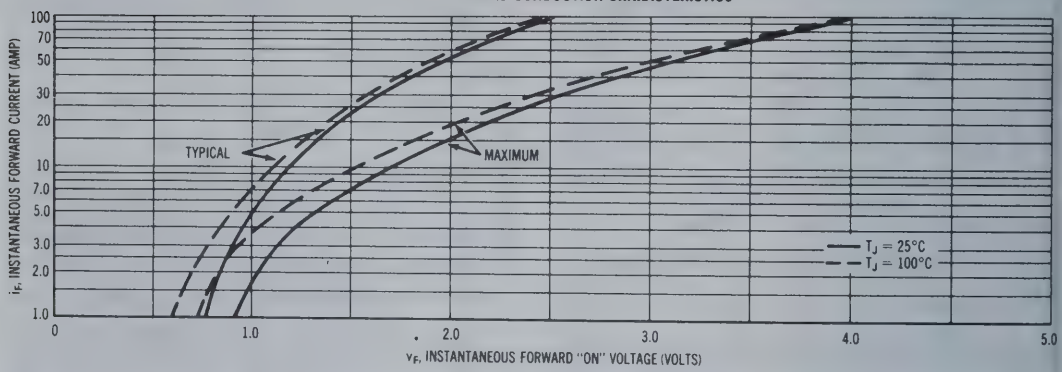


FIGURE 10 — TYPICAL THERMAL RESISTANCE OF PLATES

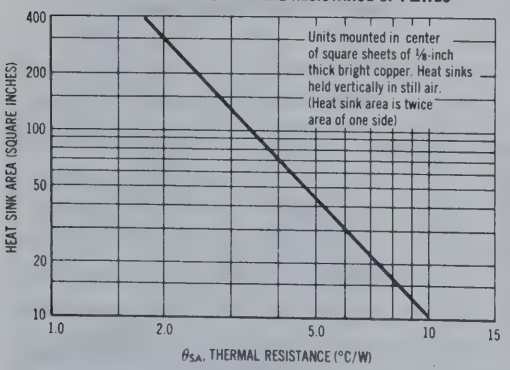
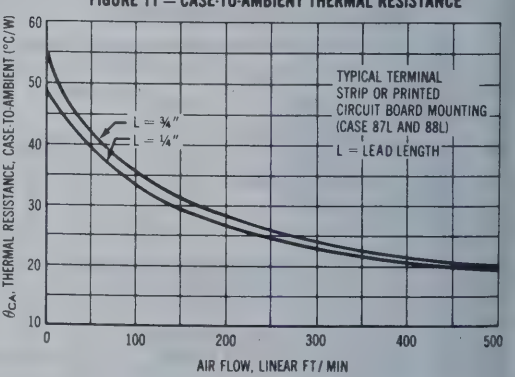
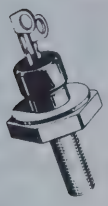


FIGURE 11 — CASE-TO-AMBIENT THERMAL RESISTANCE



2N4199 thru 2N4204 (SILICON)



CASE 63

Fast switching, high-voltage thyristors especially designed for pulse modulator applications in radar and other similar equipment. Available as JAN devices.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* (T_J=105°C)	$V_{ROM(rep)}$*	50	Volts
Repetitive Peak Forward Current (PW = 3.0 μs, Duty Cycle = 0.6%, T_C = 85°C max)	$I_{FM(rep)}$	100	Amp
Current Application Rate**	di/dt**	5000	A/μs
Peak Gate Power-Forward	P_{GFM}	20	Watts
Average Gate Power-Forward	$P_{GF(AV)}$	1.0	Watt
Peak Gate Current-Forward	I_{GFM}	5.0	Amp
Peak Gate Voltage-Forward Reverse***	V_{GFM} V_{GRM}***	10 10	Volts
Operating Junction Temperature Range Blocking State Conducting State	T_J	 -65 to +105 -65 to +200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque	—	15	in. lb.

*Characterized for unilateral applications where reverse blocking capability is not important. Higher voltage units available upon request. $V_{ROM(rep)}$ may be applied as a continuous d c voltage for zero or negative gate voltage but positive gate voltage must not be applied concurrently with a negative potential on the anode. When checking blocking capability, do not permit the applied voltage to exceed the rated voltage.

**Minimum Gate Trigger Pulse: $i_G = 200$ mA, PW = 1 μs, $t_r = 20$ ns.

***Do not reverse bias gate during forward conduction if anode current exceeds 10 amperes.

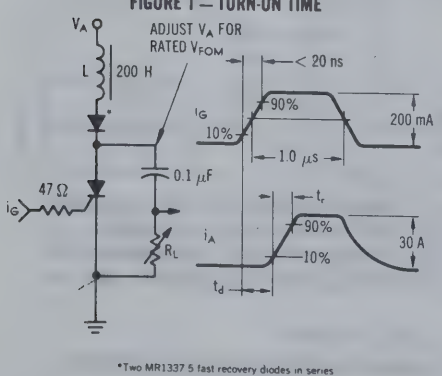
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage* (T_C = 105°C)	2N4199	15	V_{FOM}*	300	—	Volts
	2N4200			400	—	
	2N4201			500	—	
	2N4202			600	—	
	2N4203			700	—	
	2N4204			800	—	
Peak Forward and Reverse Blocking Current (Rated V_{FOM} and V_{ROM}, T_C = 105°C, gate open)		17	I_{FOM}	—	2.0	mA
			I_{ROM}	—	2.0	
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)		14	I_{GT}	—	50	mA
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = -65°C)				—	100	
Gate Trigger Voltage (Continuous dc) (Anode Voltage = rated V_{FOM}, R_L = 100 ohms, T_C = 105°C)		12	V_{GT}	0.2	—	Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)				—	1.5	
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = -65°C)				—	2.0	
Holding Current (Anode Voltage = 7.0 Vdc, gate open, T_C = 105°C)		18	I_{HO}	3.0	—	mA
Forward "On" Voltage (I_f = 2 Adc, PW = 1.0 ms max, Duty cycle ≤ 1%)		8	V_F	—	1.5	Volts
Dynamic Forward "On" Voltage (0.5 μs after 50% decay point on dynamic forward voltage waveform.) Forward Current: 30 A pulse (PFN discharge circuit.) Gate Pulse: at 200 mA, PW = 1.0 μs, t_r = 20 ns		7	$V_{F(on)}$	—	25	Volts
Turn-On Time						ns
Delay Time	All types	1, 9	t_d	—	200	
Rise Time	2N4199 and 2N4200	1, 11	t_r	—	200	
	2N4201			—	150	
	2N4202			—	130	
	2N4203 and 2N4204			—	100	
Pulse Turn-Off Time Test Conditions: PFN discharge; Forward Current = 30 A pulse; Reverse Current = 5.0 A, T_C = 85°C, dv/dt = 250 V/μs to Rated V_{FOM}; Reverse anode voltage during turn-off interval = 0 V; Reverse gate bias during turn-off interval = 6.0 V.		2, 13	$t_{off(pulse)}$	—	20	μs
Forward Voltage Application Rate (Linear Rise of Voltage) (T_C = 105°C, gate open)		16	dv/dt	250	—	V/μs
Thermal Resistance (Junction to Case)		6	θ_{JC}	—	3.0	°C/W

*V_{FOM} for all types can be applied on a continous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. When checking forward or reverse blocking capability, these devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage. Other voltage units available upon request.

TEST CIRCUITS

FIGURE 1 — TURN-ON TIME



*Two MR1337 5 fast recovery diodes in series

FIGURE 2 — TURN-OFF TIME

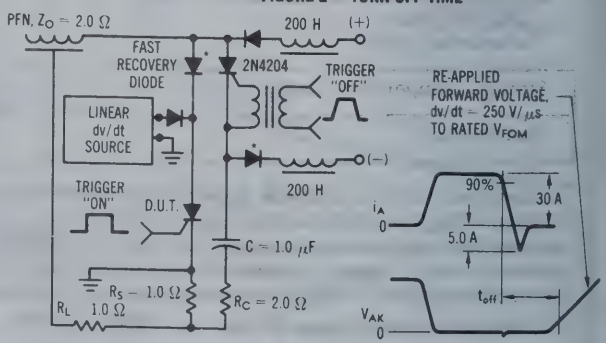
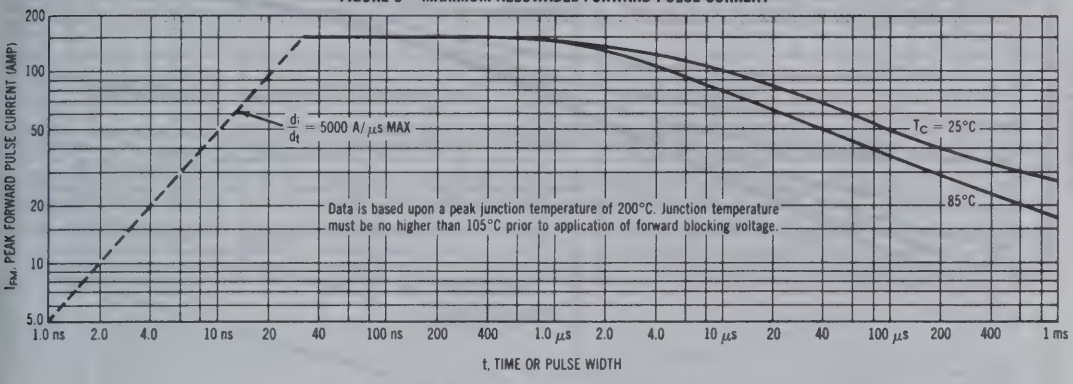


FIGURE 3 — MAXIMUM ALLOWABLE FORWARD PULSE CURRENT



CURRENT DERATING DATA

FIGURE 4 — DERATING USING NO SWITCHING LOSSES

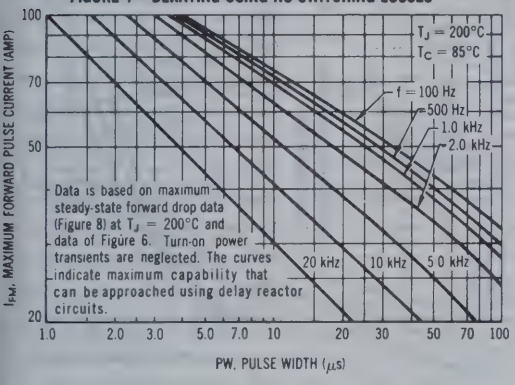
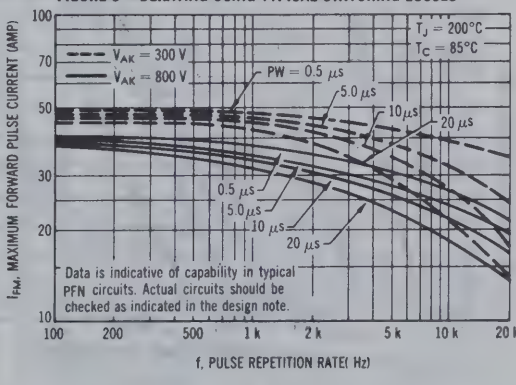


FIGURE 5 — DERATING USING TYPICAL SWITCHING LOSSES



DESIGN NOTE

Use of Transient Thermal Resistance Data

A train of periodical power pulses can be represented by the model shown in Fig. A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Fig. 6 was calculated for various duty cycles from:

$$r(t) = D + (1 - D) \cdot r(t_A + t_p) + r(t_A) - r(t_p)$$

To find $\theta_{JC}(t)$ multiply the value obtained from Fig. 6 by the steady-state value $\theta_{JC}(\infty)$. Use 3°C/W for worst-case results; use 2°C/W for typical information.

DESIGN EXAMPLE

A 2N4199 discharging a PFN, transient power pulse shown in Fig. C.

Conditions: V_{AK} = 150 V., I_{PK} = 44 A., f = 5000 Hz.

Determine: $\triangle T$

Method 1: (See Fig. A) $P_A t_A$ is chosen to have the same energy as the actual power pulse, i.e., the area under the curves are equal. P_A equals the peak of the actual power pulse. At a pulse repetition frequency of 5000 Hz and T_A = 2.14 μs (D = 0.0107); the reading on Fig. 6 is 0.039.

$$\therefore \triangle T = r(t)\theta_{JC}(\infty) P_A = (0.039)\ (3)\ (1000) = 120°C.$$

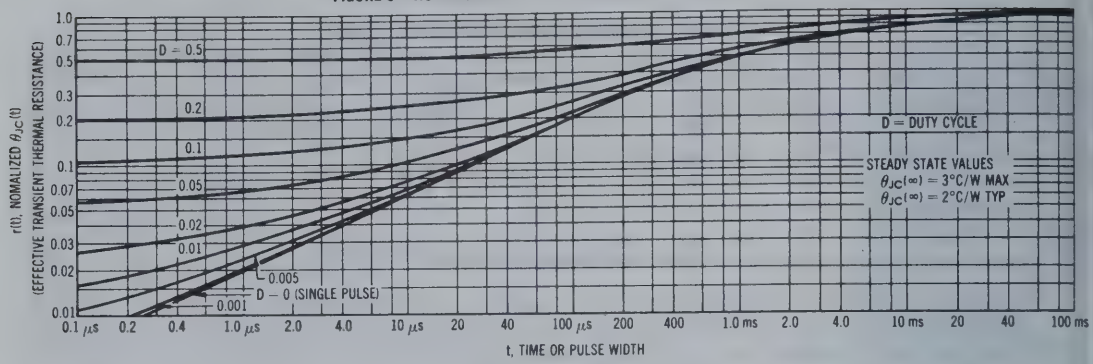
Method 2: For a power waveform where the time of the peak power is short compared to the total transient, the foregoing method results in an overly large safety factor. A pulse model closer to the real case is shown in Fig. B. Using the transient thermal resistance information for D = 0 in Fig. 6, $\triangle T(t_4)$ and $\triangle T(t_5)$ can be evaluated from

$$\triangle T(t_4) = \Big[P_1\ [r(T_1) + (1 - D_1) \cdot r(T + T_1) + D - r(T)] + P_2 [(1 - D_2) \cdot r(T) + D_2 - r(T - T_2)]\Big] \theta_{JC}(\infty)$$

$$\triangle T(t_5) = \Big[P_1 [r(T_1 + T_2) + (1 - D_1) \cdot r(T + T_1 + T_2) - r(T + T_2) - r(T_2)] + P_2 [r(T_2) + (1 - D_2 \cdot r(T + T_2) + D_2 - r(T)]\Big] \theta_{JC}(\infty)$$

The two results are compared; the one with higher value is taken for worst-case design. For the problem, values for the equivalent pulses of Fig. B are P_1 = 1000 W, P_2 = 700 W, T_1 = 1.05 μs, T_2 = 1.55 μs, $D_1 = 5.25(10^{-3})$, $D_2 = 7.75(10^{-3})$.

FIGURE 6 — NORMALIZED EFFECTIVE TRANSIENT THERMAL RESISTANCE



FORWARD "ON" VOLTAGE DATA

FIGURE 7 — TYPICAL DYNAMIC FORWARD "ON" VOLTAGE

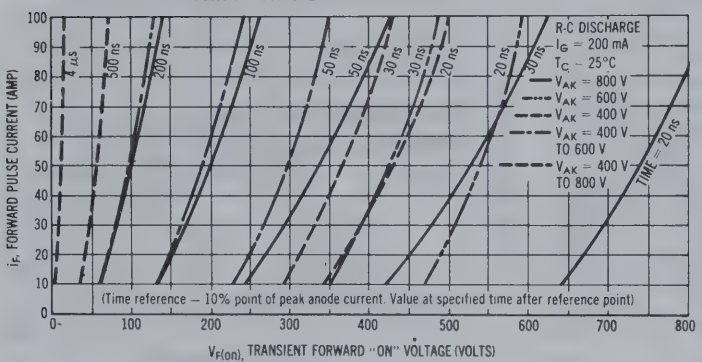
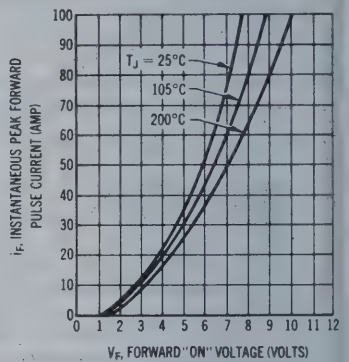


FIGURE 8 — MAXIMUM STEADY-STATE



$$\Delta T(t_A) = \left[1000\,[0.0205 + (1 - 5.25 \cdot 10^{-3})\,0.27 + 5.25 \cdot 10^{-3} - 0.27] + 700\,[(1 - 7.75 \cdot 10^{-3})\,0.27 + 7.75 \cdot 10^{-3} - 0.27] \right] 3 = 93.51°C$$

$$\Delta T(t_B) = \left[1000\,[0.032 + (1 - 5.25 \cdot 10^{-3})\,0.27 + 5.25 \cdot 10^{-3} - 0.27 - 0.0205] + 700\,[0.025 + (1 - 7.75 \cdot 10^{-3})\,0.27 + 7.75 \cdot 10^{-3} - 0.27] \right] 3 = 105.6°C$$

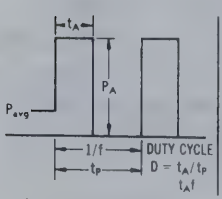


FIGURE A — SIMPLE MODEL

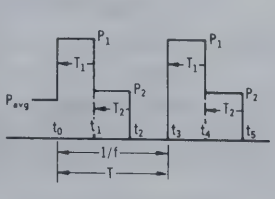


FIGURE B — MORE ACCURATE MODEL

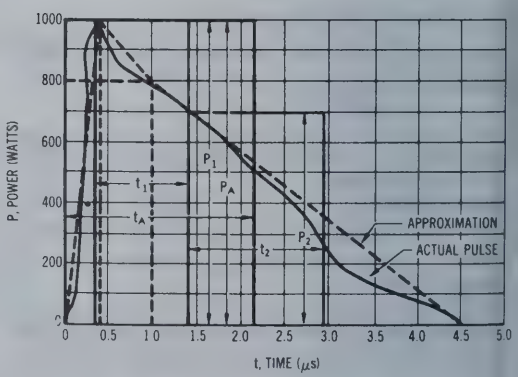


FIGURE C — AN ACTUAL TRANSIENT POWER PULSE

SWITCHING CHARACTERISTICS

FIGURE 9 — DELAY TIME

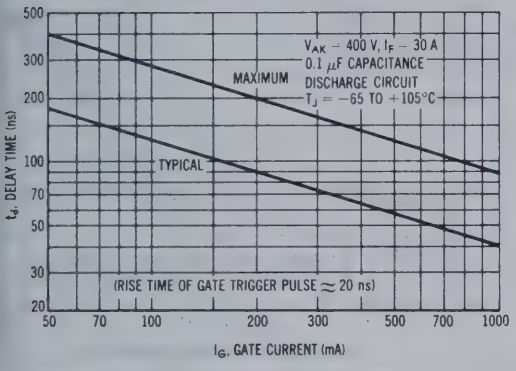


FIGURE 11 — CURRENT RISE TIME

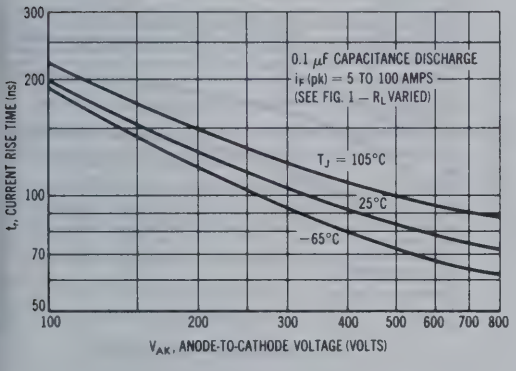
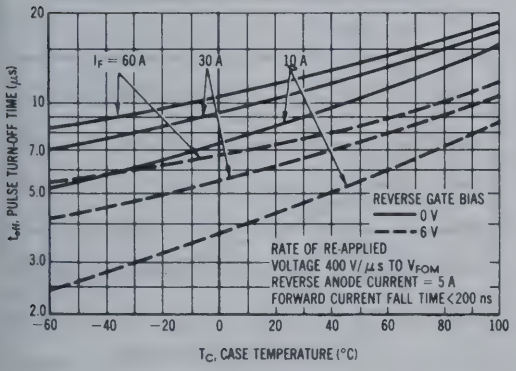


FIGURE 13 — TYPICAL TURN-OFF TIME



TRIGGERING CHARACTERISTICS

FIGURE 10 — TYPICAL PULSE TRIGGER CHARGE/CURRENT

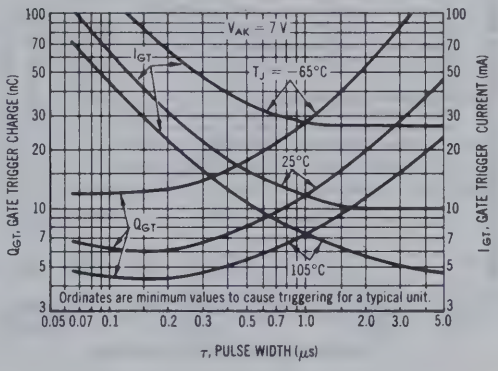


FIGURE 12 — DC GATE TRIGGER VOLTAGE

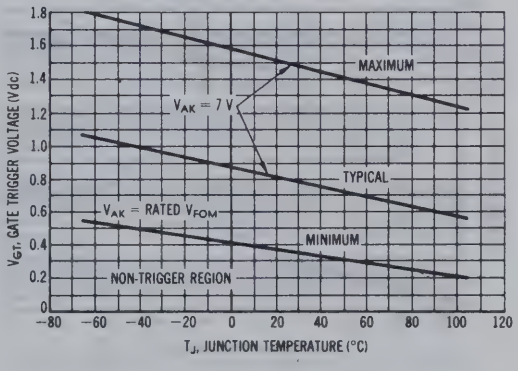


FIGURE 14 — DC GATE TRIGGER CURRENT

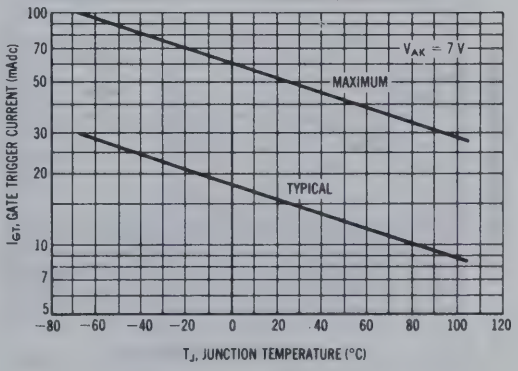


FIGURE 15 — TYPICAL BLOCKING VOLTAGE DERATING

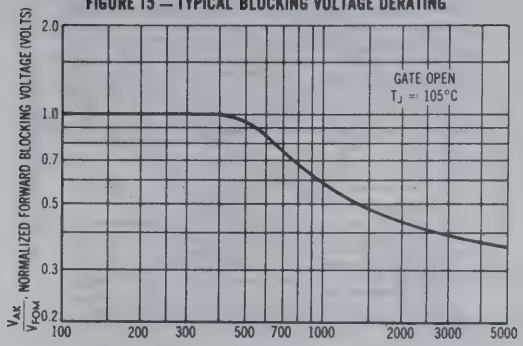


FIGURE 16 — TYPICAL dv/dt CAPABILITY

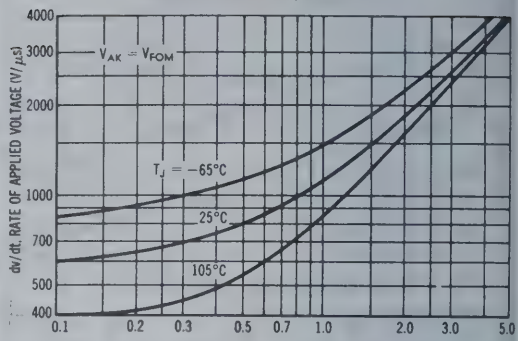


FIGURE 17 — FORWARD BLOCKING CURRENT

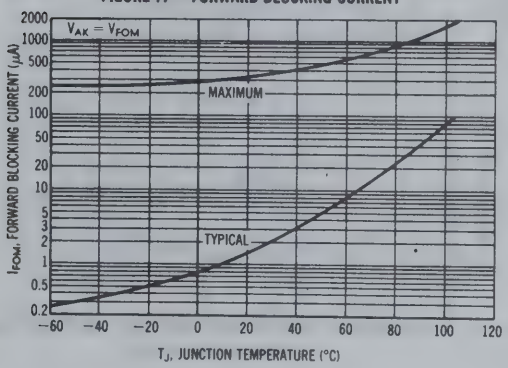


FIGURE 18 — HOLDING CURRENT

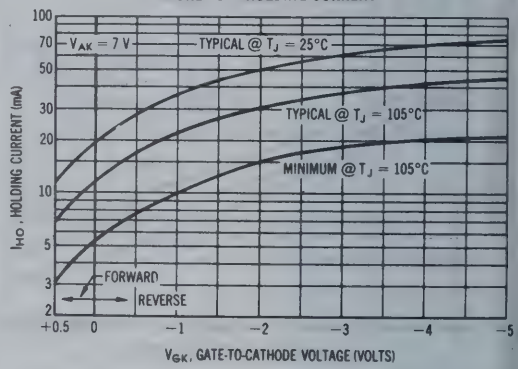


FIGURE 19 — TYPICAL ANODE-TO-CATHODE CAPACITANCE

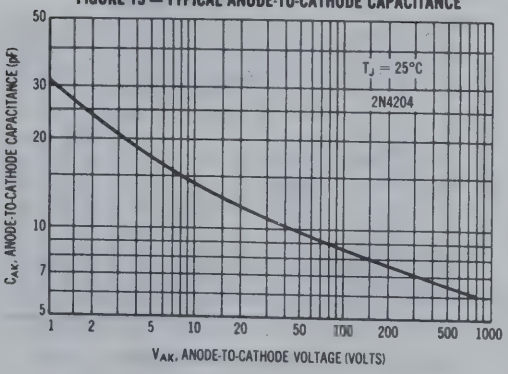
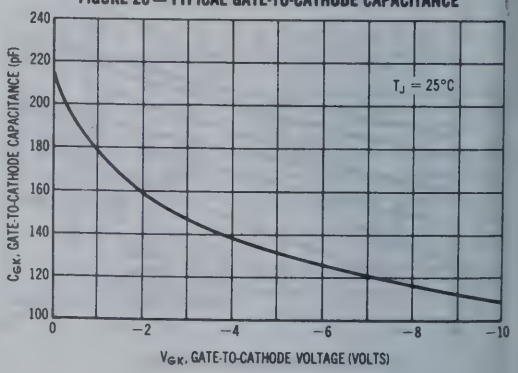


FIGURE 20 — TYPICAL GATE-TO-CATHODE CAPACITANCE



2N4212 thru 2N4216 (SILICON)



CASE 31(2)
(TO-5)

PNPN thyristors (silicon controlled rectifiers) designed for operation in mA/μA signal or detection circuits.

MAXIMUM RATINGS * (T_J = 125° C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) 2N4212	$V_{RXM(rep)}$	25	Volt
2N4213		50	
2N4214		100	
2N4215		150	
2N4216		200	
Forward Current RMS (All Conduction Angles)	I_f	1.6	Amp
Peak Surge Current (One Cycle, 60 Hz) No Repetition until Thermal Equilibrium is Restored	$I_{FM(surge)}$	15	Amp
Peak Gate Power - Forward	P_{GFM}	0.1	Watt
Average Gate Power - Forward	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current - Forward	I_{GFM}	0.1	Amp
Peak Gate Voltage - Forward	V_{GFM}	6.0	Volt
Reverse	V_{GRM}	6.0	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Lead Solder Temperature (> 1/16" from case, 10 sec. max)	-	+230	°C

* JEDEC Registered Values.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Characteristic	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1)	V_{FXM}			Volt
2N4212		25*	-	
2N4213		50*	-	
2N4214		100*	-	
2N4215		150*	-	
2N4216		200*		
Peak Reverse Blocking Current (Rated V_{RXM}, T_J = 125°C)	I_{RXM}	-	200*	μA
Peak Forward Blocking Current (Rated V_{FXM}, T_J = 125°C)	I_{FXM}	-	200*	μA
Forward "On" Voltage	V_F			Volt
(I_F = 1.0 A Peak)		-	1.5	
(I_F = 3.14 A Peak)		-	2.0*	
Gate Trigger Current (Note 2) (Anode Voltage = 7.0 V, R_L = 100 ohms)	I_{GT}			μAdc
(T_C = 25°C)		-	100	
(T_C = -65°C)		-	300*	
Gate Trigger Voltage (Anode Voltage = 7.0 V, R_L = 100 ohms, T_C = 25°C)	V_{GT}	-	0.8	Volt
(Anode Voltage = 7.0 V, R_L = 100 ohms, T_C = -65°C)	V_{GT}	-	1.0*	
(Anode Voltage = Rated V_{FXM}, R_L = 100 ohms, T_J = 125°C)	V_{GNT}	0.1*	-	
Holding Current (Anode Voltage = 7.0 V) T_C = 25°C	I_{HX}		3.0	mA
T_C = -65°C			7.0*	
Turn-On Time	t_{on}	Circuit dependent, consult manufacturer		
Turn-Off Time	t_{off}			

* JEDEC Registered Values

Notes: 1. V_{RXM} and V_{FXM} can be applied for all types on a continuous dc basis without incurring damage.

2. R_{GK} current is not included in measurement.

Thyristor devices shall not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

Thyristor devices shall not have a positive bias applied to the gate concurrently with a negative potential applied to the anode.

FIGURE 1 — CASE TEMPERATURE vs CURRENT

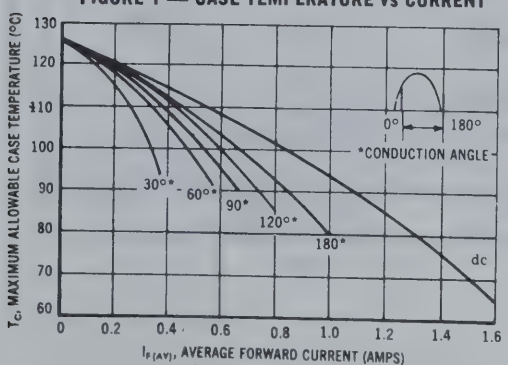
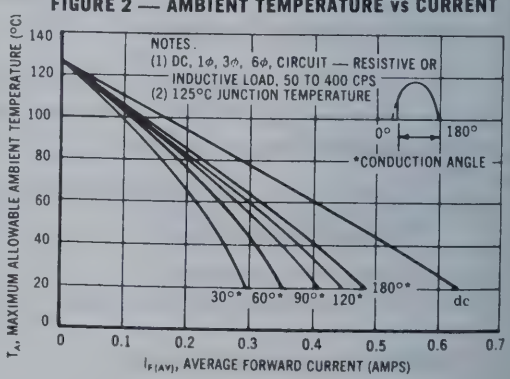


FIGURE 2 — AMBIENT TEMPERATURE vs CURRENT

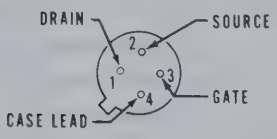


2N4220 thru 2N4222 (SILICON)
2N4220A thru 2N4222A



CASE 20(3)
(TO-72)

N-channel junction silicon field-effect transistors designed for general purpose amplifier and switching applications. "A" types guarantee low noise figure (2.5 dB maximum @ 100 kHz).



Drain and Source
may be interchanged.

MAXIMUM RATINGS

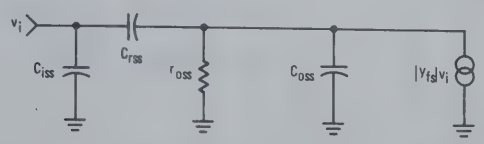
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	15	mAdc
Total Device Dissipation @ T_A = 25°C Derate Above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	-30	-	-	Vdc
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)		I_{GSS}	-	-	-0.1	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 150°C)			-	-	-100	
Gate-Source Voltage (I_D = 50 μAdc, V_{DS} = 15 Vdc)	2N4220, 2N4220A	V_{GS}	-0.5	-	-2.5	Vdc
(I_D = 200 μAdc, V_{DS} = 15 Vdc)	2N4221, 2N4221A		-1.0	-	-5.0	
(I_D = 500 μAdc, V_{DS} = 15 Vdc)	2N4222, 2N4222A		-2.0	-	-6.0	
Gate-Source Cutoff Voltage (I_D = 0.1 nAdc, V_{DS} = 15 Vdc)	2N4220, 2N4220A	$V_{GS(off)}$	-	-	-4.0	Vdc
	2N4221, 2N4221A		-	-	-6.0	
	2N4222, 2N4222A		-	-	-8.0	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	2N4220, 2N4220A	I_{DSS}*	0.5	-	3.0	mAdc
	2N4221, 2N4221A		2.0	-	6.0	
	2N4222, 2N4222A		5.0	-	15	
DYNAMIC CHARACTERISTICS						
Forward Transfer Admittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4220, 2N4220A	$\lvert y_{fs}\rvert$*	1000	2500	4000	μmhos
	2N4221, 2N4221A		2000	3500	5000	
	2N4222, 2N4222A		2500	4500	6000	
Output Admittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4220, 2N4220A	$\lvert y_{os}\rvert$*	-	-	10	μmhos
	2N4221, 2N4221A		-	-	20	
	2N4222, 2N4222A		-	-	40	
Drain-Source Resistance (V_{DS} = 0, V_{GS} = 0)	2N4220, 2N4220A	$r_{ds(on)}$	-	500	-	Ohms
	2N4221, 2N4221A		-	400	-	
	2N4222, 2N4222A		-	300	-	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	4.5	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	1.2	2.0	pF
Common-Source Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 30 MHz)		C_{osp}	-	1.5	-	pF
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 Megohm, f = 100 Hz)	2N4220A	NF	-	-	2.5	dB
	2N4221A		-	-	2.5	
	2N4222A		-	-	2.5	

*Pulse Test: Pulse Width = 630 ms, Duty Cycle = 10%

FIGURE 1 – EQUIVALENT LOW FREQUENCY CIRCUIT



*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

Common Source
Y Parameters for Frequencies
Below 30 MHz

$Y_{is} = j\omega C_{iss}$

$Y_{os} = j\omega C_{osp}^{*} + 1/r_{oss}$

$Y_{fs} = |Y_{fs}|$

$Y_{rs} = -j\omega C_{rss}$

FIGURE 2 – FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

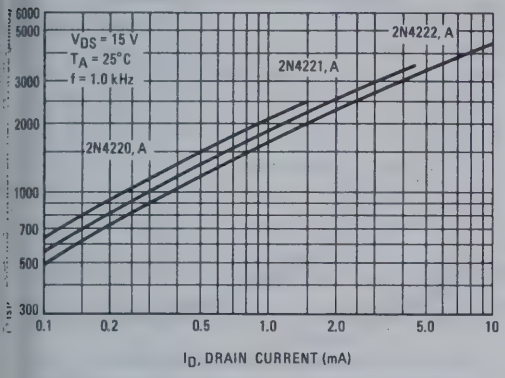


FIGURE 3 – TEMPERATURE COEFFICIENT OF Y_{fs} versus DRAIN CURRENT

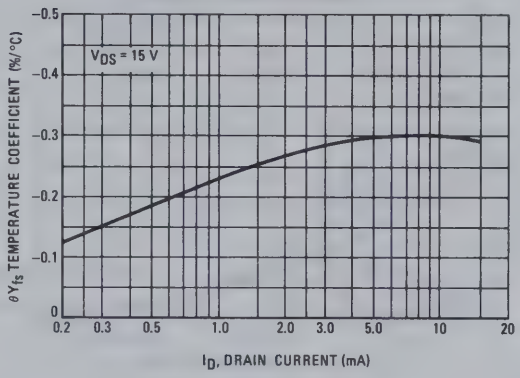


FIGURE 4 – OUTPUT RESISTANCE versus DRAIN CURRENT

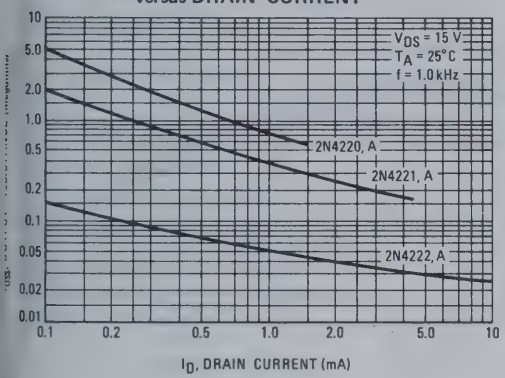


FIGURE 5 – CAPACITANCE versus DRAIN-SOURCE VOLTAGE

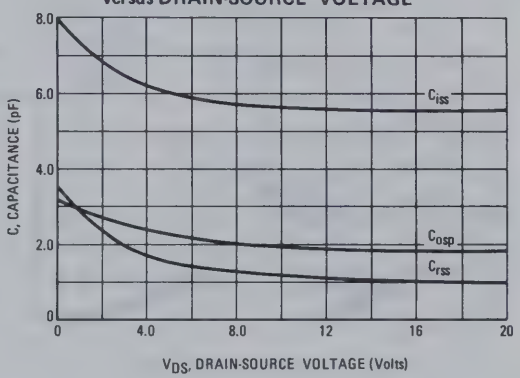


FIGURE 6 – NOISE FIGURE versus FREQUENCY

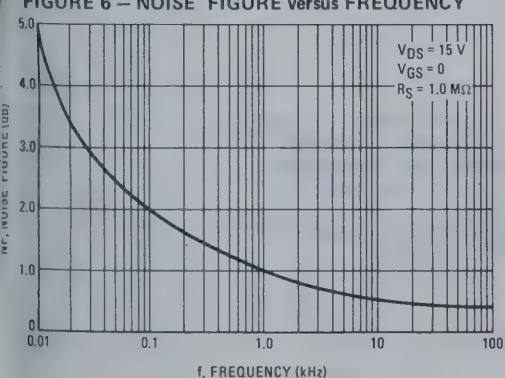


FIGURE 7 – NOISE FIGURE versus SOURCE RESISTANCE

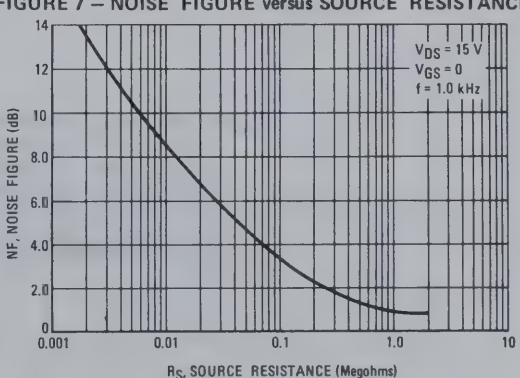


FIGURE 8 – DRAIN CURRENT versus GATE-SOURCE VOLTAGE

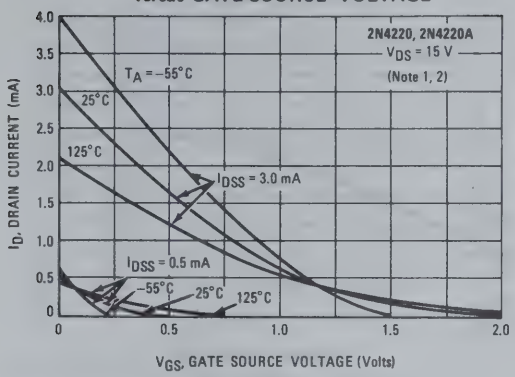


FIGURE 9 – DRAIN CURRENT versus GATE-SOURCE VOLTAGE

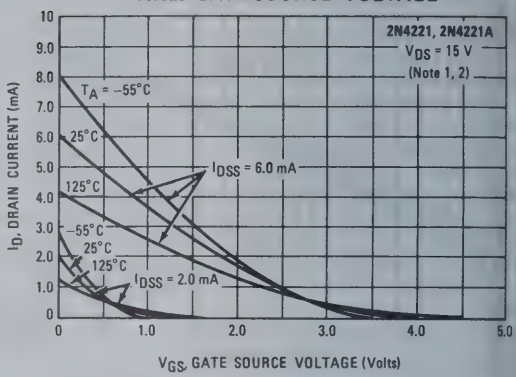


FIGURE 10 – DRAIN CURRENT versus GATE-SOURCE VOLTAGE

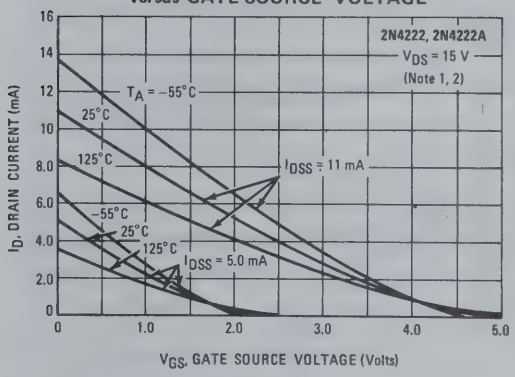
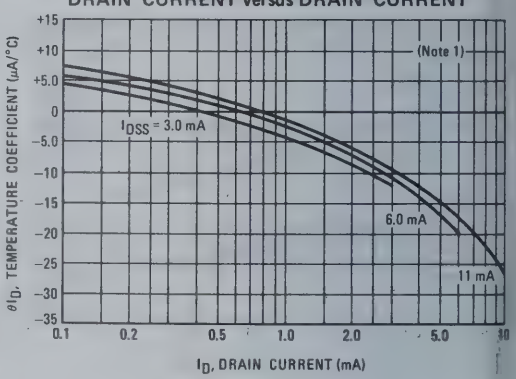


FIGURE 11 – TEMPERATURE COEFFICIENT OF DRAIN CURRENT versus DRAIN CURRENT



NOTES:

1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS} (See Figure 10).
2. Figures 8, 9, 10: Data taken in a standard printed circuit with a TO-18 type socket mounting and 1/4" lead length.

2N4223 (SILICON)
2N4224



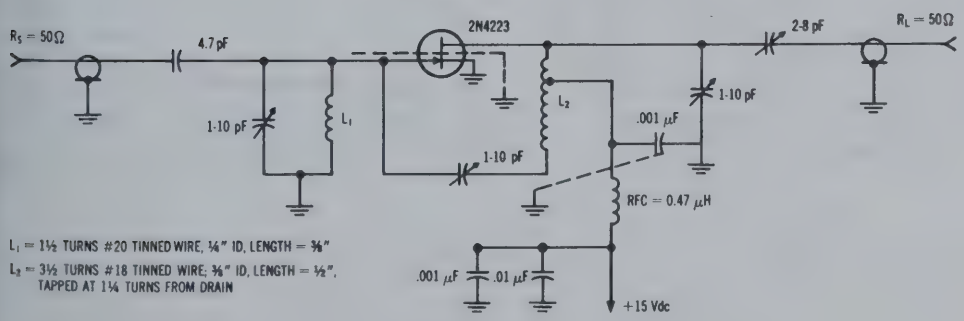
Silicon N-channel junction field-effect transistors, designed for VHF amplifier and mixer applications. Drain and Source interchangeable.

CASE 20(3)
(TO-72)

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	20	mAdc
Power Dissipation Derate above 25°C	P_D	300 2	mW mW/°C
Operating Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — NOISE FIGURE AND POWER GAIN TEST CIRCUIT



2N4223, 2N4224 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	-	Vdc
Gate Reverse Current		I_{GSS}			nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0)	2N4223		-	0.25	
	2N4224		-	0.50	
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C)	2N4223		-	250	
	2N4224		-	500	
Gate-Source Cutoff Voltage		$V_{GS(off)}$			Vdc
(I_D = 0.25 nAdc, V_{DS} = 15 Vdc)	2N4223		-	8	
(I_D = 0.50 nAdc, V_{DS} = 15 Vdc)	2N4224		-	8	
Gate-Source Voltage		V_{GS}			Vdc
(I_D = 0.3 mAdc, V_{DS} = 15 Vdc)	2N4223		1.0	7.0	
(I_D = 0.2 mAdc, V_{DS} = 15 Vdc)	2N4224		1.0	7.5	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current*		I_{DSS}*			mAdc
(V_{DS} = 15 Vdc, V_{GS} = 0)	2N4223		3	18	
	2N4224		2	20	
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance		$\|y_{fs}\|$			μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)*	2N4223		3000	7000	
	2N4224		2000	7500	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	2N4223		2700	-	
	2N4224		1700	-	
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{is})$	-	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{os})$	-	200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)		C_{iss}	-	6	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)		C_{rss}	-	2	pF
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1 k ohm, f = 200 MHz)	2N4223	NF	-	5	dB
Small-Signal Power Gain (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	2N4223	G_{ps}	10	-	dB

*Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%

FIGURE 2 –
DRAIN CURRENT versus GATE-SOURCE VOLTAGE

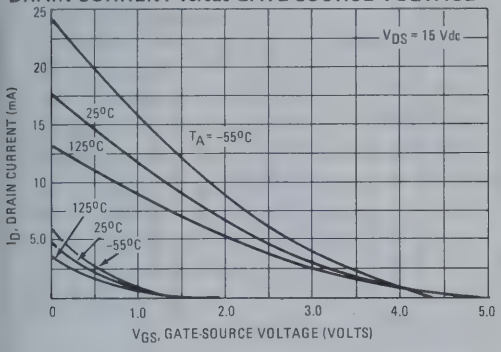


FIGURE 3 –
TEMPERATURE COEFFICIENT FOR DRAIN CURRENT

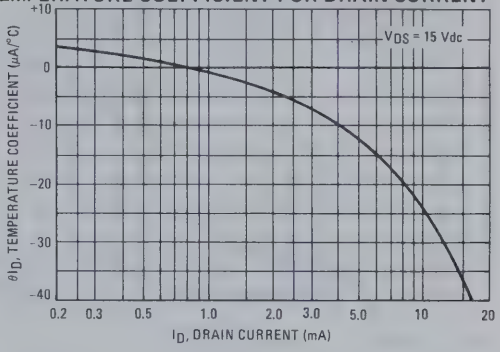


FIGURE 4 – FORWARD TRANSFER ADMITTANCE
versus GATE-SOURCE VOLTAGE

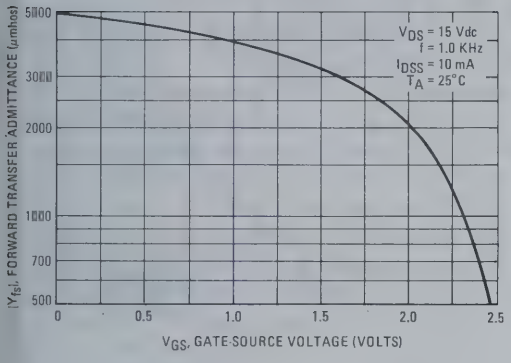


FIGURE 5 – TEMPERATURE COEFFICIENT FOR Y_{fs}
versus DRAIN CURRENT

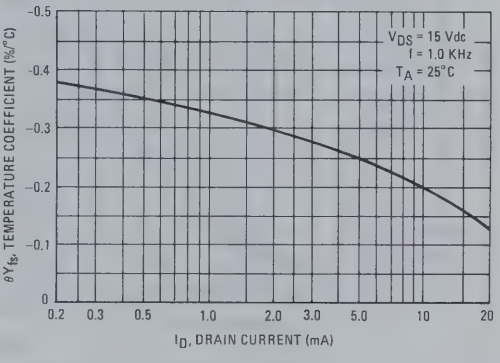


FIGURE 6 – CAPACITANCES

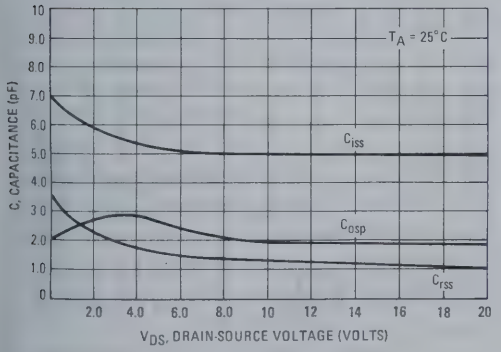


FIGURE 7 – COMMON SOURCE
NOISE FIGURE versus SOURCE RESISTANCE

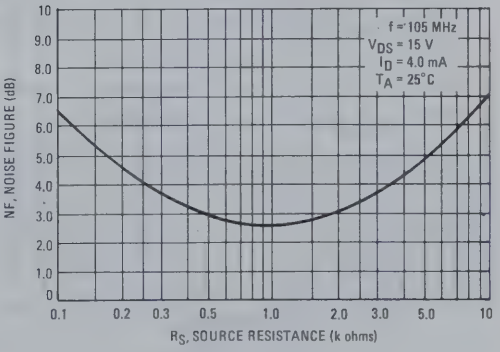


FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

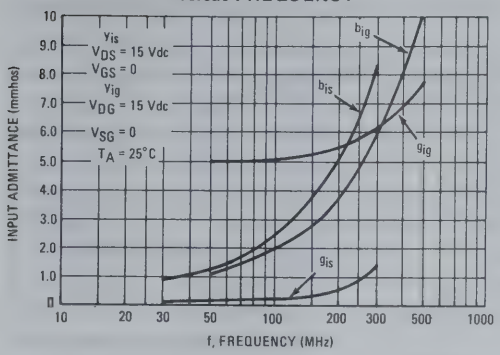


FIGURE 9 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

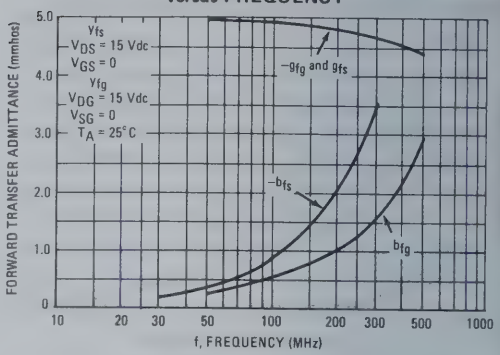


FIGURE 10 – OUTPUT ADMITTANCE versus FREQUENCY

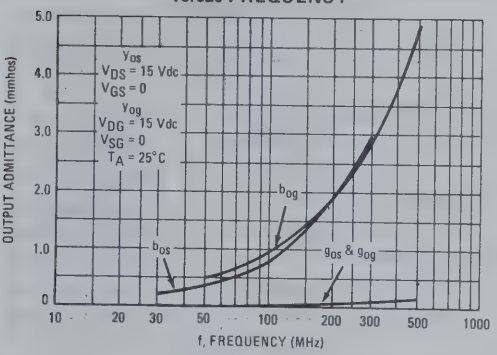


FIGURE 11 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

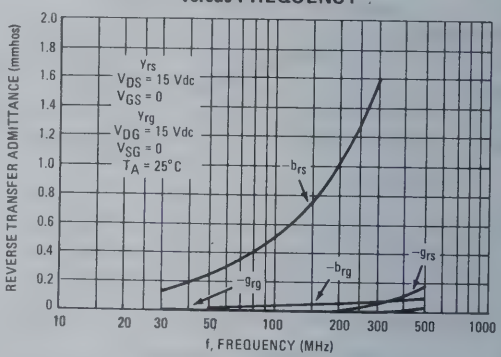


FIGURE 12 – POWER GAIN versus FREQUENCY

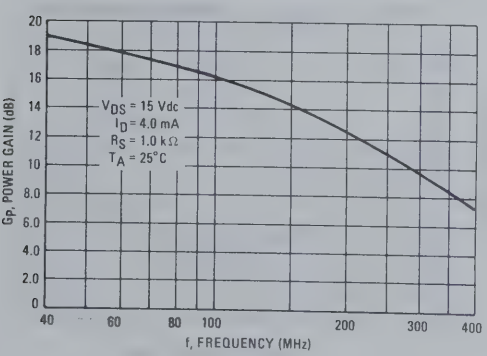
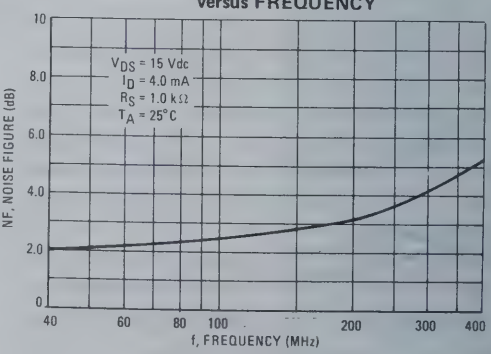
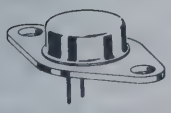


FIGURE 13 – COMMON SOURCE NOISE FIGURE versus FREQUENCY



2N4231 thru 2N4233 (SILICON)

Medium-power NPN silicon transistors designed for driver circuits, switching, and amplifier applications.



CASE 80
(TO-66)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N4231	2N4232	2N4233	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	70	90	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current - Continuous*	I_C*	3.0 5.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation T_C = 25°C Derate above 25°C	P_D	35 0.2			Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	5.0	°C/W

* The 3.0 Amp maximum I_C value is based upon JEDEC current gain requirements.
The 5.0 Amp maximum value is based upon actual current-handling capability of the device.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	2N4231 2N4232 2N4233	$BV_{CEO(sus)}$*	40 60 80	- - -	Vdc
Collector Cutoff Current		I_{CEO}			mA
(V_{CE} = 30 Vdc, I_B = 0)	2N4231		-	1.0	
(V_{CE} = 50 Vdc, I_B = 0)	2N4232		-	1.0	
(V_{CE} = 70 Vdc, I_B = 0)	2N4233		-	1.0	
Collector Cutoff Current		I_{CEX}			mA
(V_{CE} @ rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)			-	0.1	
(V_{CE} @ rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			-	1.0	
Collector Cutoff Current (V_{CB} @ rated V_{CB}, I_E = 0)		I_{CBO}	-	0.05	mA
Emitter Cutoff Current (V_{BE} = 5.0 V dc, I_C = 0)		I_{EBO}	-	500	μA
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			-
(I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)			40	-	
(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)			25	100	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)			10	-	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 1.5 Adc, I_B = 0.15 Adc)			-	0.7	
(I_C = 3.0 Adc, I_B = 0.3 Adc)			-	2.0	
Base-Emitter Voltage* (I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$*	-	1.4	Vdc

* Pulse Test, PW ≈ 300 μs, Duty Cycle ≈ 2.0%

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	4.0	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 kHz)	C_{ob}	-	200	pF
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	-	-

FIGURE 1 — NORMALIZED DC CURRENT GAIN

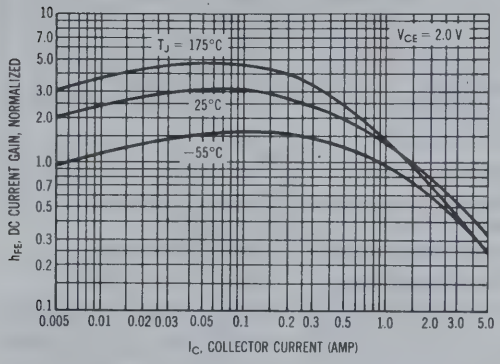


FIGURE 2 — COLLECTOR SATURATION REGION

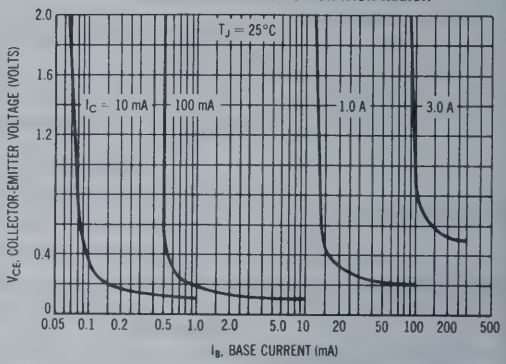


FIGURE 3 — "ON" VOLTAGES

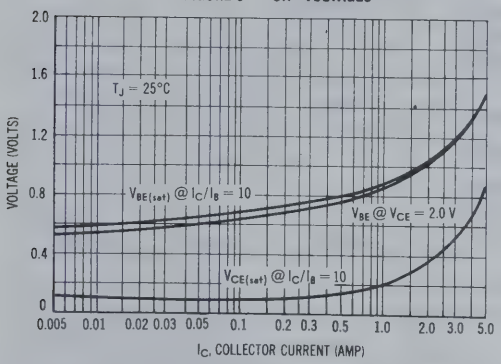


FIGURE 4 — TEMPERATURE COEFFICIENTS

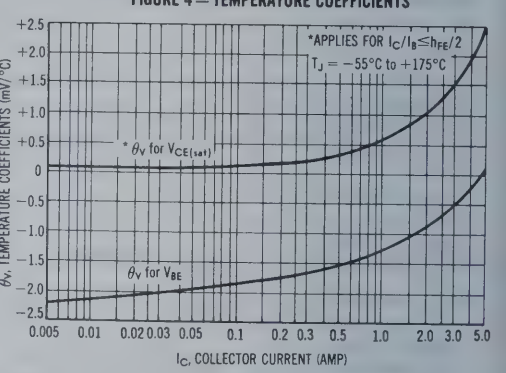


FIGURE 5 — SWITCHING TIME EQUIVALENT CIRCUIT

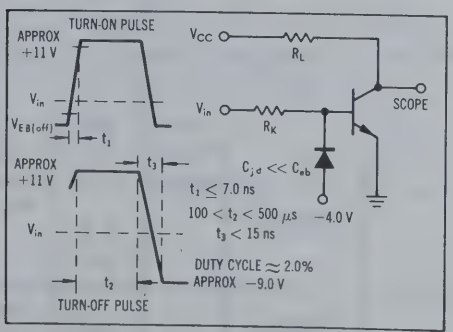


FIGURE 6 — CAPACITANCE

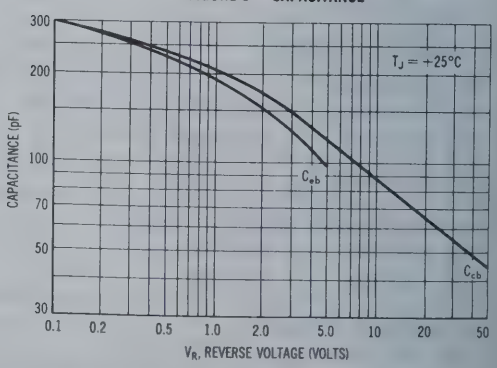


FIGURE 7 — TURN-ON TIME

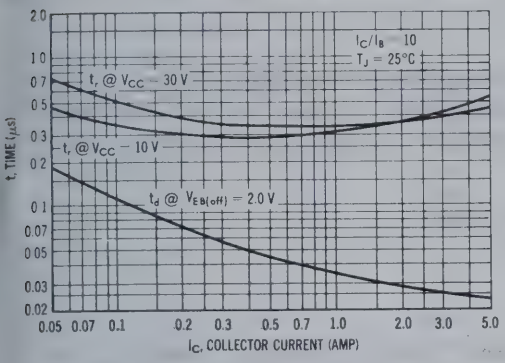
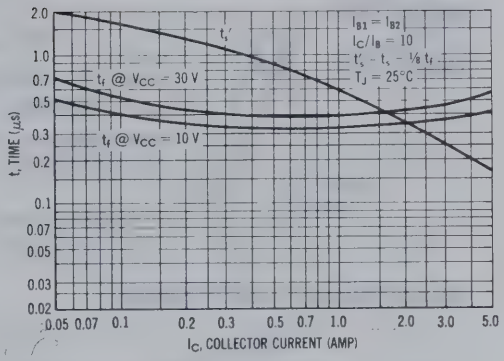


FIGURE 8 — TURN-OFF TIME



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 9 — CUT-OFF REGION

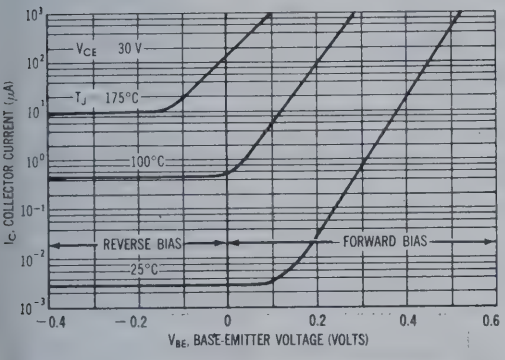


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

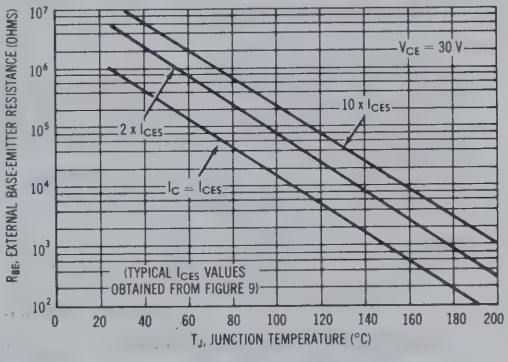
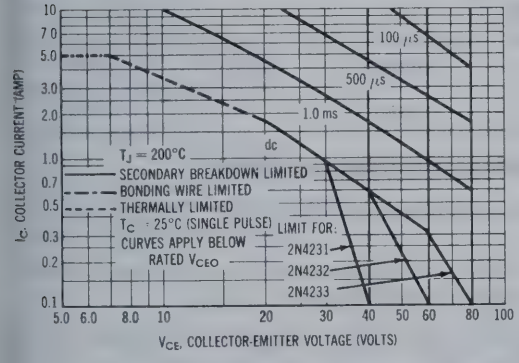


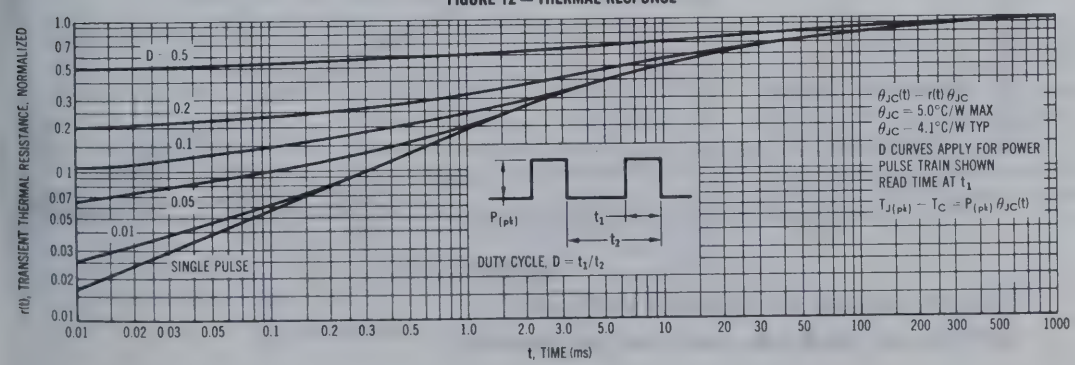
FIGURE 11 — ACTIVE-REGION SAFE-OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 11 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — THERMAL RESPONSE



2N4234 (SILICON)
2N4235
2N4236



CASE 31
(TO-5)

Collector connected to case

PNP silicon power transistors ideal for use as drivers, switches, and direct replacement of germanium medium-power devices. Complement to NPN 2N4237 thru 2N4239.

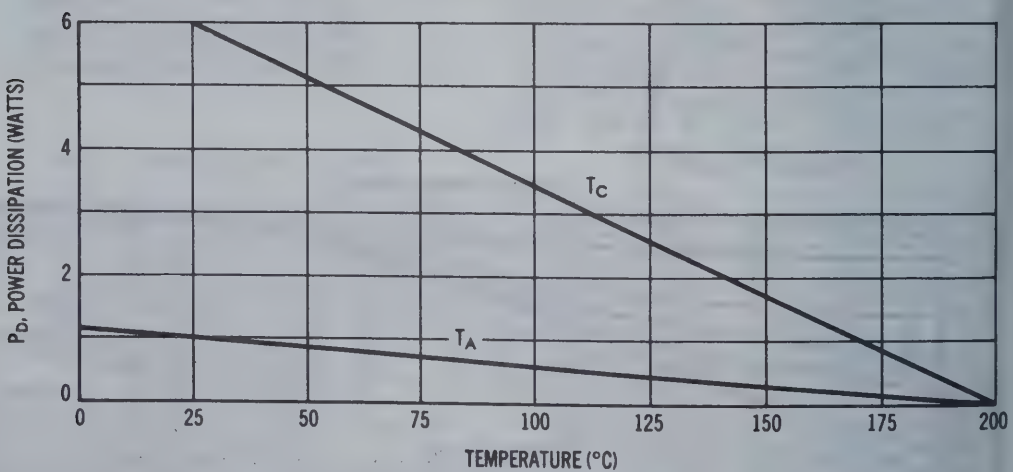
MAXIMUM RATINGS

Rating	Symbol	2N4234	2N4235	2N4236	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 7 →			Vdc
Collector Current — Continuous	I_C	← 3.0 →			Adc
Base Current	I_B	← 0.2 →			Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 1.0 → ← 5.7 →			Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 6 → ← 34 →			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	29	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.
All limits are applicable and must be observed.

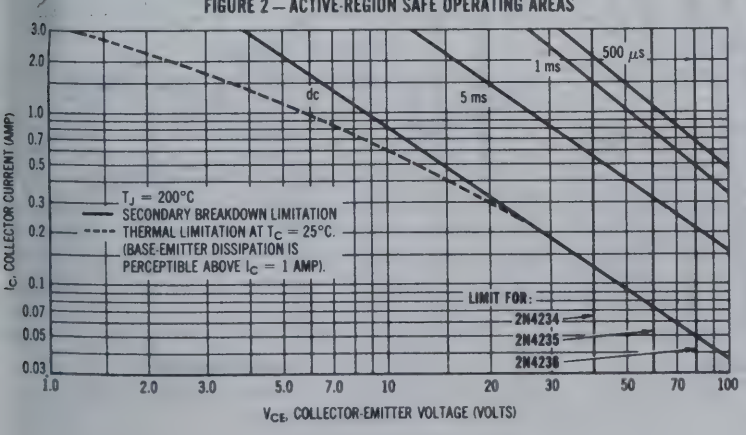
2N4234, 2N4235, 2N4236 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage * (I_C = 100 mAdc, I_B = 0)	2N4234	$BV_{CEO(sus)}$*	40	—	Vdc
	2N4235		60	—	
	2N4236		80	—	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N4234		—	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N4235		—	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N4236		—	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4234		—	0.1	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4235		—	0.1	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4236		—	0.1	
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4234		—	1.0	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4235		—	1.0	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4236		—	1.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N4234		—	0.1	
(V_{CB} = 60 Vdc, I_E = 0)	2N4235		—	0.1	
(V_{CB} = 80 Vdc, I_E = 0)	2N4236		—	0.1	
Emitter Cutoff Current (V_{BE} = 7 Vdc, I_C = 0)		I_{EBO}	—	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain *		h_{FE}*			—
(I_C = 100 mAdc, V_{CE} = 1 Vdc)			40	—	
(I_C = 250 mAdc, V_{CE} = 1 Vdc)			30	150	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)			20	—	
(I_C = 1.0 Adc, V_{CE} = 1 Vdc)			10	—	
Collector-Emitter Saturation Voltage * (I_C = 1.0 Adc, I_B = 125 mAdc)		$V_{CE(sat)}$*	—	0.6	Vdc
Base-Emitter Saturation Voltage * (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$*	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	3.0	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	100	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	—	—

*Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

FIGURE 2 — ACTIVE-REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE

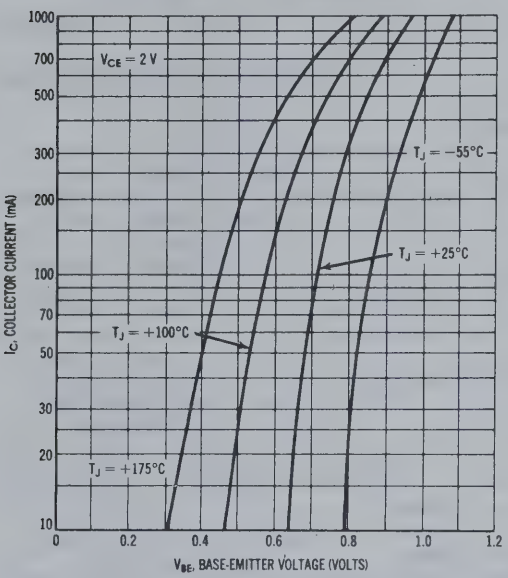
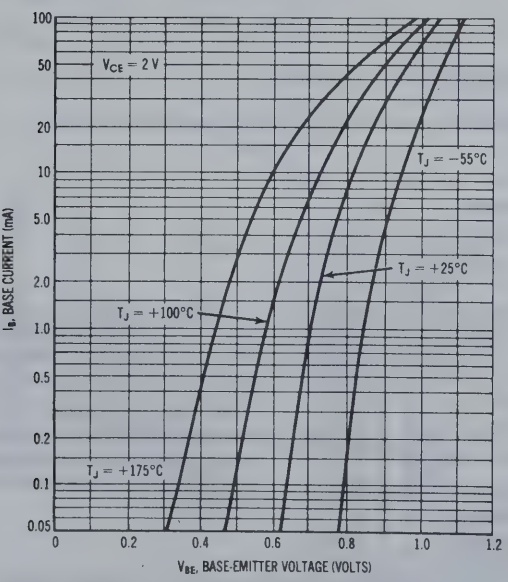


FIGURE 4 — INPUT ADMITTANCE



"OFF" REGION CHARACTERISTICS

FIGURE 5 — TRANSCONDUCTANCE

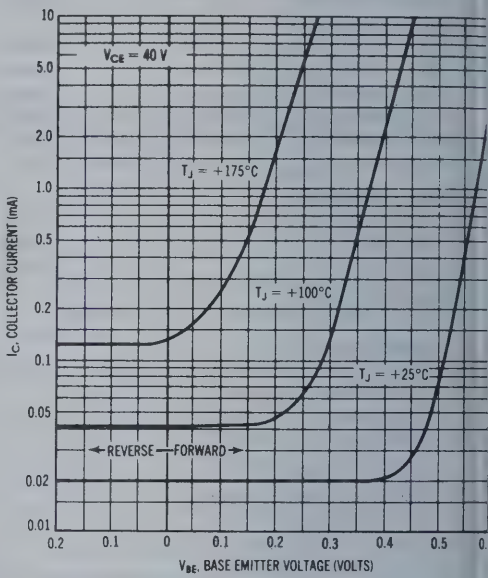


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

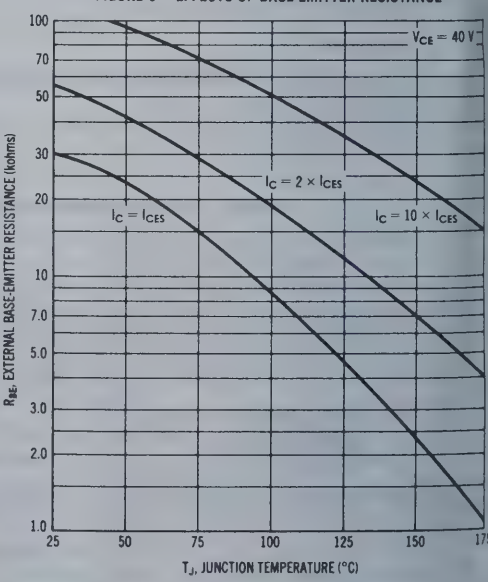
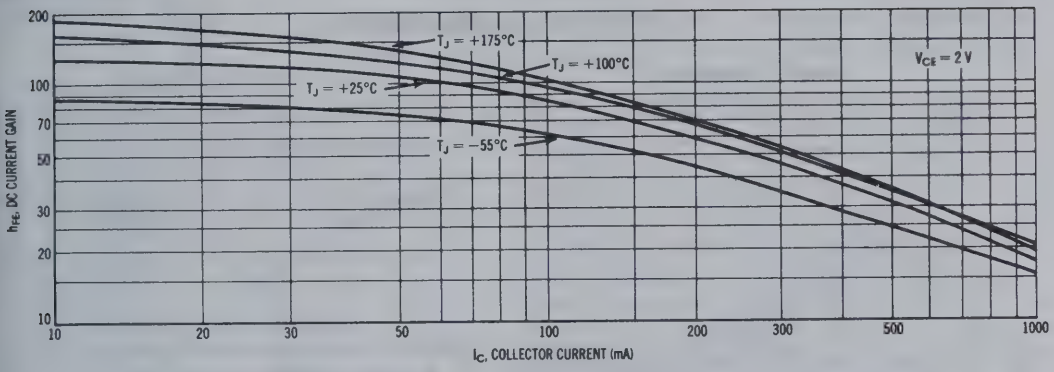


FIGURE 7 — CURRENT GAIN



SATURATION REGION CHARACTERISTICS

FIGURE 8 — COLLECTOR SATURATION REGION

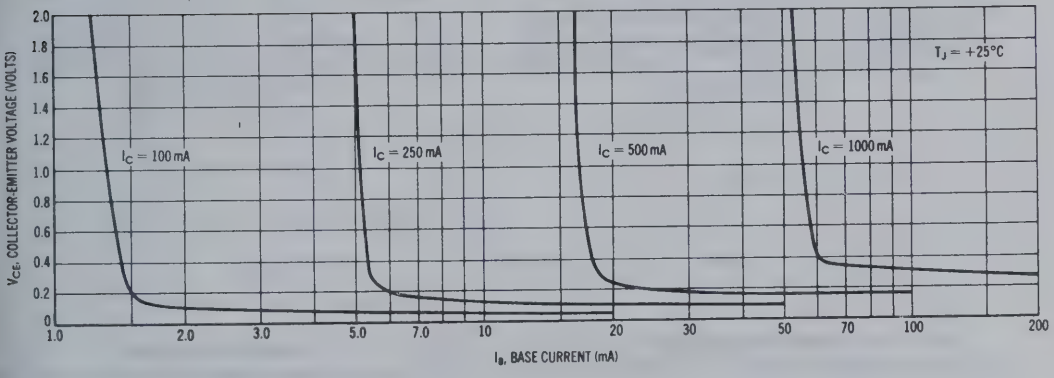


FIGURE 9 — "ON" VOLTAGES

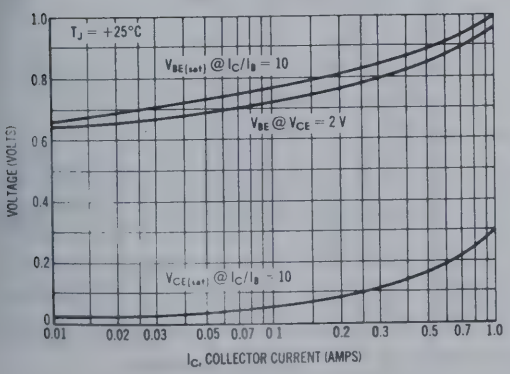
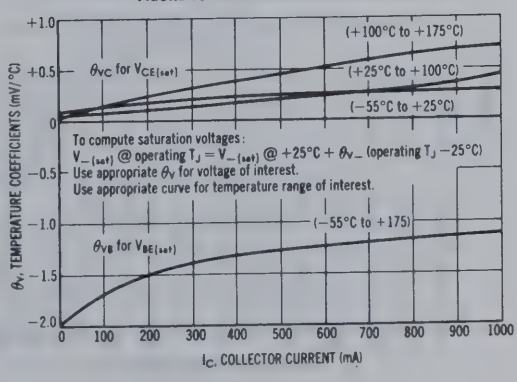


FIGURE 10 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 11 — TURN-ON TIME

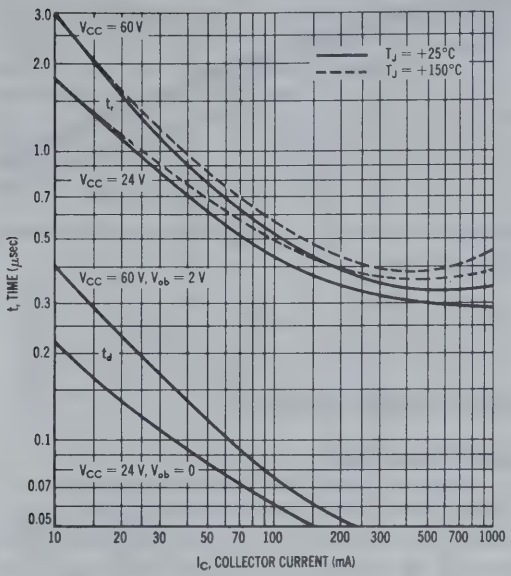


FIGURE 13 — CAPACITANCE

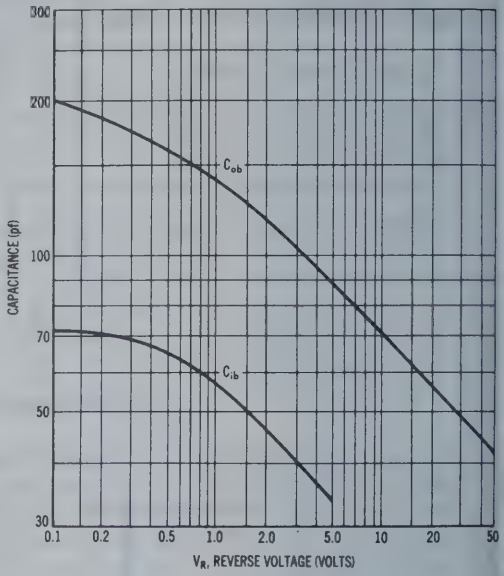


FIGURE 12 — STORAGE TIME

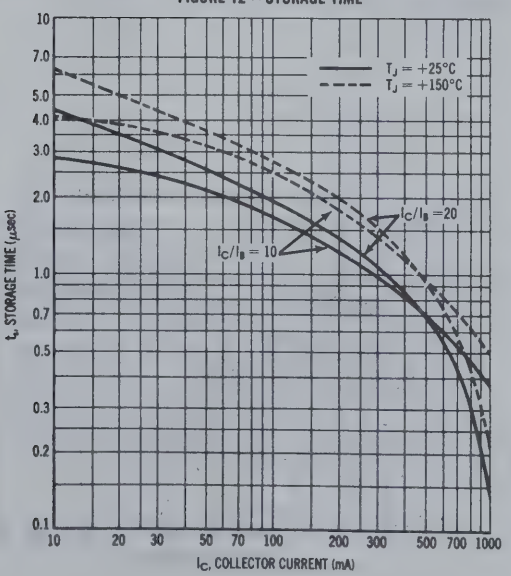
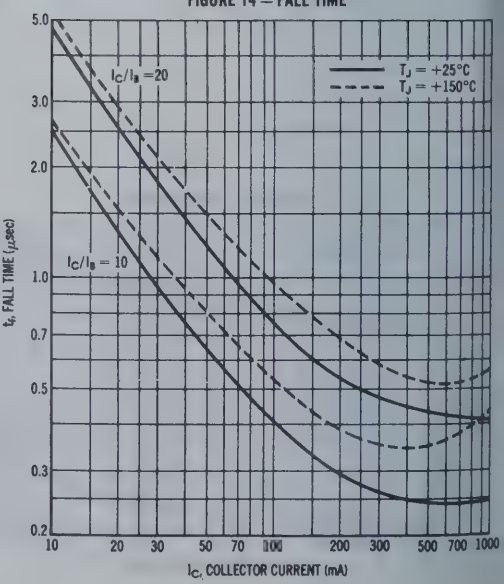


FIGURE 14 — FALL TIME



2N4237 (SILICON) thru 2N4239



Medium-power NPN silicon transistors designed for driver circuits, switching, and amplifier applications.

CASE 31
(TO-5)

Collector connected to case

MAXIMUM RATINGS

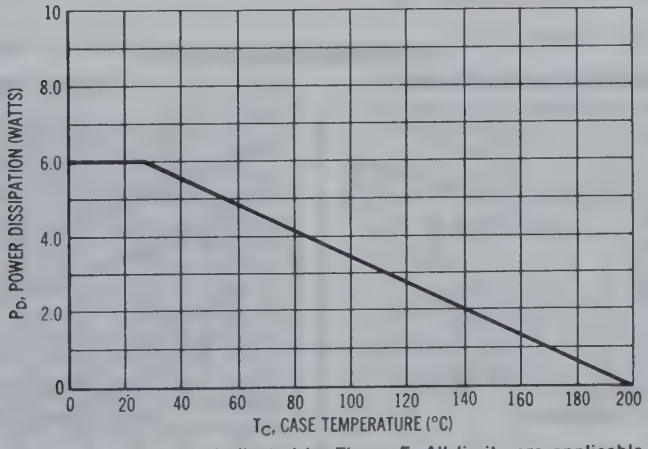
Rating	Symbol	2N4237	2N4238	2N4239	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	80	100	Vdc
Emitter-Base Voltage	V_{EB}	← 6.0 →			Vdc
Collector Current — Continuous*	I_C	← 1.0 →			Adc
		← 3.0 →			
Base Current — Continuous	I_B	← 500 →			mAdc
Total Device Dissipation @ T_C = 25°C	P_D	← 6.0 →			Watts
Derate above 25°C		← 34 →			mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +200 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	29	°C/W

*The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements. The 3.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0) 2N4237	-	$BV_{CEO(sus)}$*	40	-	Vdc
2N4238			60	-	
2N4239			80	-	
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)	-	I_{CEO}	-	0.7	mAdc
Collector Cutoff Current	12	I_{CEX}			mAdc
(V_{CE} = 45 Vdc, $V_{EB(off)}$ = 1.5 Vdc)			-	0.1	
(V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc)			-	0.1	
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)			-	0.1	
(V_{CE} = 30 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			-	1.0	
(V_{CE} = 50 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			-	1.0	
(V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CBO}, I_E = 0)	-	I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	-	I_{EBO}	-	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain*	8	h_{FE}*			-
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)			30	-	
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)			30	150	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			30	-	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			15	-	
Collector-Emitter Saturation Voltage*	9, 11, 13	$V_{CE(sat)}$*			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			-	0.3	
(I_C = 1.0 Adc, I_B = 0.1 Adc)			-	0.6	
Base-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{BE(sat)}$*	-	1.5	Vdc
Base-Emitter On Voltage* (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)	11, 13	$V_{BE(on)}$*	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)	-	f_T	2.0	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	-	C_{ob}	-	100	pF
Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	-	h_{fe}	30	-	-

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING CHARACTERISTICS

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

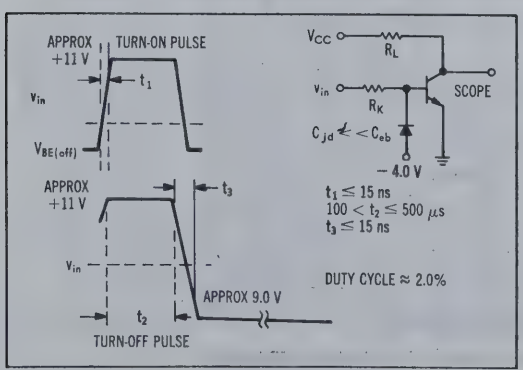


FIGURE 3 — TURN-ON TIME

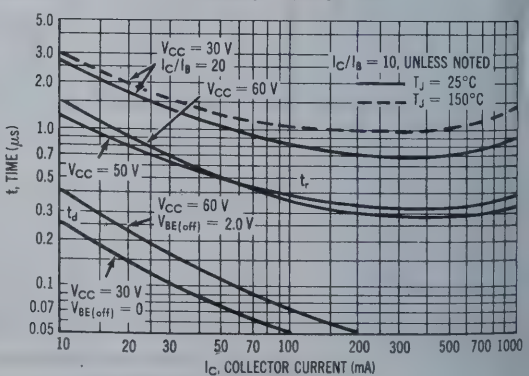


FIGURE 4 — THERMAL RESPONSE

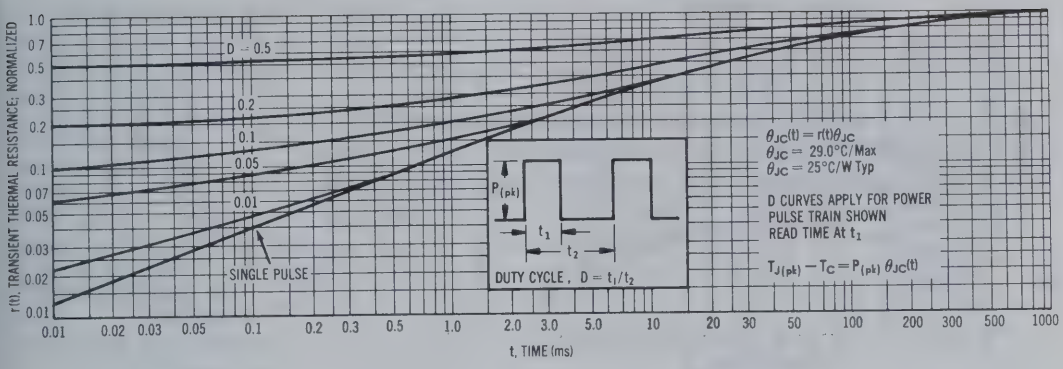
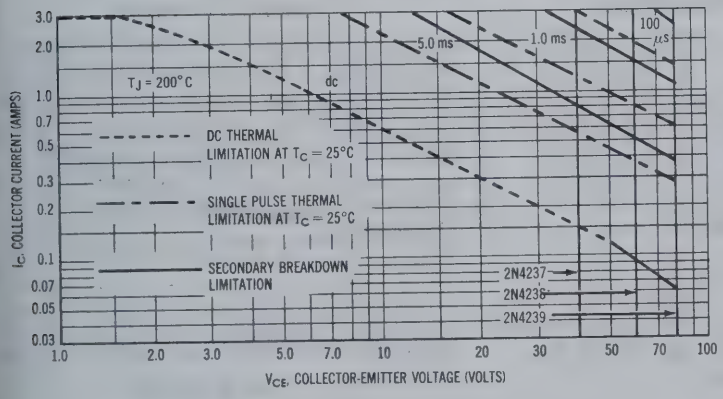


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

For this particular transistor family, the thermal curves are the limiting design values, except for a small portion of the dc curve. The pulse secondary breakdown curves are shown for information only.

FIGURE 6 — STORAGE TIME

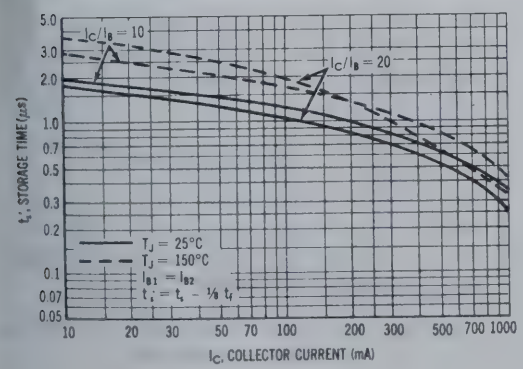
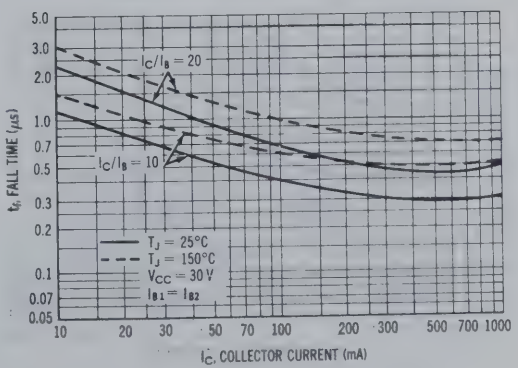


FIGURE 7 — FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 8 — CURRENT GAIN

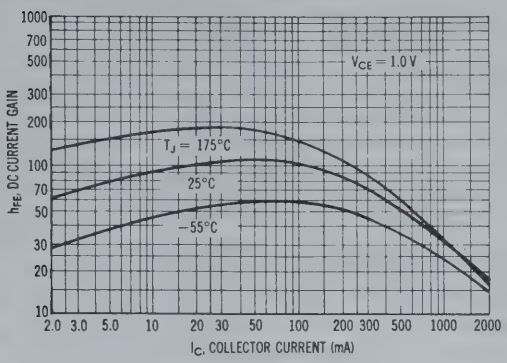


FIGURE 9 — COLLECTOR SATURATION REGION

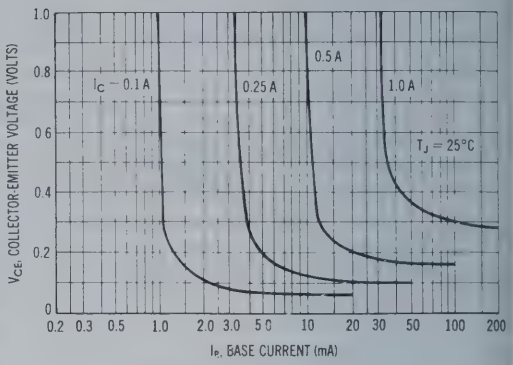


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

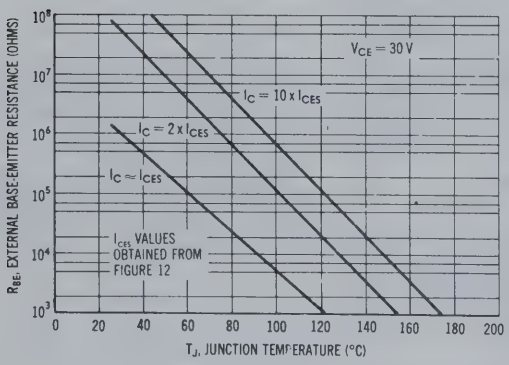


FIGURE 11 — "ON" VOLTAGE

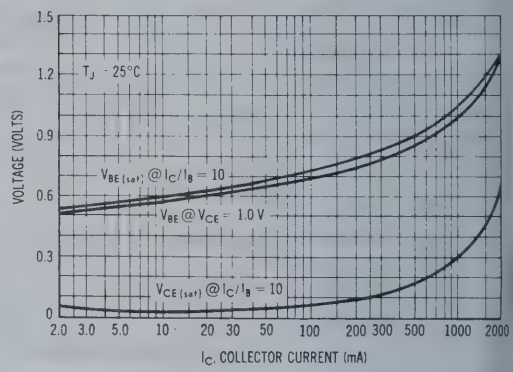


FIGURE 12 — COLLECTOR CUTOFF REGION

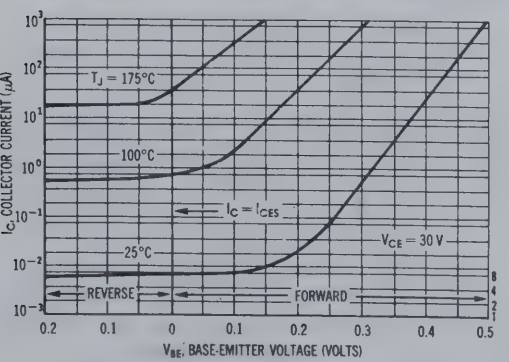
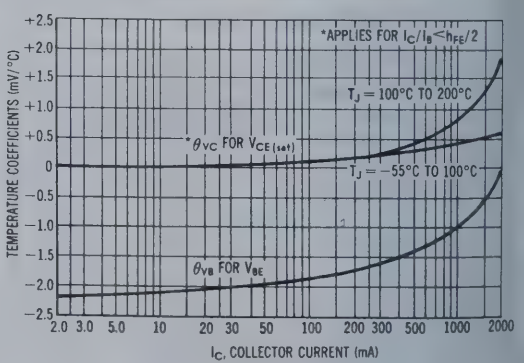


FIGURE 13 — TEMPERATURE COEFFICIENTS



2N4260 (SILICON)

2N4261



CASE 20
(TO-72)

PNP silicon annular transistors, designed for high-speed current-mode logic switching applications and for complementary circuitry with NPN types 2N3959 and 2N3960.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current - Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D	200	mW
Derate above 25°C		1.14	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_E = 0)		BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 2 Vdc)		I_{CEX}	-	0.005	μAdc
(V_{CE} = 10 Vdc, $V_{BE(off)}$ = 2 Vdc, T_A = 150°C)			-	5.0	
(V_{CE} = 10 Vdc, $V_{EB(on)}$ = 0.4 Vdc)			-	0.05	
Base Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 2 Vdc)		I_{BL}	-	0.005	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1 mAdc, V_{CE} = 1 Vdc)	1	h_{FE}	25	-	-
(I_C = 10 mAdc, V_{CE} = 1 Vdc)			30	150	
(I_C = 30 mAdc, V_{CE} = 2 Vdc)			20	-	
Collector-Emitter Saturation Voltage (I_C = 1 mAdc, I_B = 0.1 Adc)	2, 3, 4	$V_{CE(sat)}$	-	0.15	Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			-	0.35	
Base-Emitter On Voltage (I_C = 1 mAdc, V_{CE} = 1 Vdc)	3, 4	$V_{BE(on)}$	-	0.8	Vdc
(I_C = 10 mAdc, V_{CE} = 1 Vdc)			-	1.0	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5 mAdc, V_{CE} = 4 Vdc, f = 100 MHz) 2N4260	5	f_T	1200	-	MHz
2N4261			1500	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N4260			1600	-	
2N4261			2000	-	
High-Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N4260		$\lvert h_{fe} \rvert$	16	-	-
2N4261			20	-	
Output Capacitance (V_{CB} = 4 Vdc, I_E = 0, f = 100 kHz)	8	C_{ob}	-	2.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	8	C_{ib}	-	2.5	pF
Collector-Base Time Constant (I_C = 5 mAdc, V_{CE} = 4 Vdc, f = 31.8 MHz) 2N4260	6	$r_b'C_c$	-	35	ps
2N4261			-	60	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 31.8 MHz) 2N4260			-	30	
2N4261			-	50	

TYPICAL SWITCHING TIMES			Typical Performance (V_{out} = 1 V) @ 10 mA	@ 30 mA	
Turn-On Delay Time	Test Circuit Figure 7	$t_{on(delay)}$	1.0	1.2	ns
Rise Time		t_r	0.5	0.9	ns
Turn-Off Delay Time	Test Circuit Figure 7	$t_{off(delay)}$	1.0	1.2	ns
Fall-Time		t_f	1.0	1.2	ns

FIGURE 1 — DC CURRENT GAIN

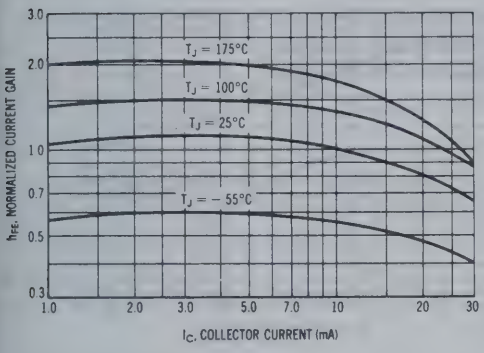


FIGURE 2 — COLLECTOR SATURATION REGION

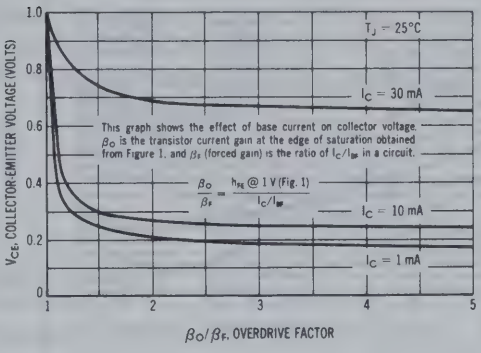


FIGURE 3 — "ON" VOLTAGES

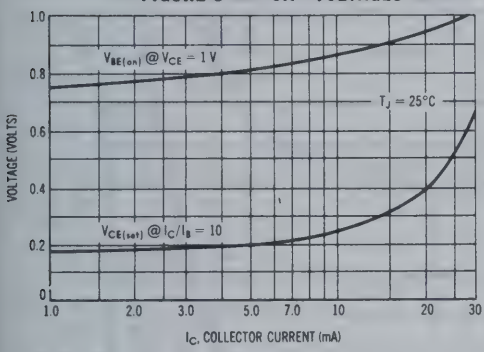


FIGURE 4 — TEMPERATURE COEFFICIENTS

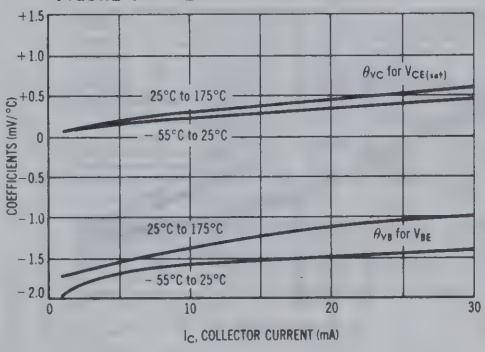


FIGURE 5 —
CURRENT-GAIN — BANDWIDTH PRODUCT

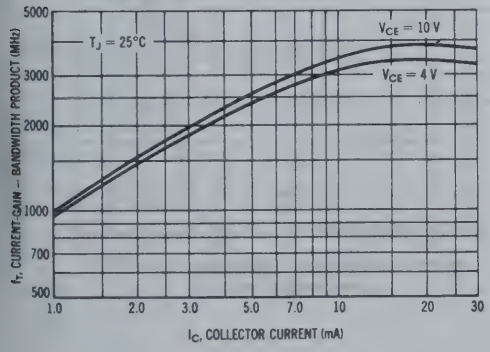


FIGURE 6 —
COLLECTOR-BASE TIME CONSTANT

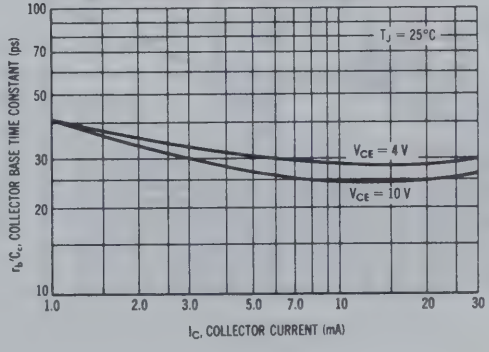
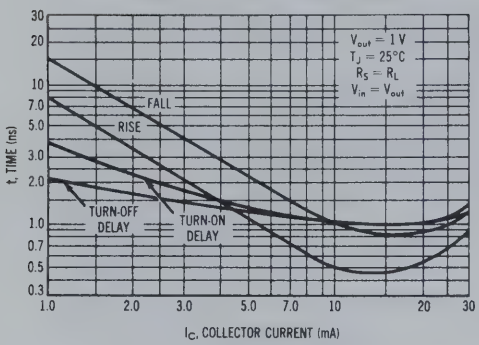
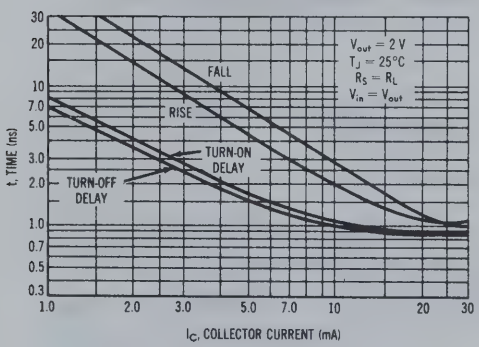
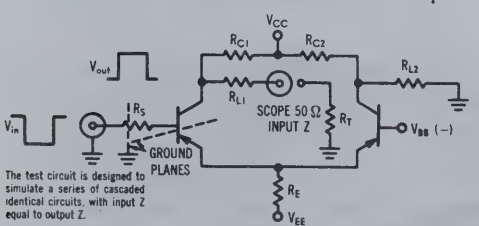


FIGURE 7 — SWITCHING TIMES







The test circuit is designed to simulate a series of cascaded identical circuits, with input Z equal to output Z.

$V_{in} = V_{out} = 2$ V $V_{BB} = 1$ V $R_{C1} = R_{C2}$								$V_{in} = V_{out} = 1$ V $V_{BB} = 0.5$ V $R_{C1} = R_{C2}$						
I_C mA	R_S ohms	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{BB} volts	V_{CC} volts	R_S ohms	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{BB} volts	V_{CC} volts
1	2 k	6 k	3 k	3 k	10 k	10	16	1 k	6 k	1.2 k	1.2 k	24 k	24	32
5	360	3.56 k	400	450	2 k	10	47	175	1 k	200	250	3 k	15	27
10	160	1 k	200	250	3 k	30	26.3	75	300	100	150	3 k	30	17
20	62	300	100	150	1 k	20	16	25	150	25	75	1 k	20	11
30	28	157	66	116	1 k	30	13	8	77	0	50	1 k	30	9

FIGURE 8 — CAPACITANCE

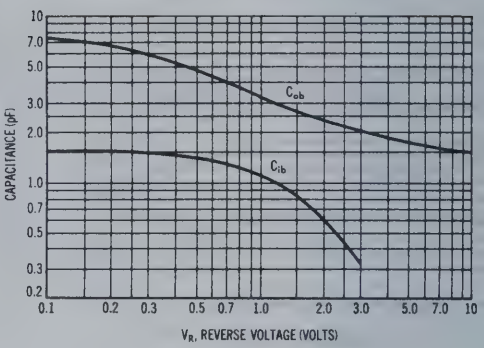
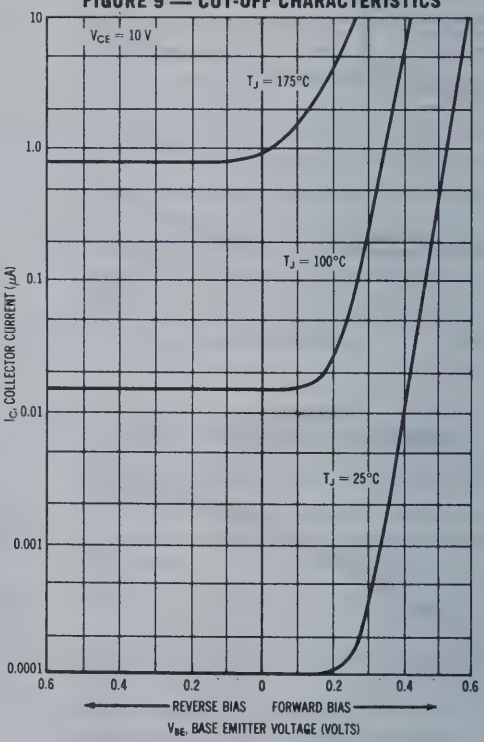
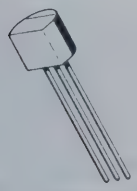


FIGURE 9 — CUT-OFF CHARACTERISTICS



2N4264 (SILICON)

2N4265



CASE 29(1)
(TO-92)

NPN silicon annular transistors, designed for low-level, saturated logic applications featuring one-piece, injection-molded plastic package for high reliability.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

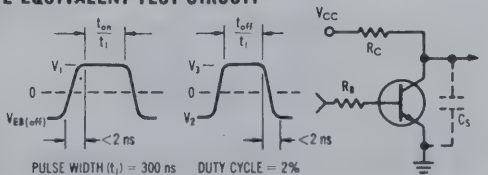
Rating	Symbol	2N4264	2N4265	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ $T_A = 60°C$	P_D	210		mW
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

FIGURE 1 — SWITCHING TIME EQUIVALENT TEST CIRCUIT

TEST CONDITION	I_C	V_{CC}	R_B	R_C	$C_{S(max)}$	$V_{EB(off)}$	V_1	V_2	V_3
	mA	V	Ω	Ω	pF	V	V	V	V
A	10	3	3300	270	4	−1.5	10.55	−4.15	10.70
B	10	10	560	960	4	—	—	−4.65	6.55
C	100	10	560	96	12	−2.0	6.35	−4.65	6.55



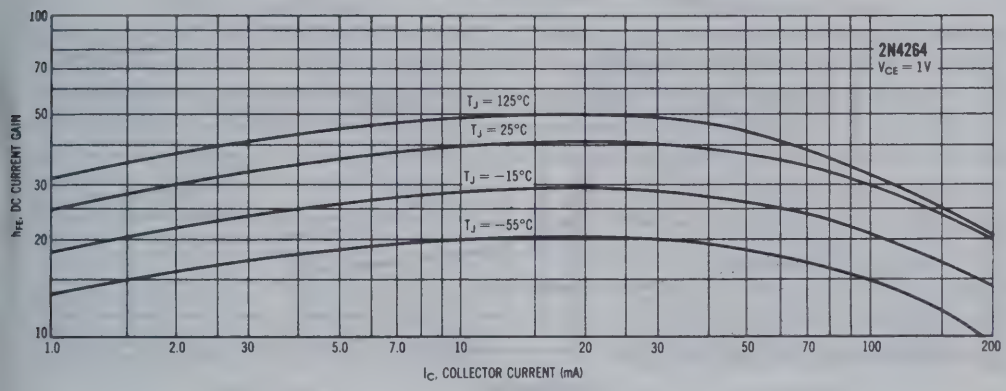
PULSE WIDTH (t_1) = 300 ns DUTY CYCLE = 2%

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_E = 0)	2N4264		BV_{CEO}	15	—	Vdc
	2N4265			12	—	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc)			I_{CEX}	—	100	nAdc
Base Cutoff Current (V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc)			I_{BL}	—	0.1	μAdc
(V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 100°C)				—	10	
ON CHARACTERISTICS						
DC Current Gain (I_C = 1 mAdc, V_{CE} = 1 Vdc)	2N4264	2	h_{FE}	25	—	—
	2N4265			50	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N4264			40	160	
	2N4265			100	400	
(I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55°C)	2N4264			20	—	
	2N4265			45	—	
(I_C = 30 mAdc, V_{CE} = 1 Vdc)	2N4264			40	—	
	2N4265			90	—	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N4264			30	—	
	2N4265			55	—	
(I_C = 200 mAdc, V_{CE} = 1 Vdc)	2N4264			20	—	
	2N4265			35	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		5, 6, 7	$V_{CE(sat)}$	—	0.22	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)				—	0.35	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		6, 7	$V_{BE(sat)}$	0.65	0.80	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)				0.75	0.95	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)			f_T	300	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)		12	C_{ob}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		12	C_{ib}	—	8.0	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	Figure 1, Test Condition A V_{CC} = 3 Vdc, $V_{EB(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3 mAdc	1	t_{on}	—	25	ns
Turn-Off Time	Figure 1, Test Condition A V_{CC} = 3 Vdc, I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1.5 mAdc	1	t_{off}	—	35	ns
Storage Time	Figure 1, Test Condition B V_{CC} = 10 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc	1	t_s	—	20	ns
Delay Time	Figure 1, Test Condition C V_{CC} = 10 Vdc, $V_{EB(off)}$ = 2 Vdc, I_C = 100 mAdc, I_{B1} = 10 mAdc	1, 8	t_d	—	8.0	ns
Rise Time		1, 9	t_r	—	15	ns
Storage Time	Figure 1, Test Condition C V_{CC} = 10 Vdc, I_C = 100 mAdc, I_{B1} = I_{B2} = 10 mAdc	1, 10	t_s	—	20	ns
Fall Time		1, 11	t_f	—	15	ns
Total Control Charge	V_{CC} = 3 Vdc, I_C = 10 mAdc, I_B = mAdc	3, 13	Q_T	—	80	pC

CURRENT GAIN CHARACTERISTICS

FIGURE 2 — MINIMUM CURRENT GAIN



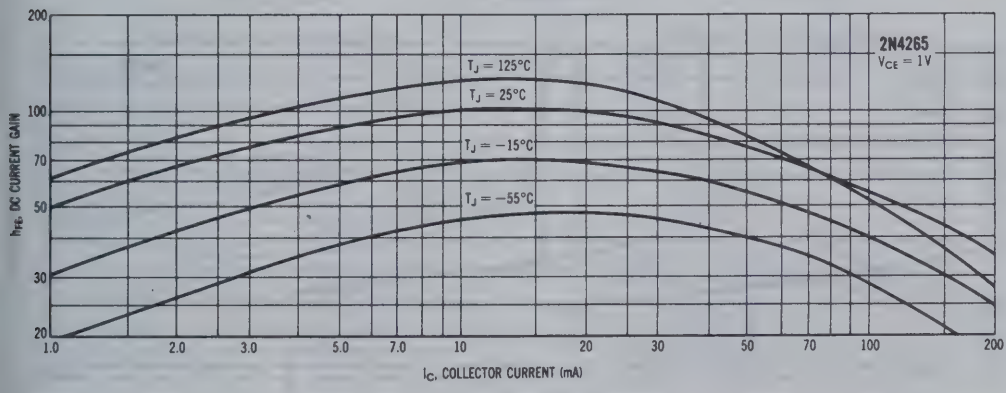


FIGURE 3 — Q_T TEST CIRCUIT

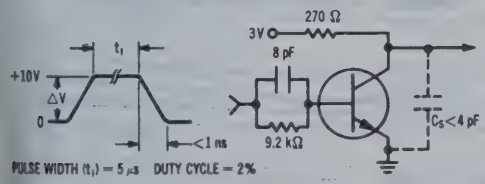
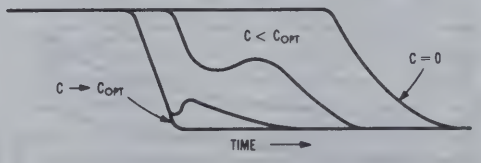


FIGURE 4 — TURN-OFF WAVEFORM



NOTE 1

When a transistor is held in a conductive state by a base current, I_b, a charge, Q_s, is developed or "stored" in the transistor. Q_s may be written: $Q_s = Q_i + Q_v + Q_x$.

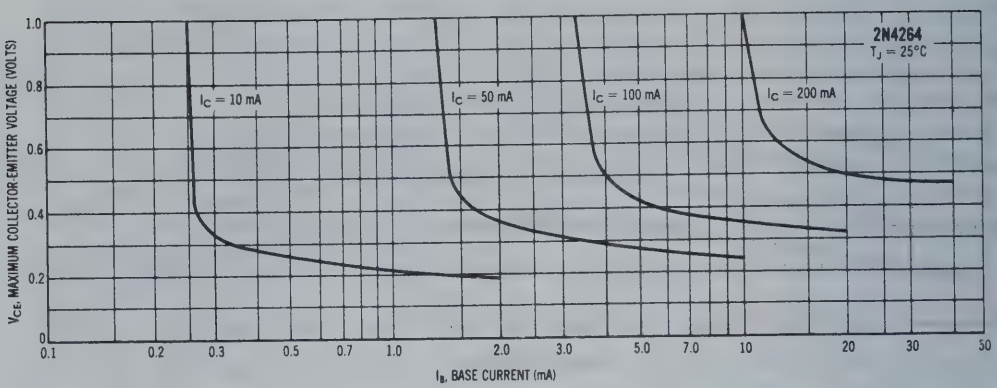
Q_i is the charge required to develop the required collector current. This charge is primarily a function of alpha cutoff frequency. Q_v is the charge required to charge the collector-base feedback capacity. Q_x is excess charge resulting from overdrive, i.e., operation in saturation.

The charge required to turn a transistor "on" to the edge of saturation is the sum of Q_i and Q_v which is defined as the active region charge, Q_A. $Q_A = I_{B1}t_r$ when the transistor is driven by a constant current step (I_{B1}) and $I_{B1} << \frac{I_C}{h_{FE}}$.

If I_b were suddenly removed, the transistor would continue to conduct until Q_s is removed from the active regions through an external path or through internal recombination. Since the internal recombination time is long compared to the ultimate capability of a transistor, a charge, Q_T, of opposite polarity, equal in magnitude, can be stored on an external capacitor, C, to neutralize the internal charge and considerably reduce the turn-off time of the transistor. Figure 3 shows the test circuit and Figure 4 the turn-off waveform. Given Q_T from Figure 13, the external C for worst-case turn-off in any circuit is: $C = Q_T/\triangle V$, where $\triangle V$ is defined in Figure 3.

"ON" CONDITION CHARACTERISTICS

FIGURE 5 — COLLECTOR SATURATION REGION



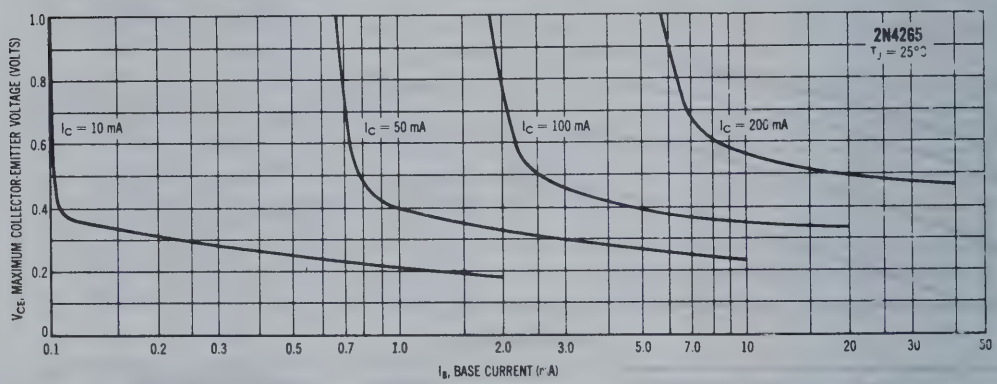


FIGURE 6 — SATURATION VOLTAGE LIMITS

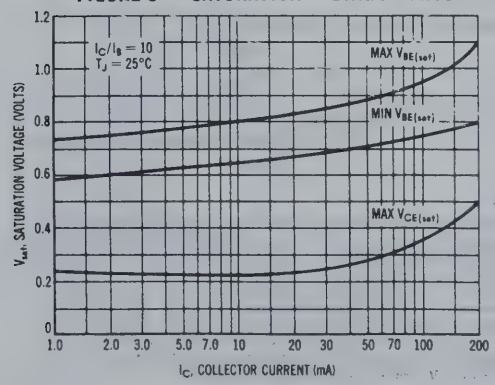
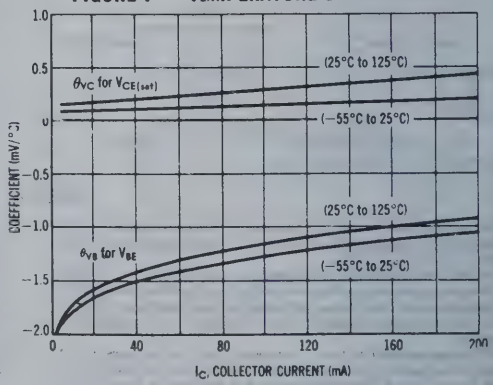


FIGURE 7 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 8 — DELAY TIME

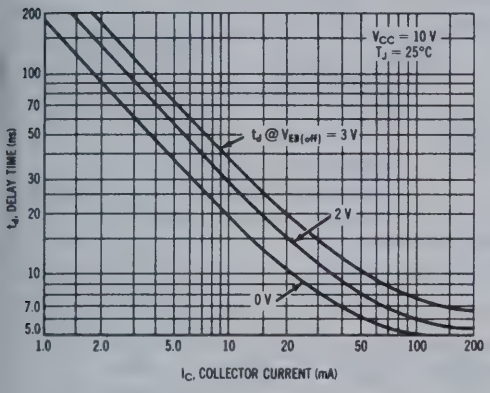


FIGURE 9 — RISE TIME

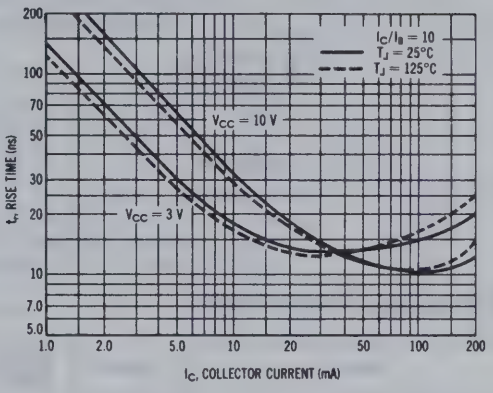


FIGURE 10 — STORAGE TIME

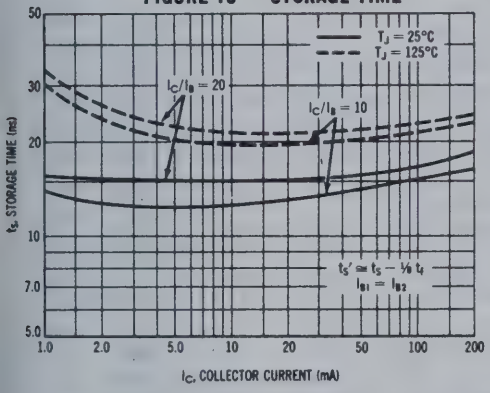


FIGURE 11 — FALL TIME

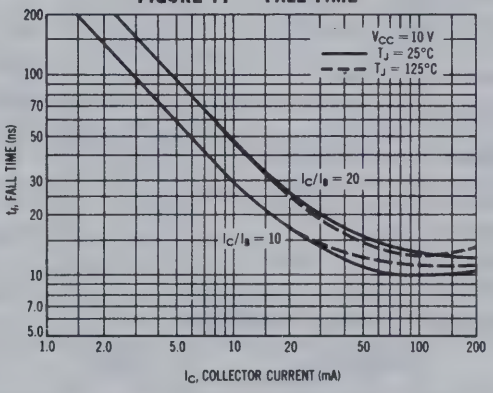


FIGURE 12 — JUNCTION CAPACITANCE

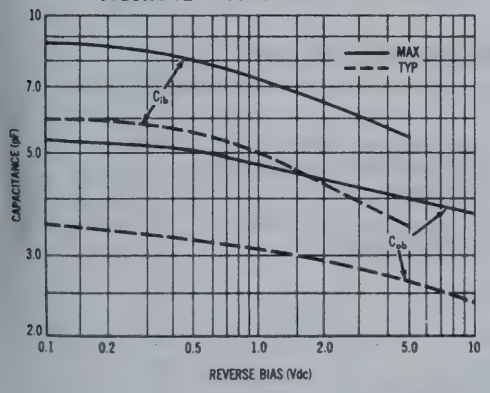
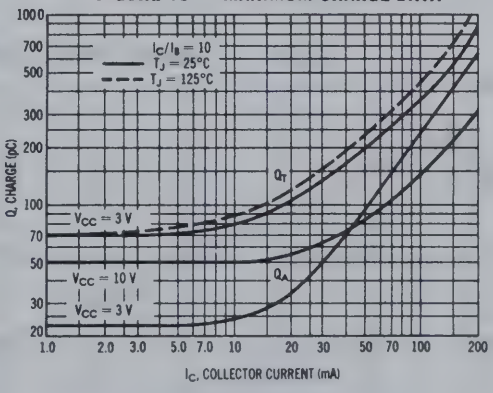
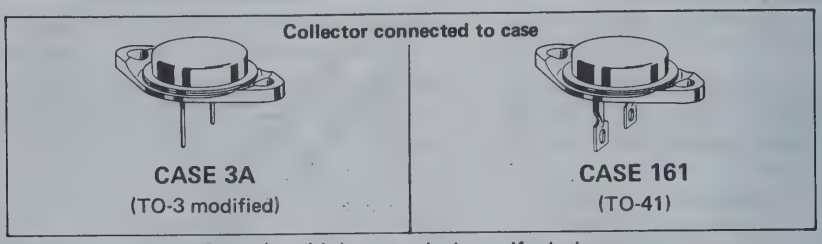


FIGURE 13 — MAXIMUM CHARGE DATA



2N4276 (GERMANIUM) thru 2N4283

PNP germanium power transistors designed for high current applications requiring high-gain and low saturation voltages.



For units with lugs attached, specify devices MP4276 etc. (TO-41 package)

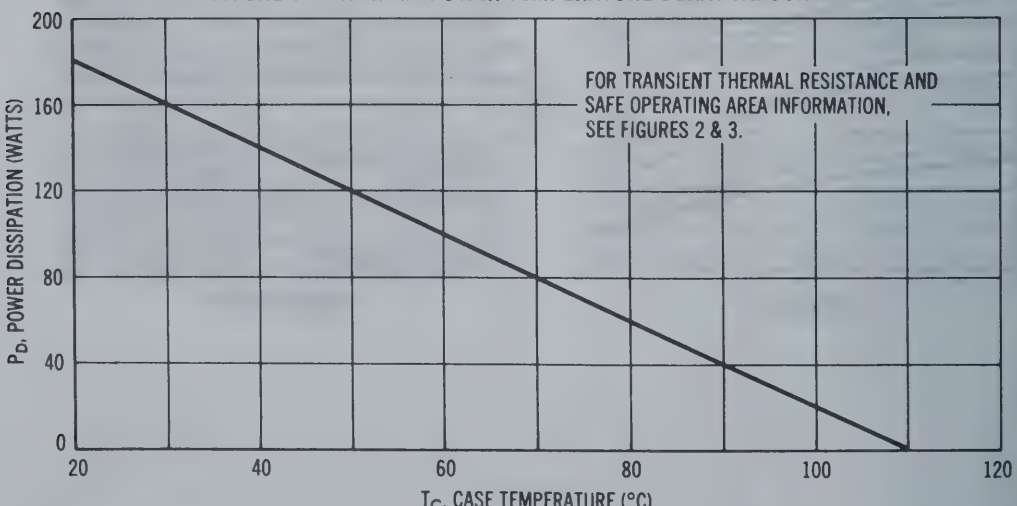
MAXIMUM RATINGS

Rating	Symbol	2N4276 2N4277	2N4278 2N4279	2N4280 2N4281	2N4282 2N4283	Unit
Collector-Emitter Voltage	V_{CEO}	20	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	30	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	20	25	30	40	Vdc
Collector Current — Continuous *	I_C*	60				Adc
Total Device Dissipation @ T_C = 25°C	P_D	170				Watts
Derate above 25°C		2.0				W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	°C/W

FIGURE 1 — AVERAGE POWER-TEMPERATURE DERATING CURVE



*JEDEC Registered Values, For True Capability See Figure 3.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage† (I_C = 1.0 Adc, I_B = 0)	2N4276, 2N4277	BV_{CEO}†	20	-	Vdc
	2N4278, 2N4279		30	-	
	2N4280, 2N4281		45	-	
	2N4282, 2N4283		60	-	
Collector-Emitter Breakdown Voltage (I_C = 300 mAdc, V_{BE} = 0)	2N4276, 2N4277	BV_{CES}	30	-	Vdc
	2N4278, 2N4279		45	-	
	2N4280, 2N4281		60	-	
	2N4282, 2N4283		75	-	
Floating Potential (V_{CB} = 30 Vdc, I_E = 0)	2N4276, 2N4277	V_{EBF}	-	0.5	Vdc
(V_{CB} = 45 Vdc, I_E = 0)	2N4278, 2N4279		-	0.5	
(V_{CB} = 60 Vdc, I_E = 0)	2N4280, 2N4281		-	0.5	
(V_{CB} = 75 Vdc, I_E = 0)	2N4282, 2N4283		-	0.5	
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4276, 2N4277	I_{CEX}	-	15	mAdc
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4278, 2N4279		-	15	
(V_{CE} = 45 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4280, 2N4281		-	15	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4282, 2N4283		-	15	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	0.2	mAdc
(V_{CB} = 30 Vdc, I_E = 0)	2N4276, 2N4277		-	4.0	
(V_{CB} = 45 Vdc, I_E = 0)	2N4278, 2N4279		-	4.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N4280, 2N4281		-	4.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N4282, 2N4283		-	4.0	
Emitter Cutoff Current (V_{BE} = 20 Vdc, I_C = 0)	2N4276, 2N4277	I_{EBO}	-	4.0	mAdc
(V_{BE} = 20 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 25 Vdc, I_C = 0)	2N4278, 2N4279		-	4.0	
(V_{BE} = 25 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 30 Vdc, I_C = 0)	2N4280, 2N4281		-	4.0	
(V_{BE} = 30 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 40 Vdc, I_C = 0)	2N4282, 2N4283		-	4.0	
(V_{BE} = 40 Vdc, I_C = 0, T_C = +71°C)			-	15	
ON CHARACTERISTICS					
DC Current Gain† (I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N4276, 2N4278, 2N4280, 2N4282	h_{FE}†	60	120	-
	2N4277, 2N4279, 2N4281, 2N4283		80	180	
(I_C = 60 Adc, V_{CE} = 2.0 Vdc)			15	-	
Collector-Emitter Saturation Voltage† (I_C = 15 Adc, I_B = 1.0 Adc)		$V_{CE(sat)}$†	-	0.15	Vdc
(I_C = 60 Adc, I_B = 6.0 Adc)			-	0.3	
Base-Emitter Saturation Voltage† (I_C = 15 Adc, I_B = 1.0 Adc)		$V_{BE(sat)}$†	-	0.6	Vdc
(I_C = 60 Adc, I_B = 6.0 Adc)			-	1.0	
SMALL SIGNAL CHARACTERISTICS					
Common-Emitter Cutoff Frequency (I_C = 15 Adc, V_{CE} = 2.0 Vdc)		$f_{\alpha e}$	2.0	-	kHz

† To avoid excessive heating of the collector junction, perform test with pulse method.

FIGURE 2 — TRANSIENT THERMAL RESISTANCE

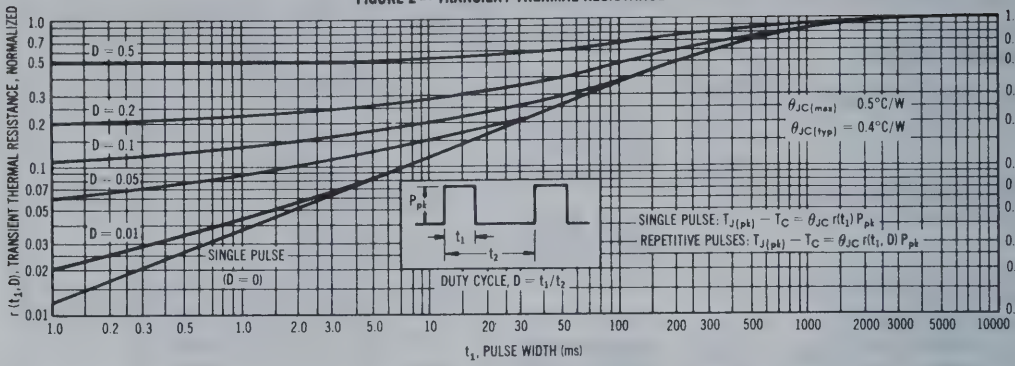
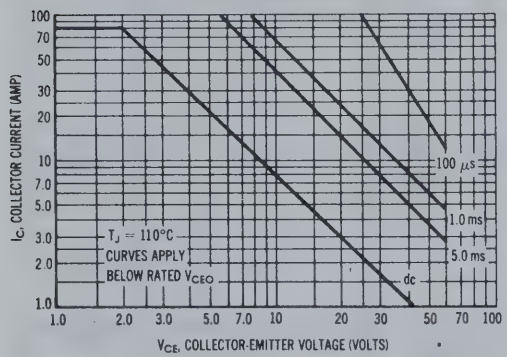


FIGURE 3 — ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e. the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 110°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 110°C$. $T_{J(pk)}$ may be calculated from the data in Figure 2. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 4 — SWITCHING TEST CIRCUIT

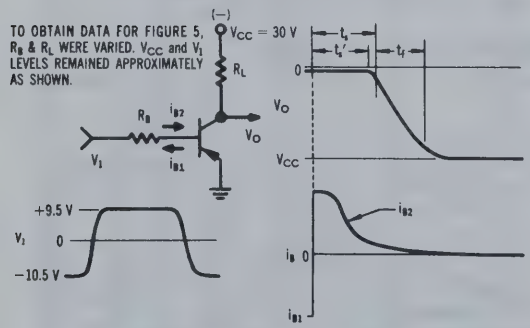
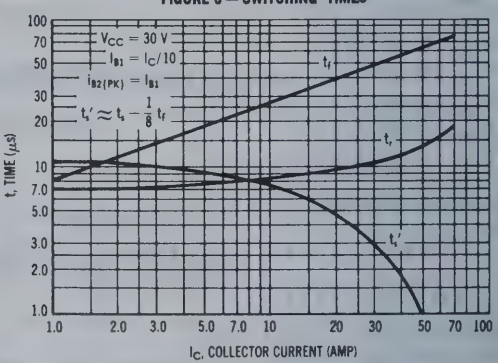


FIGURE 5 — SWITCHING TIMES



The switching performance of this transistor is determined primarily by the gain-bandwidth product, f_T*, and the behavior of the base-spreading resistance, r_b'

In the case of rise time, the base-spreading resistance plays a small part, and the test circuit delivers a constant current step of turn-on current to the transistor (I_{B1}). Therefore, the curve of t_r on Figure 5 follows theory closely, i.e.:

$$t_r \approx 0.8 \frac{I_C}{I_{B1}} \cdot \frac{1}{2\pi f_T}$$

From the curve, it can be seen that f_T is roughly constant with current; using the equation, its large signal value can be calculated to be approximately 120 kHz at the 20-Amp level. A lower supply voltage will increase rise time slightly.

Turn-off time is slow because of conductivity modulation which occurs in the base region. When the transistor is held "on" in saturation, the base region becomes filled with excess charge; i.e., charge in excess of that necessary to sustain the circuit limited value of I_C. As a result, the base resistivity and consequently r_b' become very low. During turn off, as the excess charge is reduced, the accompanying increase in resistivity causes a marked reduction in the turn-off current, I_{B2}, as can be seen from the waveforms of Figure 4. During fall time, the i_{B2} current is very low causing an extended fall time.

Only a slight improvement in turn-off performance is achieved with a "speed-up" capacitor placed across R_B. This unusual behavior occurs because r_b' limits the amount of reverse current which can be achieved. Also, it seems evident that r_b' increases with applied reverse current, so that efforts to speed up the turn-off behavior are somewhat futile.

In most applications, switching time will be close to the values shown on Figure 5. Delay time is not shown as it is negligible in comparison to the other times.

* $f_T \sim f_{ae} \times h_{fe}$

TYPICAL DC CHARACTERISTICS

FIGURE 6 — DC CURRENT GAIN

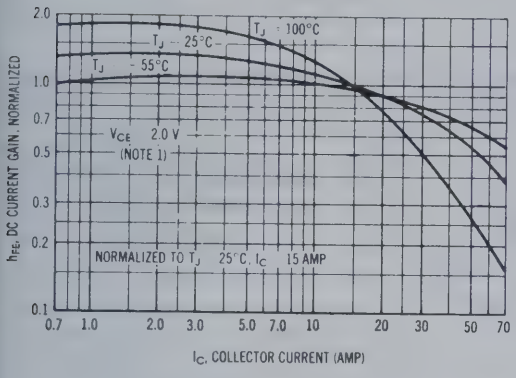


FIGURE 7 — COLLECTOR SATURATION REGION

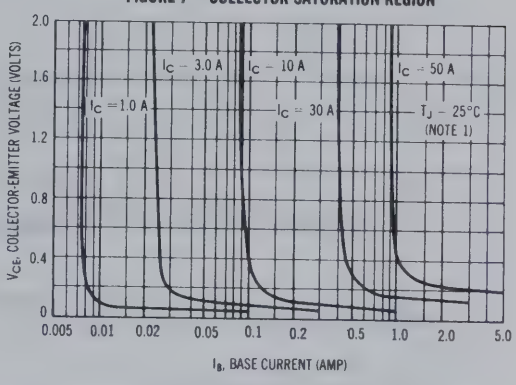


FIGURE 8 — EFFECTS OF BASE-EMITTER RESISTANCE

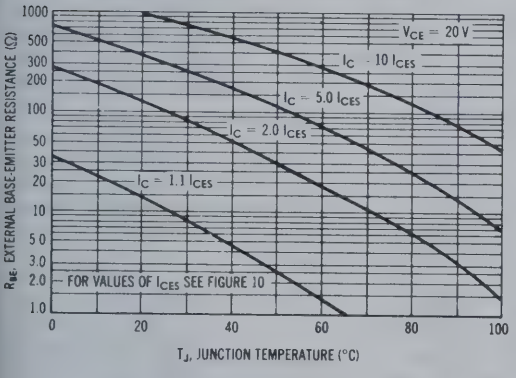


FIGURE 9 — "ON" VOLTAGES

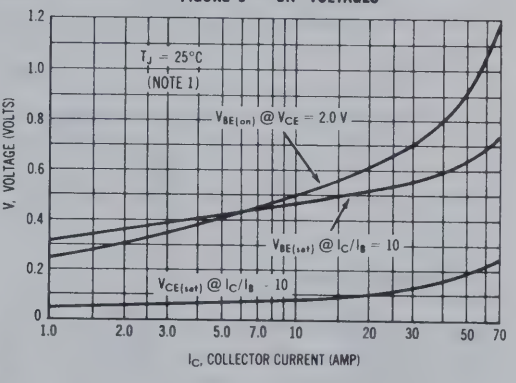
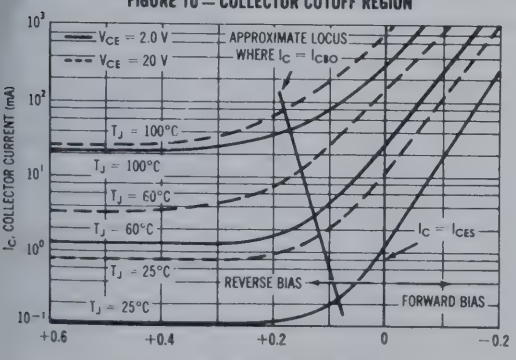
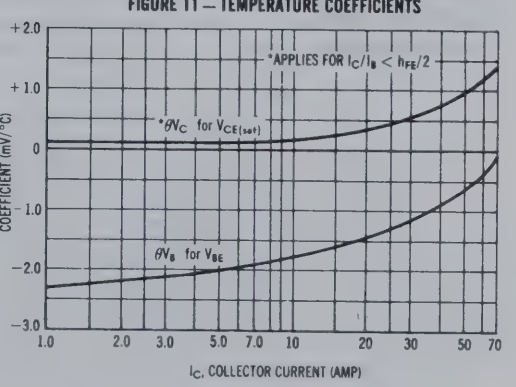


FIGURE 10 — COLLECTOR CUTOFF REGION



NOTE 1: Data is obtained from pulse tests and adjusted to nullify the effect of I_{CBO}.

FIGURE 11 — TEMPERATURE COEFFICIENTS



2N4342 (SILICON)
2N4343

SILICON P-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for high-gain audio frequency applications.

- High Forward Transadmittance —
  $|y_{fs}|$ = 4.0 mmhos (Min) @ V_{DS} = -10 Vdc (2N4343)
- Low Noise Figure —
  NF = 1.5 dB (Max) @ f = 100 Hz
- Low Drain-Source "ON" Resistance —
  $r_{ds(on)}$ = 350 Ohms (Max) @ f = 1.0 kHz (2N4343)

P-CHANNEL
JUNCTION FIELD-EFFECT
TRANSISTORS

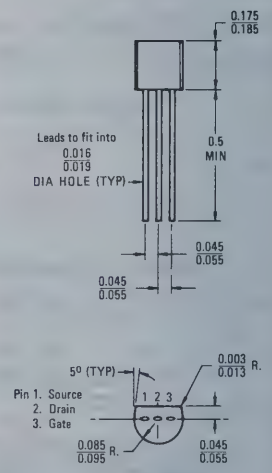
(Type A)



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +125	°C

*Indicates JEDEC Registered Data.



CASE 29 (7)
TO-92

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = -10 Vdc, I_D = 1.0 μAdc)	2N4342 2N4343	$V_{GS(off)}$	 1.0 2.0	 5.5 10	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 65°C)		I_{GSS}	 – –	 10 0.5	 nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = -10 Vdc, V_{GS} = 0)	2N4342 2N4343	I_{DSS}	 4.0 10	 12 30	mAdc
Gate-Source Voltage (V_{DS} = -10 Vdc, I_D = 0.4 mAdc) (V_{DS} = -10 Vdc, I_D = 1.0 mAdc)	2N4342 2N4343	V_{GS}	0.7 1.8	5.0 9.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N4342 2N4343	$r_{ds(on)}$	– –	700 350	Ohms
Forward Transadmittance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4342 2N4343	Y_{fs}	2000 4000	6000 8000	μmhos
Forward Transconductance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	2N4342 2N4343	$Re(y_{fs})$	1500 3000	– –	μmhos
Output Admittance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4342 2N4343	Y_{os}	– –	75 100	μmhos
Input Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	20	pF
Reverse Transfer Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	5.0	pF
Common-Source Noise Figure (V_{DS} = -10 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 15 Hz) (V_{DS} = -10 Vdc, V_{GS} = 2.0 Vdc, R_G = 1.0 Megohm, f = 100 Hz, BW = 15 Hz)	2N4342 2N4343	NF	– –	1.5 1.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = -10 Vdc, V_{GS} = 0, f = 100 Hz, BW = 15 Hz) (V_{DS} = -10 Vdc, V_{GS} = 2.0 Vdc, f = 100 Hz, BW = 15 Hz)	2N4342 2N4343	E_n	– –	0.08 0.08	$\mu V/\sqrt{Hz}$

*Indicates JEDEC Registered Data.

2N4351 (SILICON)



CASE 20 (2)
(TO-72)

Silicon N-channel MOS field effect transistors, designed for enhancement-mode operation in low power switching applications. The 2N4351 is complementary with type 2N4352.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	± 30	Vdc
Drain Current	I_D	30	mAdc
Power Dissipation at T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Power Dissipation at T_C = 25°C Derate about 25°C	P_D	800 4.56	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Substrate connected to source.

Characteristic	Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μA, V_{GS} = 0)	—	$V_{(BR)DSS}$	25	—	Vdc
Gate Leakage Current (V_{GS} = ±30 Vdc, V_{DS} = 0)	—	I_{GSS}	—	10	pAdc
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	—	I_{DSS}	—	10	nAdc
ON CHARACTERISTICS					
Gate-Source Threshold Voltage (V_{DS} = 10 V, I_D = 10 μA)	—	$V_{GS(TH)}$	1.0	5	Vdc
"ON" Drain Current (V_{GS} = 10 V, V_{DS} = 10 V)	3	$I_{D(on)}$	3	—	mAdc
Drain-Source "ON" Voltage (I_D = 2 mA, V_{GS} = 10 V)	—	$V_{DS(on)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Drain-Source Resistance (V_{GS} = 10 V, I_D = 0, f = 1 kHz)	4	$r_{ds(on)}$	—	300	ohms
Forward Transfer Admittance (V_{DS} = 10 V, I_D = 2 mA, f = 1 kHz)	1	$\lvert y_{fs} \rvert$	1000	—	μmho
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 140 kHz)	2	C_{rss}	—	1.3	pF
Input Capacitance (V_{DS} = 10 V, V_{GS} = 0, f = 140 kHz)	2	C_{iss}	—	5.0	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = 10 V, f = 140 kHz)	—	$C_{d(sub)}$	—	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay	I_D = 2.0 mAdc, V_{DS} = 10 Vdc, V_{GS} = 10 Vdc (See Figure 10; Times Circuit Determined)	6, 10	t_{d1}	—	45	ns
Rise Time		7, 10	t_r	—	65	ns
Turn-Off Delay		8, 10	t_{d2}	—	60	ns
Fall Time		9, 10	t_f	—	100	ns

FIGURE 1 — FORWARD TRANSFER ADMITTANCE

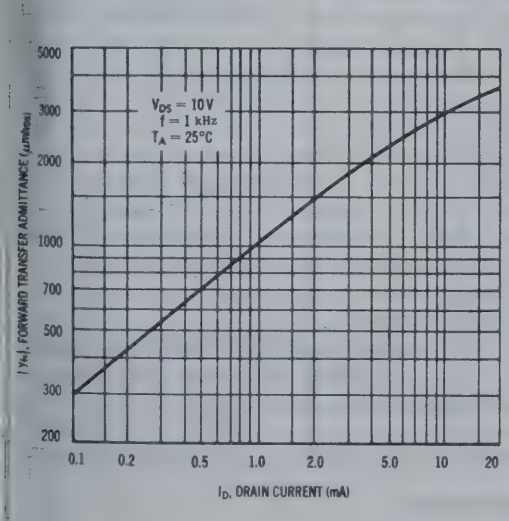


FIGURE 2 — CAPACITANCE

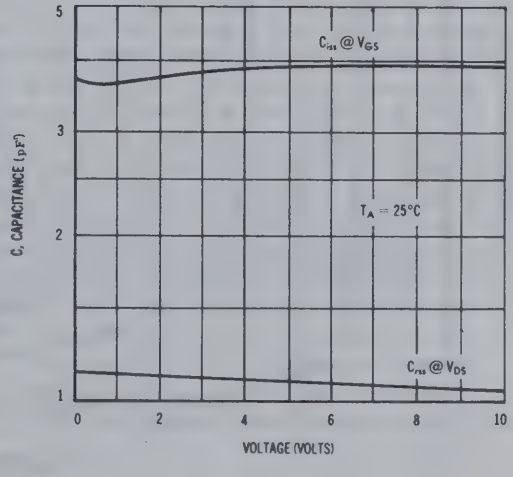


FIGURE 3 — TRANSFER CHARACTERISTICS

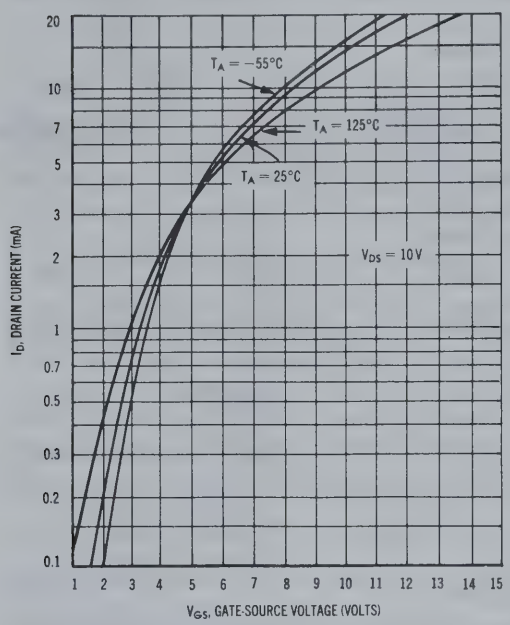


FIGURE 4 — DRAIN SOURCE "ON" RESISTANCE

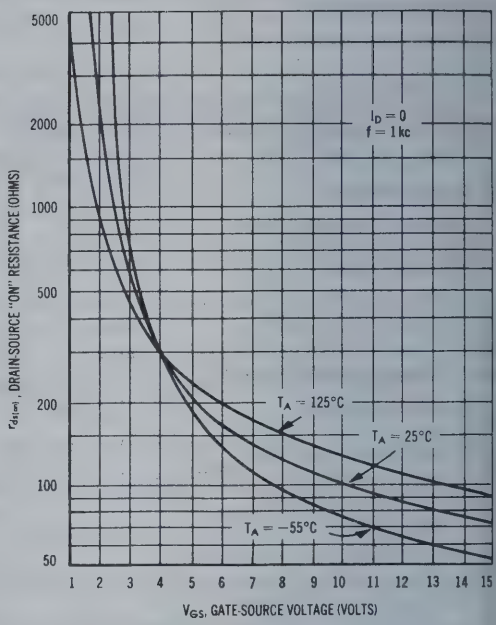
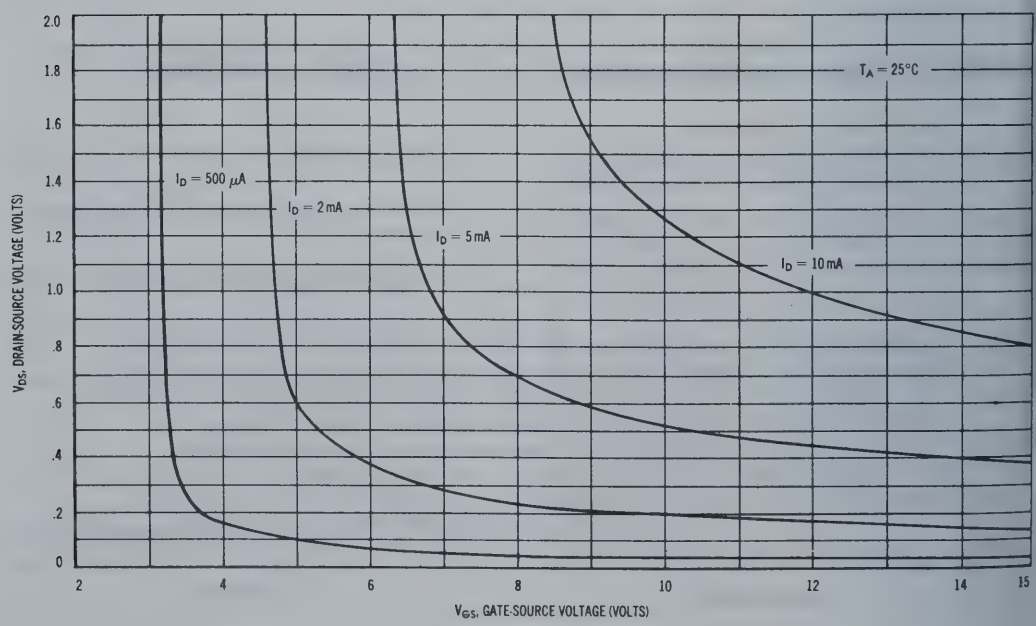


FIGURE 5 — "ON" DRAIN-SOURCE VOLTAGE



SWITCHING CHARACTERISTICS

($T_A = 25°C$)

FIGURE 6 — TURN-ON DELAY TIME

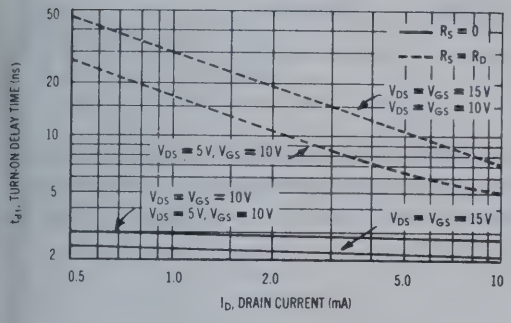


FIGURE 7 — RISE TIME

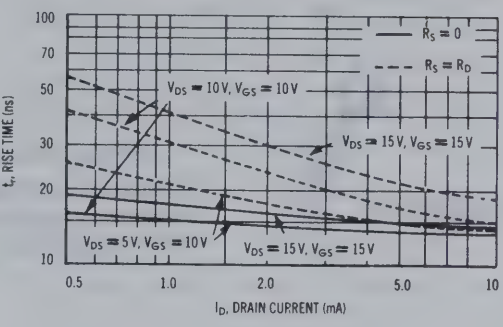


FIGURE 8 — TURN-OFF DELAY TIME

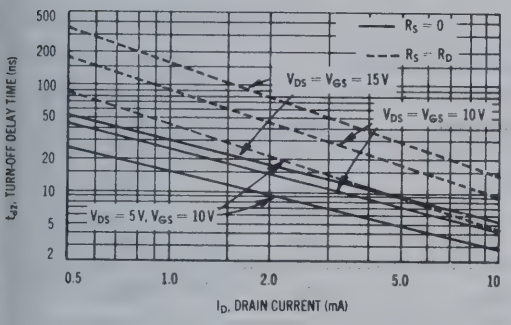


FIGURE 9 — FALL TIME

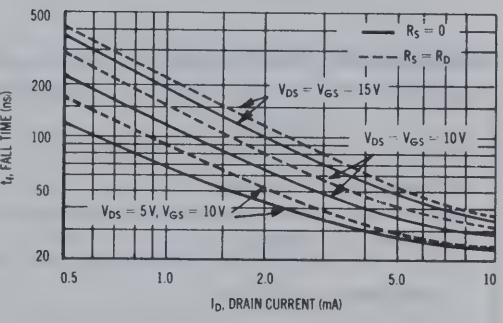


FIGURE 10 — SWITCHING CIRCUIT and WAVEFORMS

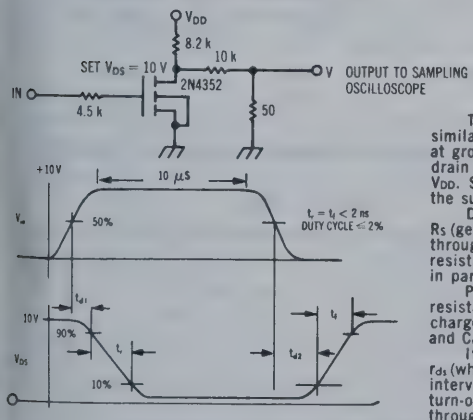
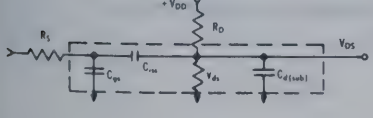


FIGURE 11 — SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance) (Figure 11). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

2N4352 (SILICON)



CASE 20 (2)
(TO-72)

Silicon P-channel MOS field-effect transistor designed for enhancement-mode operation in low-power switching applications. The 2N4352 is complementary with type 2N4351.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	± 30	Vdc
Drain Current	I_D	30	mAdc
Power Dissipation at T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	800 4.56	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Substrate connected to source.

Characteristic	Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = -10 μA, V_{GS} = 0)	—	$V_{(BR)DSS}$	25	—	Vdc
Gate Leakage Current (V_{GS} = ±30 V, V_{DS} = 0)	—	I_{GSS}	—	10	pAdc
Zero-Gate Voltage Drain Current (V_{DS} = -10 V, V_{GS} = 0)	—	I_{DSS}	—	10	nAdc
ON CHARACTERISTICS					
Gate-Source Threshold Voltage (V_{DS} = -10 V, I_D = -10 μA)	—	$V_{GS(TH)}$	1.0	5.0	Vdc
"ON" Drain Current (V_{GS} = -10 V_{DS} = -10 V)	3	$I_{D(on)}$	3.0	—	mA
Drain-Source "ON" Voltage (I_D = -2.0 mA, V_{GS} = -10 V)	5	$V_{DS(on)}$	—	1.0	V
SMALL SIGNAL CHARACTERISTICS					
Drain-Source Resistance (V_{GS} = -10 V, I_D = 0, f = 1 kHz)	4	$r_{ds(on)}$	—	600	ohms
Forward Transfer Admittance (V_{DS} = -10 V, I_D = 2 mA, f = 1 kHz)	1	$\lvert y_{fs} \rvert$	1000	—	μmho
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 140 kHz)	2	C_{rss}	—	1.3	pF
Input Capacitance (V_{DS} = -10 V, V_{GS} = 0, f=140 kHz)	2	C_{iss}	—	5.0	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$= -10 V, f=140 kHz)	—	$C_{d(sub)}$	—	4.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay	I_D = -2.0 mAdc, V_{DS} = -10 Vdc, V_{GS} = -10 V (See Figure 10, Times Circuit Determined)	6, 10	t_{d1}	—	45	ns
Rise Time		7, 10	t_r	—	65	ns
Turn-Off Delay		8, 10	t_{d2}	—	60	ns
Fall Time		9, 10	t_f	—	100	ns

FIGURE 1 — FORWARD TRANSFER ADMITTANCE

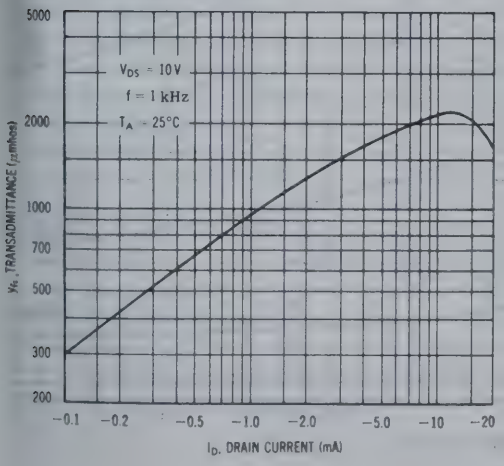


FIGURE 2 — CAPACITANCE

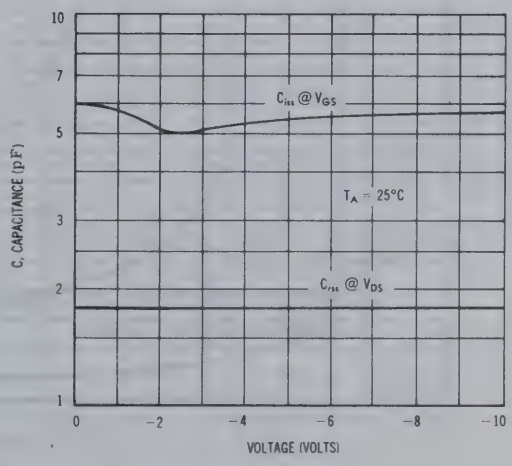


FIGURE 3 — TRANSFER CHARACTERISTICS

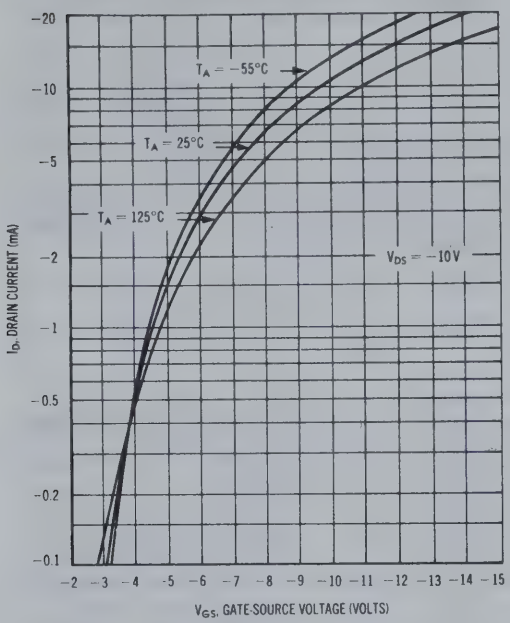


FIGURE 4 — DRAIN SOURCE "ON" RESISTANCE

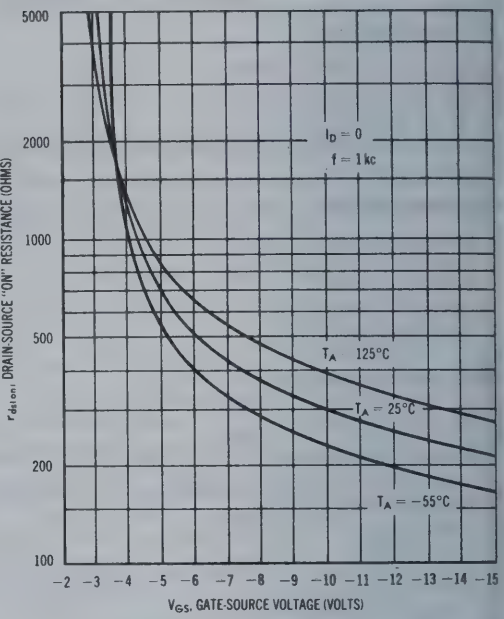
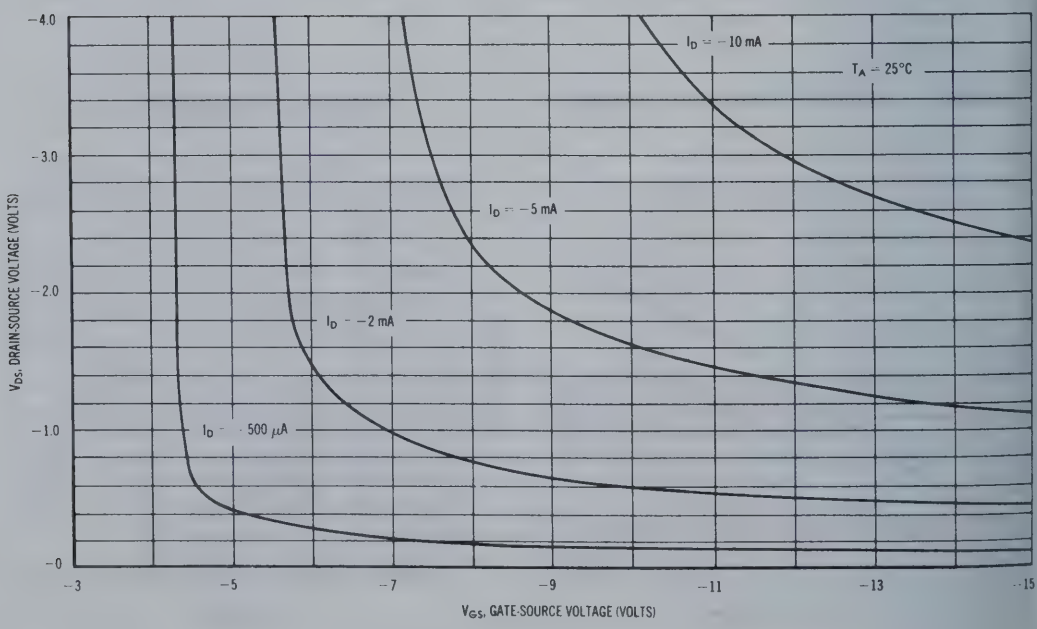


FIGURE 5 — "ON" DRAIN-SOURCE VOLTAGE



SWITCHING CHARACTERISTICS

($T_A = 25°C$)

FIGURE 6 — TURN-ON DELAY TIME

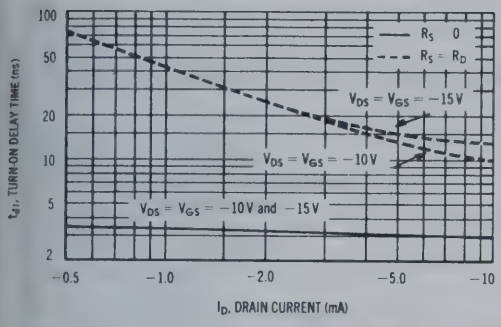


FIGURE 7 — RISE TIME

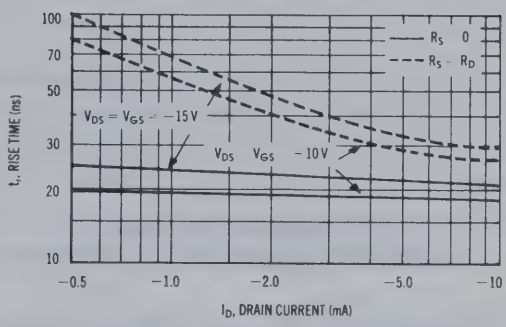


FIGURE 8 — TURN-OFF DELAY TIME

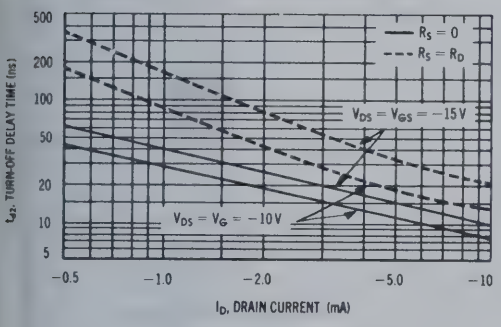


FIGURE 9 — FALL TIME

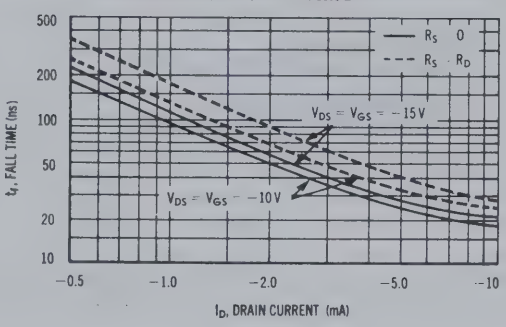
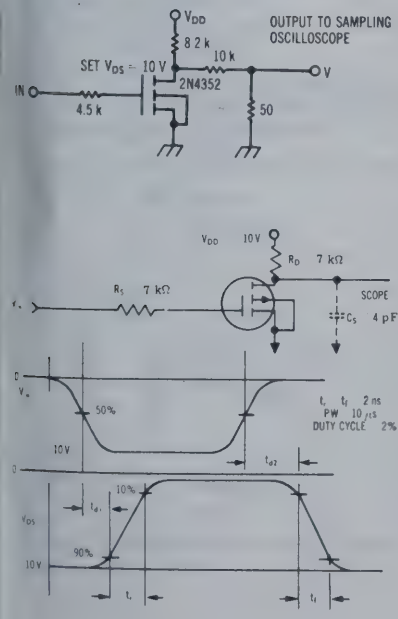


FIGURE 10 — SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

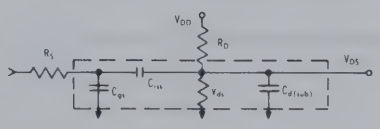
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance) (Figure 11). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 11 — SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



2N4360 (SILICON)

SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for low-power audio frequency applications

- Forward Transadmittance — $|y_{fs}| = 2.0$ mmhos (Min) @ $V_{DS} = -10$ Vdc
- Low Reverse Transfer Capacitance — $C_{rss} = 5.0$ pF (Max) @ $V_{DS} = -10$ Vdc

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)

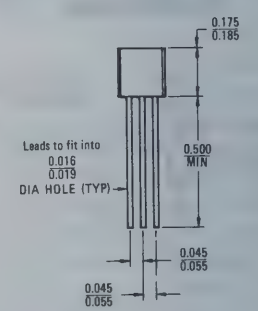


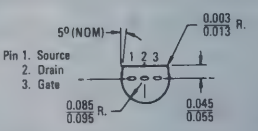
Case 29 with leads formed to a TO-18 configuration.

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-20	Vdc
Drain-Gate Voltage	V_{DG}	-20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Gate Current	I_G	50	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	200 2.0	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +125	^oC

*Indicates JEDEC Registered Data.





CASE 29(7)
TO-92

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	20	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = -10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	0.7	10	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	–	10	nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 65°C)		–	0.5	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (Note 1) (V_{DS} = -10 Vdc, V_{GS} = 0)	I_{DSS}	3.0	30	mAdc
Gate-Source Voltage (V_{DS} = -10 Vdc, I_D = 0.3 mAdc)	V_{GS}	0.4	9.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	–	700	Ohms
Forward Transadmittance (Note 1) (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert y_{fs} \rvert$	2000	8000	μmhos
Forward Transconductance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	$Re(y_{fs})$	1500	–	μmhos
Output Admittance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert y_{os} \rvert$	–	100	μmhos
Input Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	20	pF
Reverse Transfer Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	5.0	pF
Common-Source Noise Figure (V_{DS} = -10 Vdc, I_D = 1.0 mAdc, R_G = 1.0 Megohm, f = 100 Hz)	NF	–	5.0	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = -10 Vdc, I_D = 1.0 mAdc, f = 100 Hz, BW = 15 Hz)	E_n	–	0.19	$\mu V/\sqrt{Hz}$

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

2N4391 (SILICON)
2N4392
2N4393

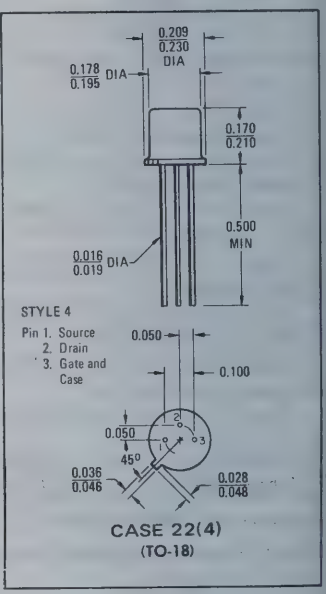
SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

- Low Drain-Source "On" Resistance — $r_{ds(on)}$ = 30 Ohms (Max) @ f = 1.0 kHz (2N4391)
- Low Gate Reverse Current — I_{GSS} = 0.1 nAdc (Max) @ V_{GS} = 20 Vdc
- Guaranteed Switching Characteristics

N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS
(Type A)



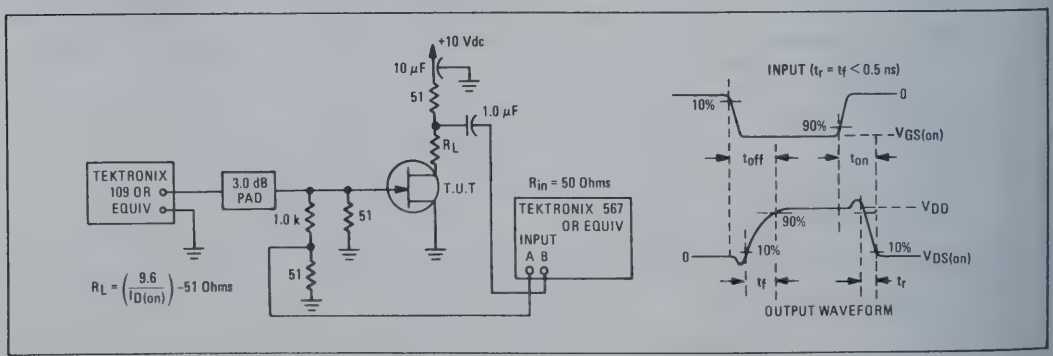


CASE 22(4)
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 SWITCHING TIMES TEST CIRCUIT



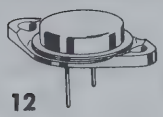
2N4391, 2N4392, 2N4393 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		$V_{GS(f)}$	-	1.0	Vdc
Gate-Source Voltage (V_{DS} = 20 Vdc, I_D = 1.0 nAdc)	2N4391 2N4392 2N4393	V_{GS}	4.0 2.0 0.5	10 5.0 3.0	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	-	0.1	nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)			-	0.2	μAdc
Drain-Cutoff Current (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc)	2N4391	$I_{D(off)}$	-	0.1	nAdc
(V_{DS} = 20 Vdc, V_{GS} = 7.0 Vdc)	2N4392		-	0.1	
(V_{DS} = 20 Vdc, V_{GS} = 5.0 Vdc)	2N4393		-	0.1	
(V_{DS} = 20 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)	2N4391		-	0.2	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 7.0 Vdc, T_A = 150°C)	2N4392		-	0.2	
(V_{DS} = 20 Vdc, V_{GS} = 5.0 Vdc, T_A = 150°C)	2N4393		-	0.2	
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current* (V_{DS} = 20 Vdc, V_{GS} = 0)	2N4391 2N4392 2N4393	I_{DSS}*	50 25 5.0	150 75 30	mAdc
Drain-Source "ON" Voltage (I_D = 12 mAdc, V_{GS} = 0)	2N4391	$V_{DS(on)}$	-	0.4	Vdc
(I_D = 6.0 mAdc, V_{GS} = 0)	2N4392		-	0.4	
(I_D = 3.0 mAdc, V_{GS} = 0)	2N4393		-	0.4	
Static Drain-Source "ON" Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	2N4391 2N4392 2N4393	$r_{DS(on)}$	- - -	30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N4391 2N4392 2N4393	$r_{ds(on)}$	- - -	30 60 100	Ohms
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	14	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)	2N4391	C_{rss}	-	3.5	pF
(V_{DS} = 0, V_{GS} = 7.0 Vdc, f = 1.0 MHz)	2N4392		-	3.5	
(V_{DS} = 0, V_{GS} = 5.0 Vdc, f = 1.0 MHz)	2N4393		-	3.5	
SWITCHING CHARACTERISTICS					
Turn-On Time (See Figure 1) ($I_{D(on)}$ = 12 mAdc)	2N4391	t_{on}	-	15	ns
($I_{D(on)}$ = 6.0 mAdc)	2N4392		-	15	
($I_{D(on)}$ = 3.0 mAdc)	2N4393		-	15	
Rise Time (See Figure 1) ($I_{D(on)}$ = 12 mAdc)	2N4391	t_r	-	5.0	ns
($I_{D(on)}$ = 6.0 mAdc)	2N4392		-	5.0	
($I_{D(on)}$ = 3.0 mAdc)	2N4393		-	5.0	
Turn-Off Time (See Figure 1) ($V_{GS(off)}$ = 12 Vdc)	2N4391	t_{off}	-	20	ns
($V_{GS(off)}$ = 7.0 Vdc)	2N4392		-	35	
($V_{GS(off)}$ = 5.0 Vdc)	2N4393		-	50	
Fall Time (See Figure 1) ($V_{GS(off)}$ = 12 Vdc)	2N4391	t_f	-	15	ns
($V_{GS(off)}$ = 7.0 Vdc)	2N4392		-	20	
($V_{GS(off)}$ = 5.0 Vdc)	2N4393		-	30	

*Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

2N4398 (SILICON)
2N4399



CASE 12
(TO-3 modified)

High-power PNP silicon transistors for use in power amplifier and switching circuits; serves as direct replacements for germanium high-power devices.

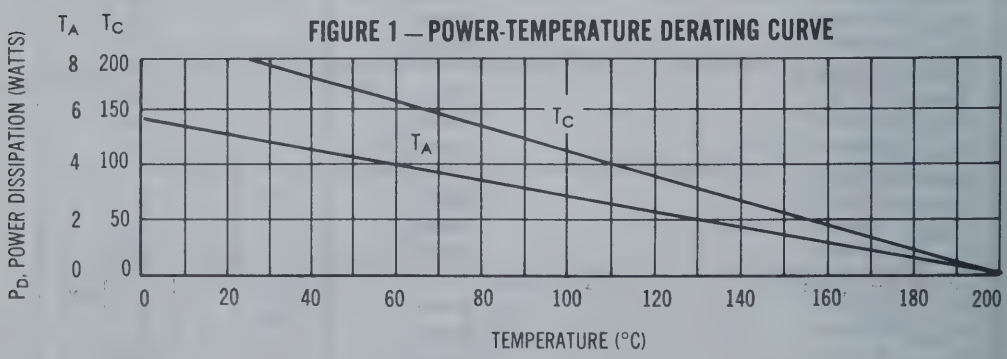
Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N4398	2N4399	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current-Continuous	I_C	30		Adc
Peak		50		
Base Current	I_B	7.5		Adc
Total Device Dissipation @ $T_A = 25^oC$	P_D	5.0		Watts
Total Device Dissipation @ $T_C = 25^oC$	P_D	200		Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	$^oC/W$
Thermal Resistance, Case to Ambient	θ_{CA}	34	$^oC/W$



Safe Area Curves are indicated by Figure 13. All limits are applicable and must be observed.

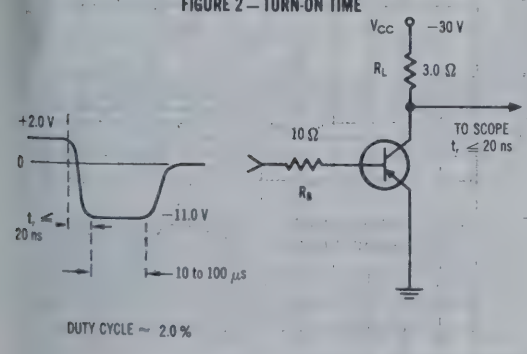
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)	2N4398	13	$BV_{CEO(sus)}$*	40	—	Vdc
	2N4399			60	—	
Collector Cutoff Current (V_{CE} = 40 Vdc, I_B = 0)	2N4398		I_{CEO}	—	5.0	mAdc
(V_{CE} = 60 Vdc, I_B = 0)	2N4399			—	5.0	
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	Both	7, 8	I_{CEX}	—	10	mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4398			—	5.0	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4399			—	5.0	
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	2N4398	7, 8	I_{CBO}	—	1.0	mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N4399			—	1.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)			I_{EBO}	—	5.0	mAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		9	h_{FE}*	40	—	—
(I_C = 15 Adc, V_{CE} = 2.0 Vdc)				15	60	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)				5.0	—	
Collector-Emitter Saturation Voltage* (I_C = 10 Adc, I_B = 1.0 Adc)		10, 11, 12	$V_{CE(sat)}$*	—	0.75	Vdc
(I_C = 15 Adc, I_B = 1.5 Adc)				—	1.0	
(I_C = 20 Adc, I_B = 2.0 Adc)				—	2.0	
Base-Emitter Saturation Voltage* (I_C = 10 Adc, I_B = 1.0 Adc)		11, 12	$V_{BE(sat)}$*	—	1.6	Vdc
(I_C = 15 Adc, I_B = 1.5 Adc)				—	1.85	
(I_C = 20 Adc, I_B = 2.0 Adc)				—	2.5	
Base-Emitter On Voltage* (I_C = 15 Adc, V_{CE} = 2.0 Vdc)		11, 12	$V_{BE(on)}$*	—	1.7	Vdc
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)				—	3.0	
DYNAMIC CHARACTERISTICS						
Current Gain — Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)			f_T	4.0	—	MHz
Small Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)			h_{fe}	40	—	—
Rise Time	(V_{CC} = 30 Vdc, I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)	2, 5	t_r	—	0.4	μs
Storage Time		2, 3, 6	t_s	—	1.5	μs
Fall Time		2, 3, 6	t_f	—	0.6	μs

* Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%

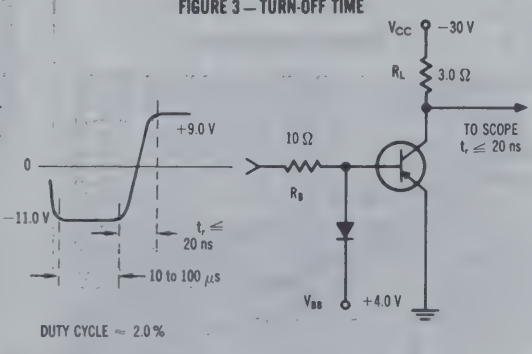
SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 2 — TURN-ON TIME



DUTY CYCLE ≈ 2.0%

FIGURE 3 — TURN-OFF TIME



DUTY CYCLE ≈ 2.0%

FOR CURVES OF FIGURES 5 & 6, R_B, R_L, & V_{CC} ARE VARIED.
INPUT LEVELS ARE APPROXIMATELY AS SHOWN.

TYPICAL TRANSIENT CHARACTERISTICS

FIGURE 4 — CAPACITANCES

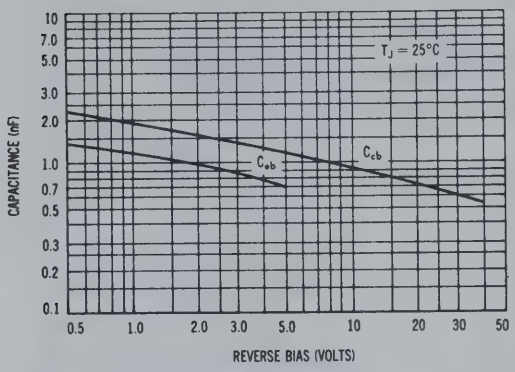


FIGURE 5 — TURN-ON TIME

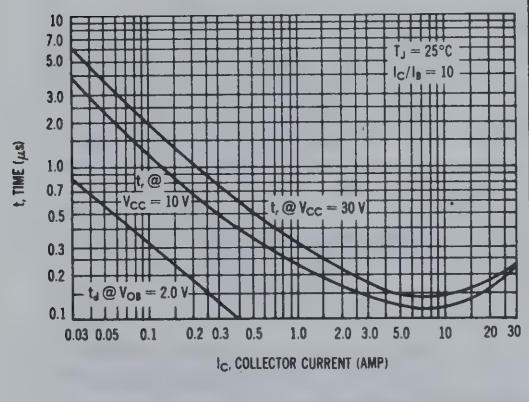
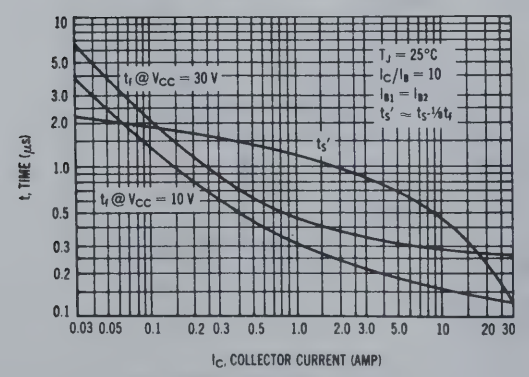


FIGURE 6 — TURN-OFF TIME



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 7 — TRANSCONDUCTANCE

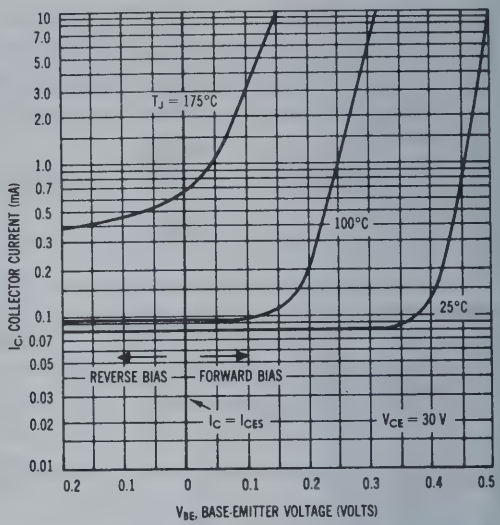
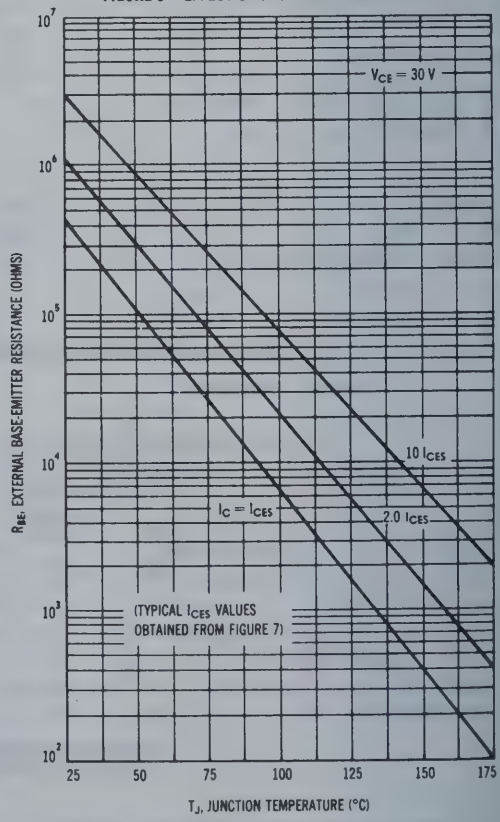


FIGURE 8 — EFFECT OF BASE-EMITTER RESISTANCE



TYPICAL "ON" REGION CHARACTERISTICS

FIGURE 9 — NORMALIZED DC CURRENT GAIN

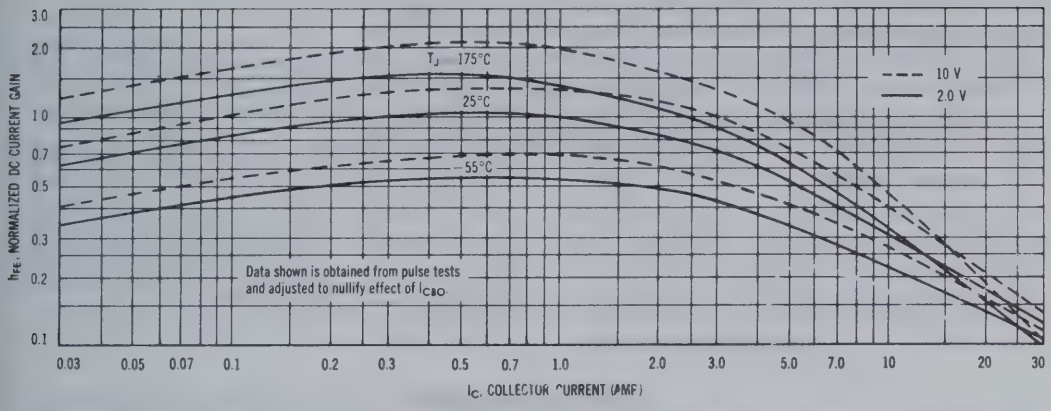


FIGURE 10 — COLLECTOR SATURATION REGION

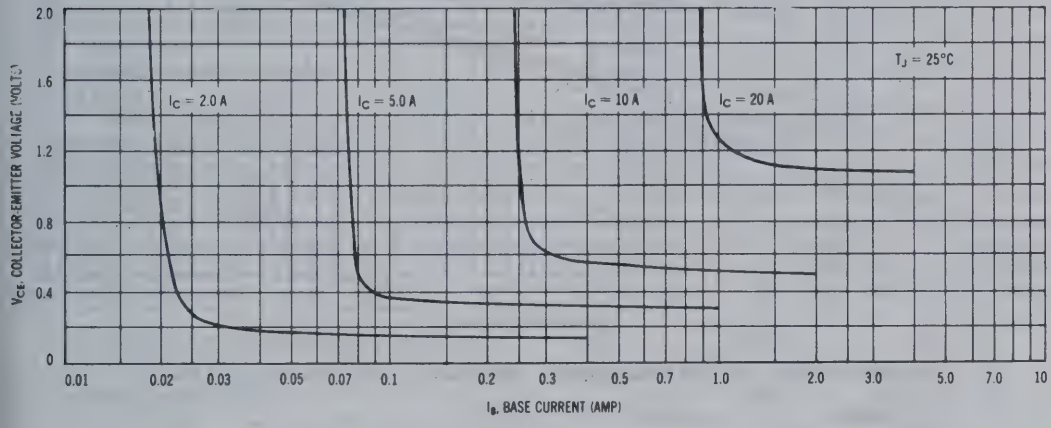


FIGURE 11 — "ON" VOLTAGES

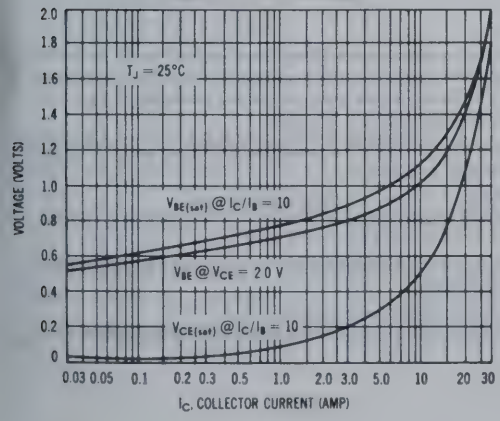
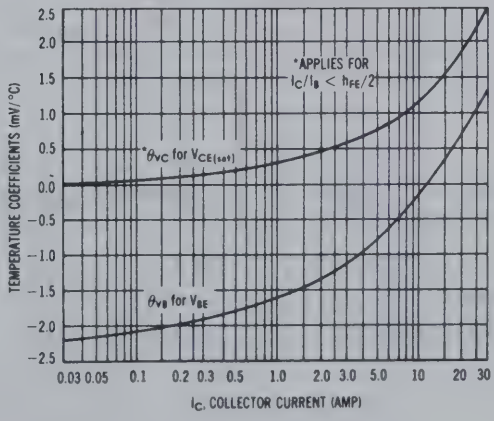
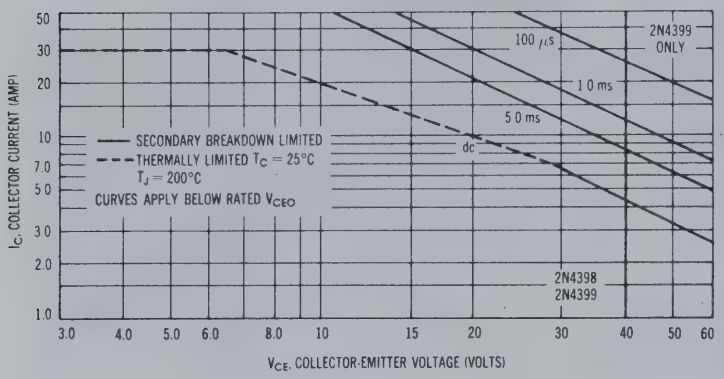


FIGURE 12 — TEMPERATURE COEFFICIENTS



RATINGS AND THERMAL DATA

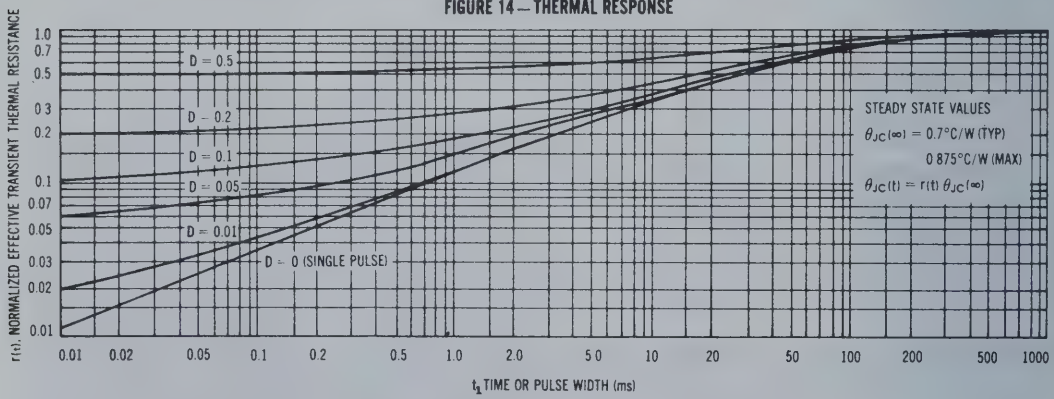
FIGURE 13 — ACTIVE-REGION SAFE OPERATING AREA



The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

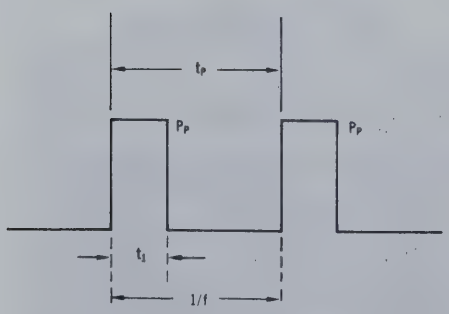
The data of Figure 13 is based upon $T_{J(pk)}$ = 200°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 200°C. $T_{J(pk)}$ may be calculated from the data in Figure 14. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by the secondary breakdown.

FIGURE 14 — THERMAL RESPONSE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 f = \frac{t_1}{t_p}$

PEAK PULSE POWER – P_p

A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 14 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 14 by the steady state value $\theta_{JC}(\infty)$.

Example:

The 2N4398 is dissipating 100 watts under the following conditions: t_1 = 1.0 ms, t_p = 5.0 ms. (D = 0.2)

Using Figure 14, at a pulse width of 1.0 ms and D = 0.2, the reading of r (t) is 0.28.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_p \times \theta_{JC}(\infty) = 0.28 \times 100 \times 0.875 = 24.5°C$$

2N4400 (SILICON)
2N4401



CASE 29(1)
(TO-92)

NPN silicon annular transistors designed for general purpose switching and amplifier applications and for complementary circuitry with PNP types 2N4402 and 2N4403. Features one-piece, injection-molded plastic package for high reliability.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current - Continuous	I_C	600	mAdc
Total Device Dissipation T_A = 25°C	P_D	310	mW
Derate above 25°C		2.81	mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.137	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1 mAdc, I_B = 0)			BV_{CEO}*	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)			BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)			BV_{EBO}	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 35 Vdc, $V_{EB(off)}$ = 0.4 Vdc)			I_{CEX}	—	0.1	μAdc
Base Cutoff Current (V_{CE} = 35 Vdc, $V_{EB(off)}$ = 0.4 Vdc)			I_{BL}	—	0.1	μAdc
ON CHARACTERISTICS						
DC Current Gain		15	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N4401			20	—	
(I_C = 1 mAdc, V_{CE} = 1 Vdc)	2N4400			20	—	
	2N4401			40	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N4400			40	—	
	2N4401			80	—	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)*	2N4400			50	150	
	2N4401			100	300	
(I_C = 500 mAdc, V_{CE} = 2 Vdc)*	2N4400			20	—	
	2N4401			40	—	
Collector-Emitter Saturation Voltage*		16, 17, 18	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)				—	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)				—	0.75	
Base-Emitter Saturation Voltage*		17, 18	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)				0.75	0.95	
(I_C = 500 mAdc, I_B = 50 mAdc)				—	1.2	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N4400		f_T	200	—	MHz
	2N4401			250	—	
Collector-Base Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz, emitter guarded)		3	C_{cb}	—	6.5	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz, collector guarded)		3	C_{eb}	—	30	pF
Input Impedance (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N4400	12	h_{ie}	0.5	7.5	k ohms
	2N4401			1.0	15	
Voltage Feedback Ratio (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		13	h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N4400	11	h_{fe}	20	250	—
	2N4401			40	500	
Output Admittance (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		14	h_{oe}	1.0	30	μmhos
SWITCHING CHARACTERISTICS						
Delay Time	V_{CC} = 30 Vdc, $V_{EB(off)}$ = 2 Vdc,	1, 5	t_d	—	15	ns
Rise Time	I_C = 150 mAdc, I_{B1} = 15 mAdc	1, 5, 6	t_r	—	20	ns
Storage Time	V_{CC} = 30 Vdc, I_C = 150 mAdc,	2, 7	t_s	—	225	ns
Fall Time	I_{B1} = I_{B2} = 15 mAdc	2, 8	t_f	—	30	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

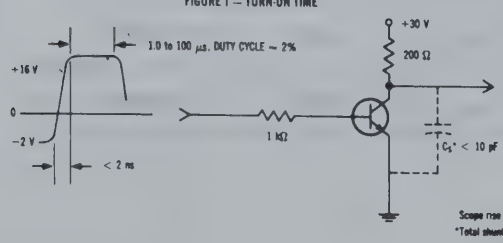
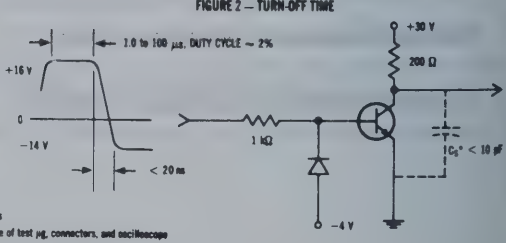


FIGURE 2 — TURN-OFF TIME



Scope rise time < 4 ns

*Total shunt capacitance of test jig, connectors, and oscilloscope

TRANSIENT CHARACTERISTICS

——— 25°C — — — 100°C

FIGURE 3 — CAPACITANCES

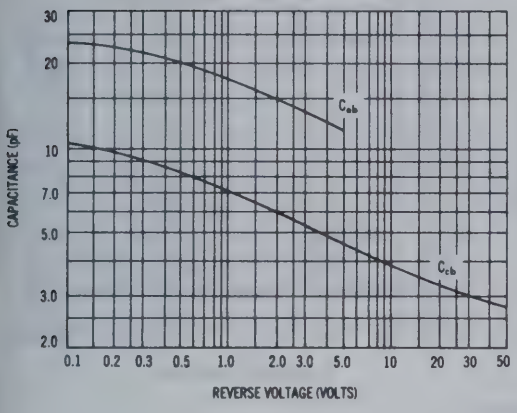


FIGURE 4 — CHARGE DATA

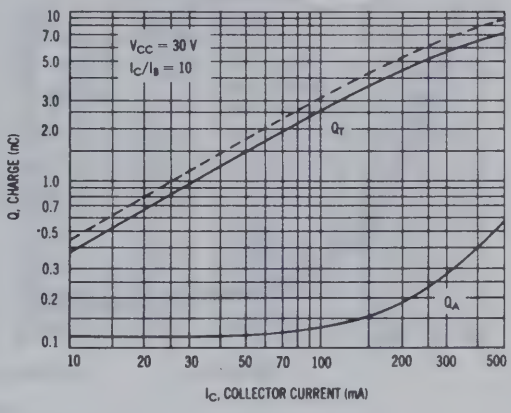


FIGURE 5 — TURN-ON TIME

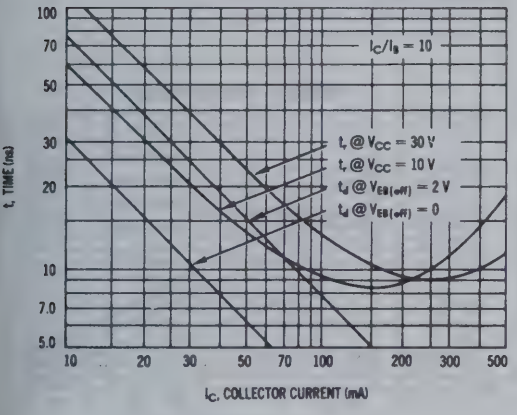


FIGURE 6 — RISE AND FALL TIMES

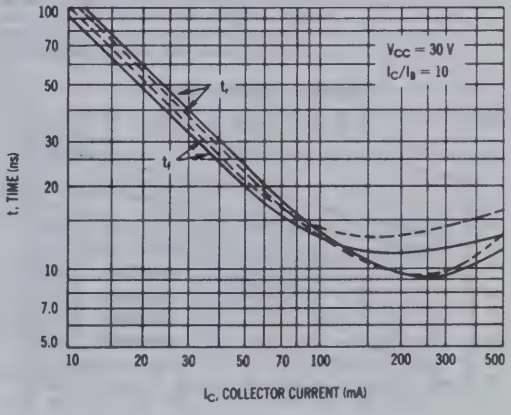


FIGURE 7 — STORAGE TIME

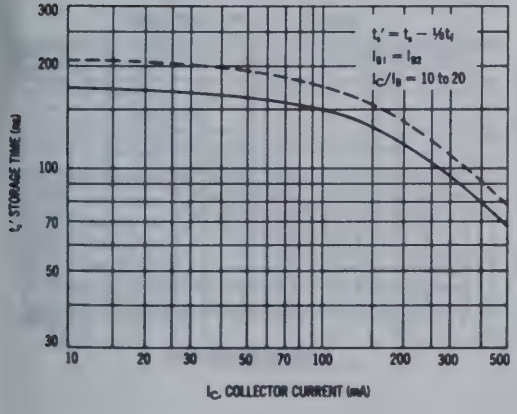
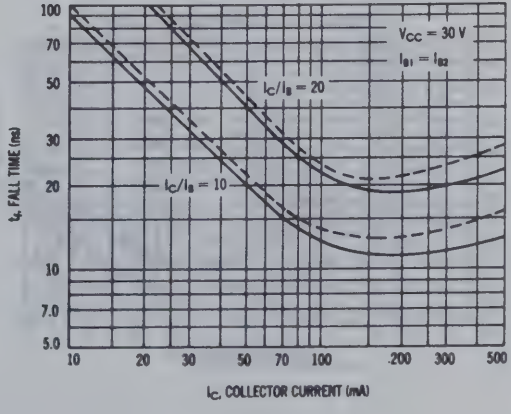


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 9 — FREQUENCY EFFECTS

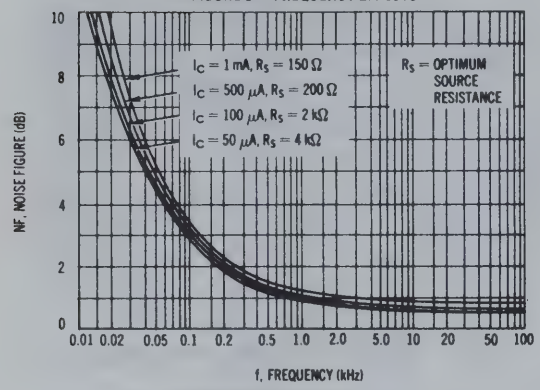
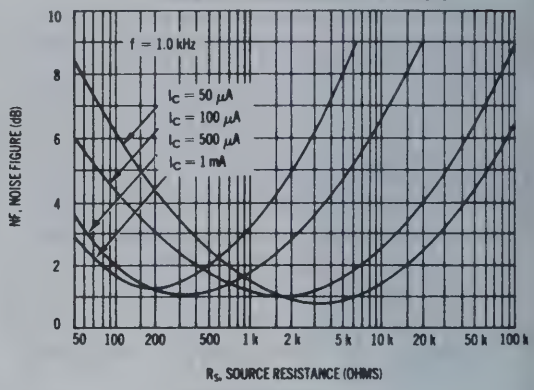


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the 2N4400 and 2N4401 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 11 — CURRENT GAIN

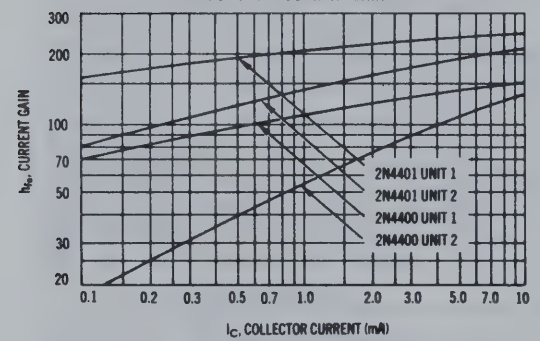


FIGURE 12 — INPUT IMPEDANCE

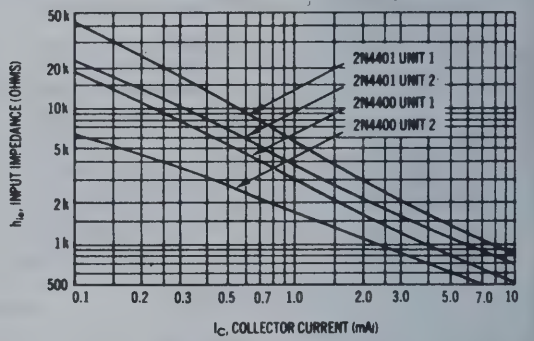


FIGURE 13 — VOLTAGE FEEDBACK RATIO

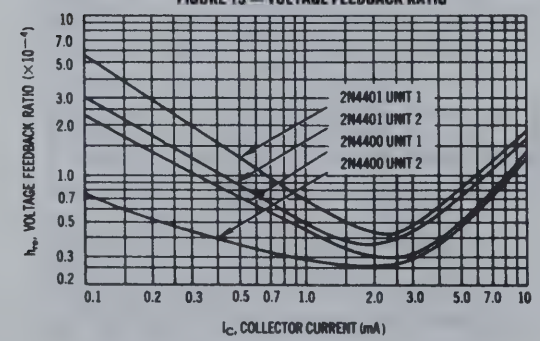
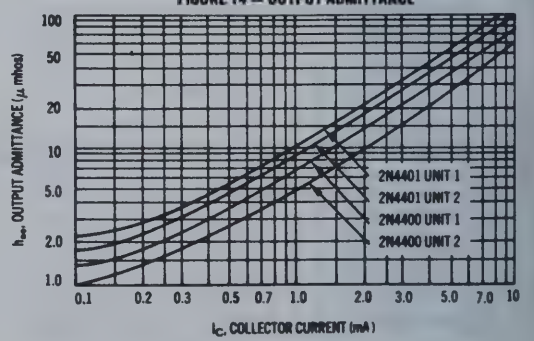


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

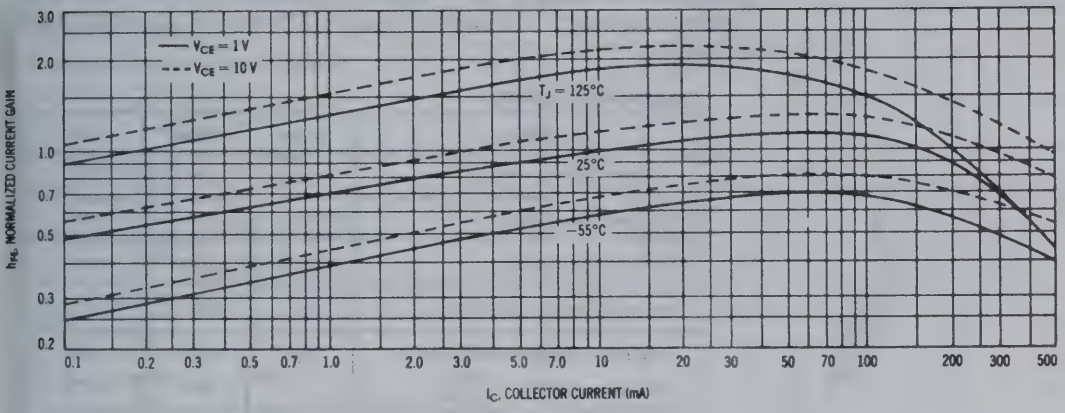


FIGURE 16 — COLLECTOR SATURATION REGION

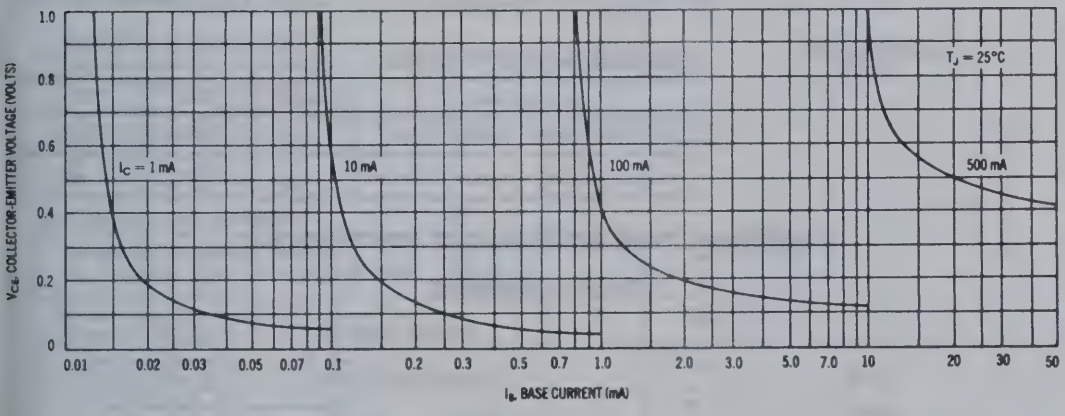


FIGURE 17 — "ON" VOLTAGES

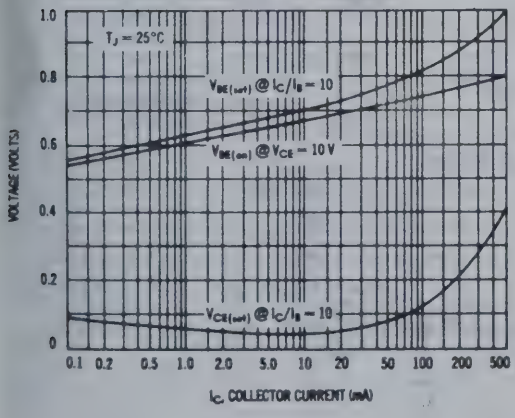
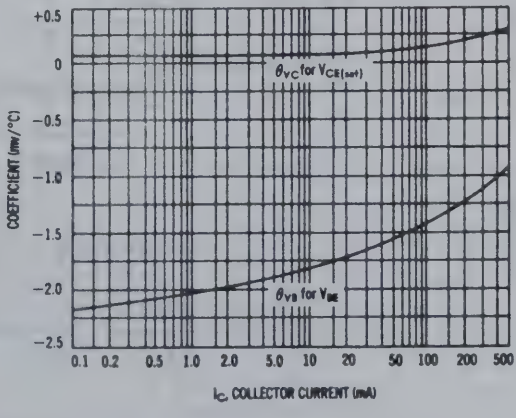


FIGURE 18 — TEMPERATURE COEFFICIENTS



2N4402 (SILICON)
2N4403

PNP silicon annular transistors designed for general purpose switching and amplifier applications and for complementary circuitry with NPN types 2N4400 and 2N4401.



CASE 29 (1)
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	600	mAdc
Total Device Dissipation $T_A = 25^oC$	P_D	310	mW
Derate above 25^oC		2.81	$mW/^oC$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.137	$^oC/mW$
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	$^oC/mW$

SWITCHING TIME EQUIVALENT TEST CIRCUIT

·· FIGURE 1 — TURN-ON TIME

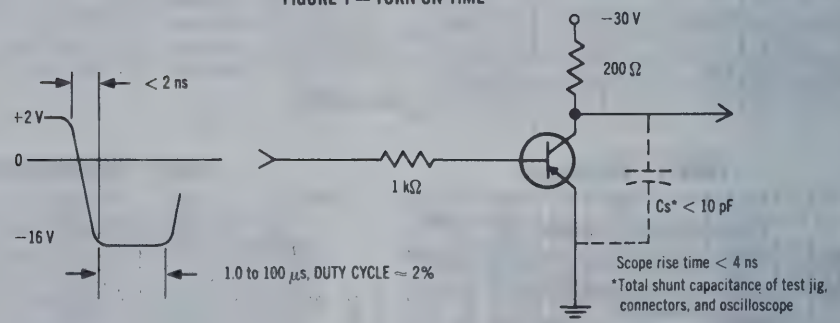
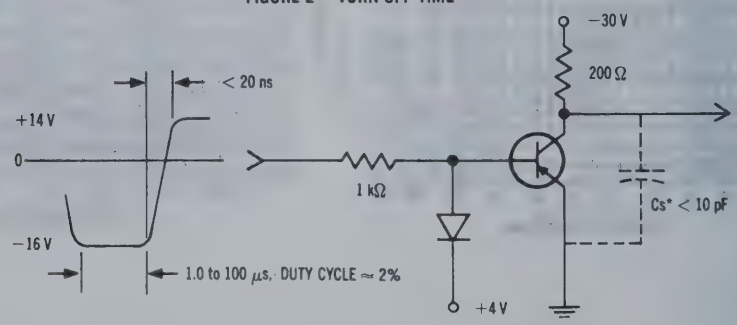


FIGURE 2 — TURN-OFF TIME



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1 mAdc, I_B = 0)			BV_{CEO}*	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)			BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)			BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 35 Vdc, $V_{BE(off)}$ = 0.4 Vdc)			I_{CEX}	—	0.1	μAdc
Base Cutoff Current (V_{CE} = 35 Vdc, $V_{BE(off)}$ = 0.4 Vdc)			I_{BL}	—	0.1	μAdc
ON CHARACTERISTICS						
DC Current Gain		15	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N4403			30	—	
(I_C = 1 mAdc, V_{CE} = 1 Vdc)	2N4402			30	—	
	2N4403			60	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N4402			50	—	
	2N4403			100	—	
(I_C = 150 mAdc, V_{CE} = 2 Vdc)*	2N4402			50	150	
	2N4403			100	300	
(I_C = 500 mAdc, V_{CE} = 2 Vdc)*				20	—	
Collector-Emitter Saturation Voltage*		16, 17, 18	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)				—	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)				—	0.75	
Base-Emitter Saturation Voltage*		17, 18	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)				0.75	0.95	
(I_C = 500 mAdc, I_B = 50 mAdc)				—	1.3	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N4402		f_T	150	—	MHz
	2N4403			200	—	
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz, emitter guarded)		3	C_{cb}	—	8.5	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz, collector guarded)		3	C_{eb}	—	30	pF
Input Impedance (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N4402	12	h_{ie}	750	7.5k	ohms
	2N4403			1.5k	15k	
Voltage Feedback Ratio (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		13	h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N4402	11	h_{fe}	30	250	—
	2N4403			60	500	
Output Admittance (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		14	h_{oe}	1.0	100	μmhos

SWITCHING CHARACTERISTICS

Delay Time	V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2 Vdc,	1, 5	t_d	—	15	ns
Rise Time	I_C = 150 mAdc, I_{B1} = 15 mAdc	1, 5, 6	t_r	—	20	ns
Storage Time	V_{CC} = 30 Vdc, I_C = 150 mAdc,	2, 7	t_s	—	225	ns
Fall Time	I_{B1} = I_{B2} = 15 mAdc	2, 8	t_f	—	30	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

TRANSIENT CHARACTERISTICS

——— 25°C — — — 100°C

FIGURE 3 — CAPACITANCES

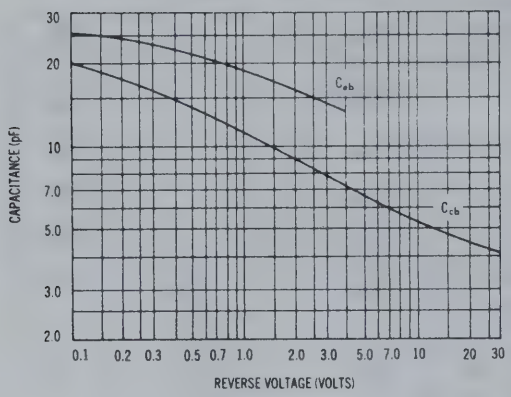


FIGURE 4 — CHARGE DATA

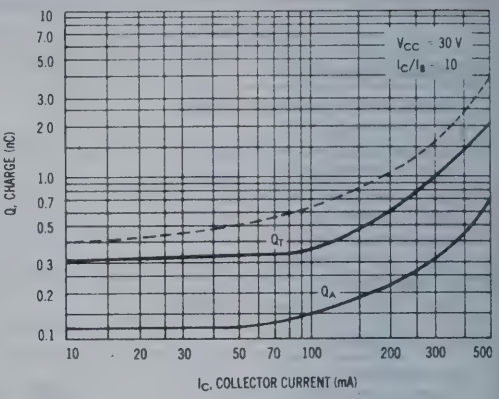


FIGURE 5 — TURN-ON TIME

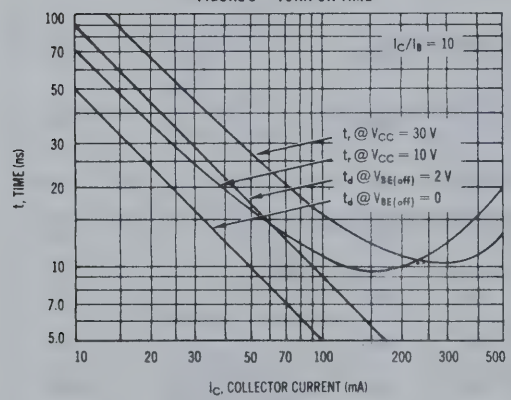


FIGURE 6 — RISE TIME

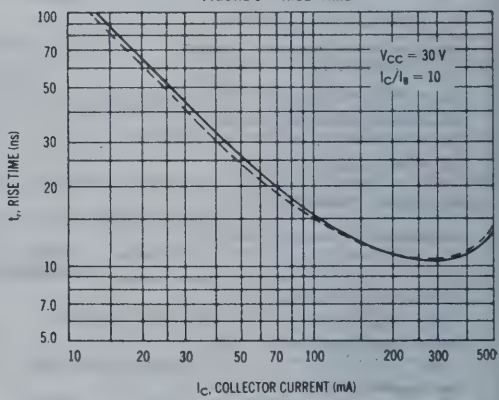


FIGURE 7 — STORAGE TIME

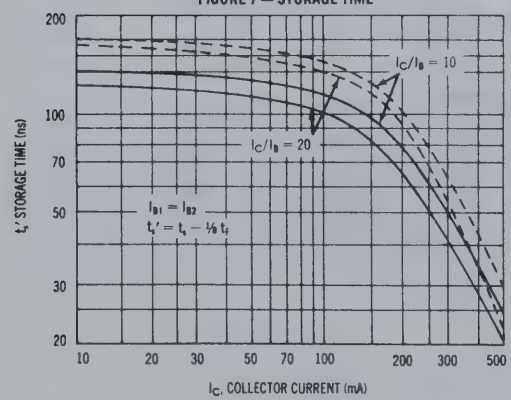
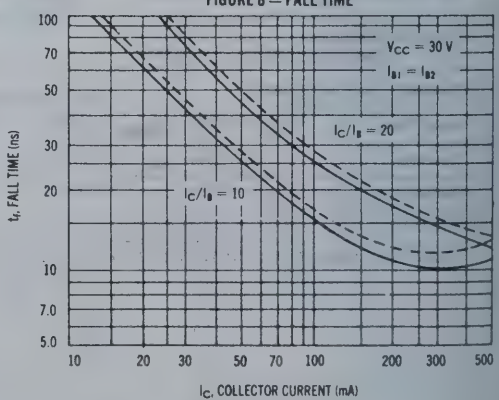


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 9 — FREQUENCY EFFECTS

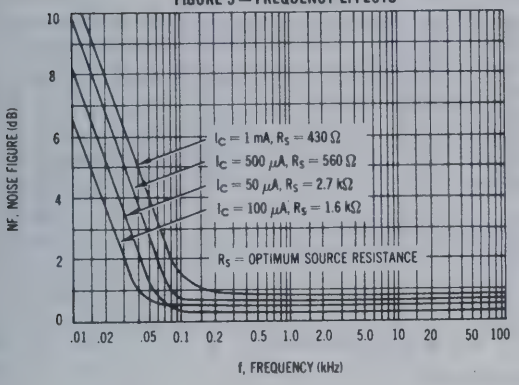
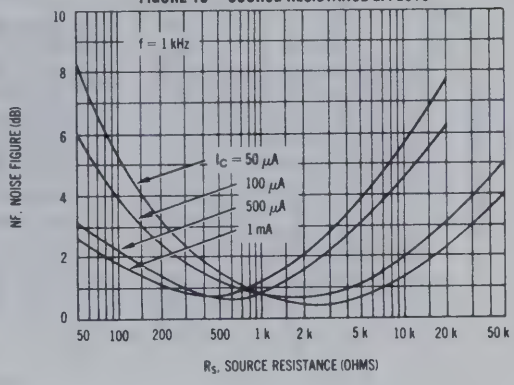


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the 2N4402 and 2N4403 lines, and the same units were used to develop the correspondingly-numbered curves on each graph.

FIGURE 11 — CURRENT GAIN

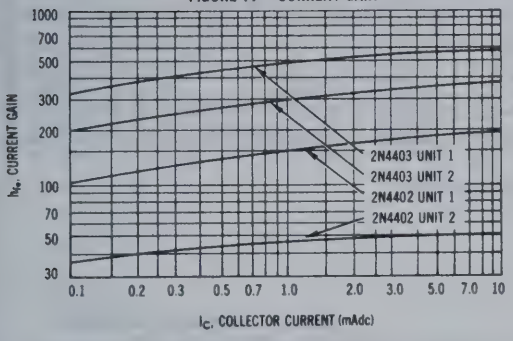


FIGURE 12 — INPUT IMPEDANCE

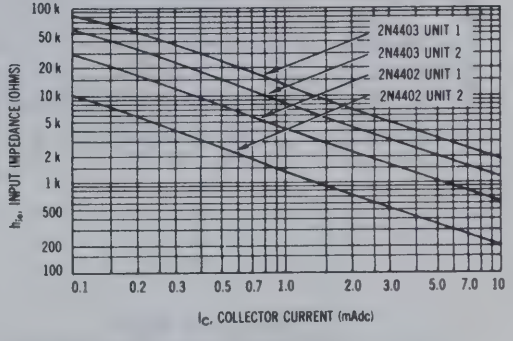


FIGURE 13 — VOLTAGE FEEDBACK RATIO

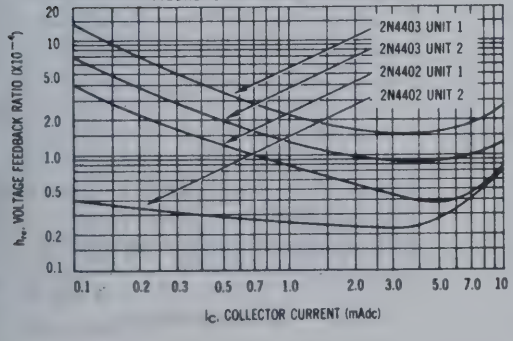
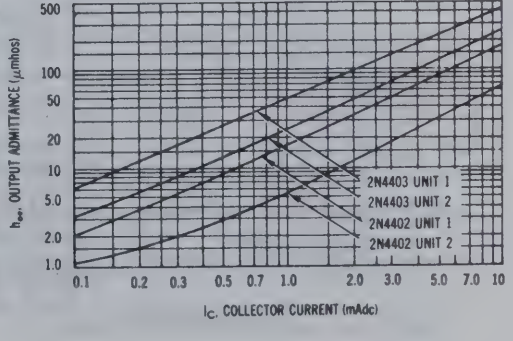


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

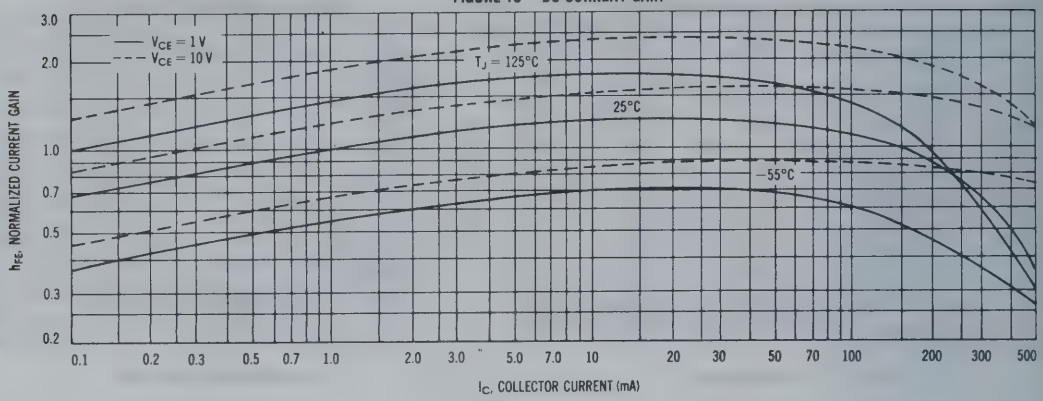


FIGURE 16 — COLLECTOR SATURATION REGION

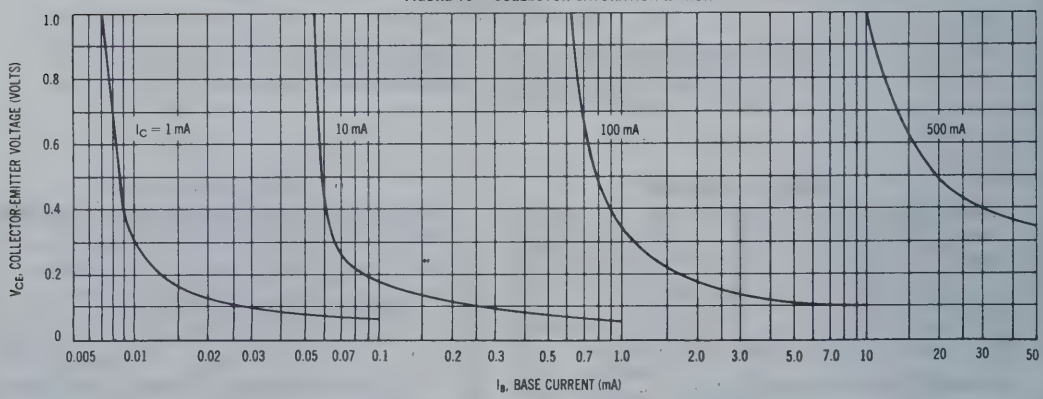


FIGURE 17 — "ON" VOLTAGE

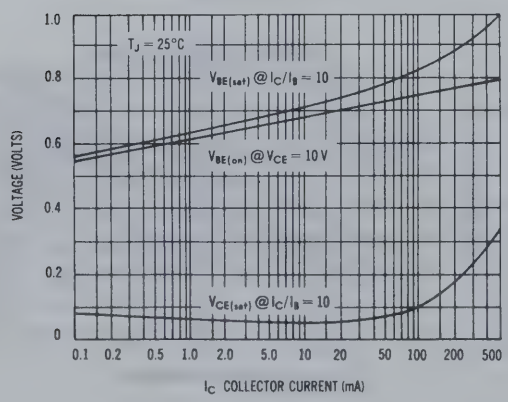
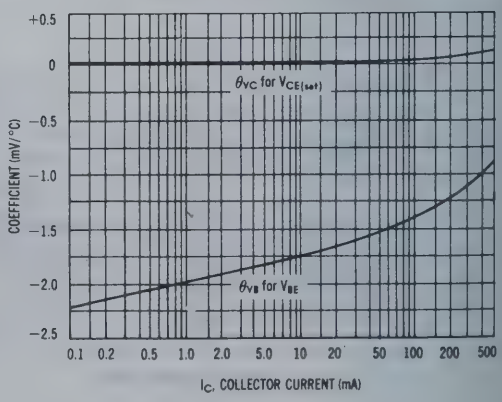
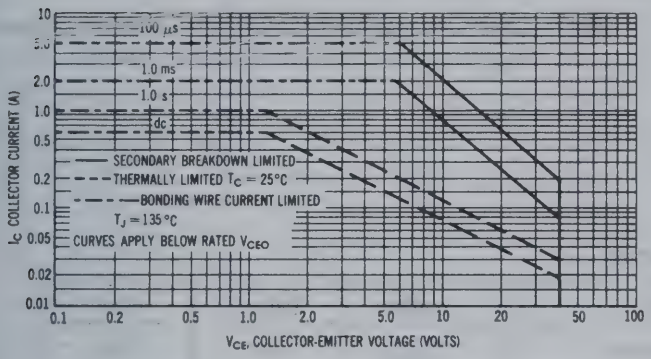


FIGURE 18 — TEMPERATURE COEFFICIENTS



RATINGS AND THERMAL DATA

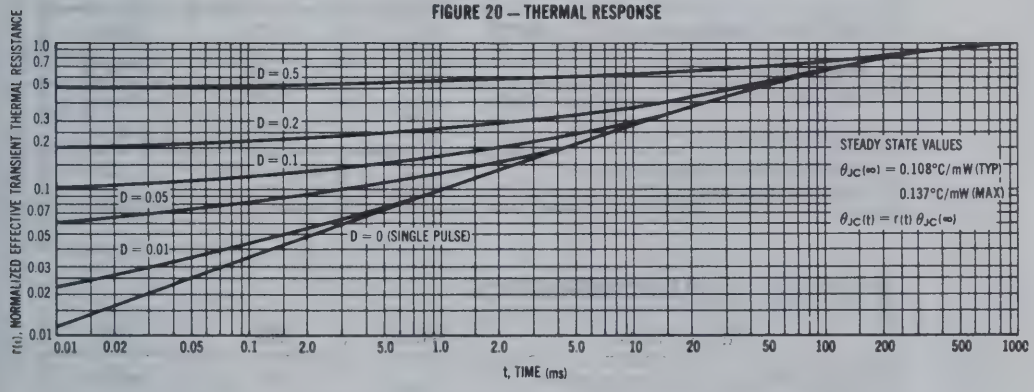
FIGURE 19 — ACTIVE-REGION SAFE OPERATING AREA



The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

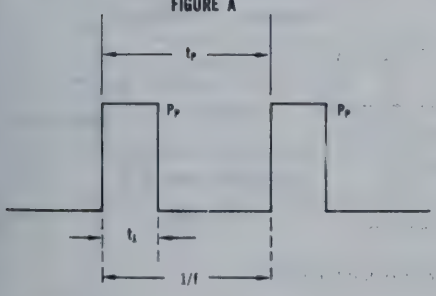
The data of Figure 19 is based upon $T_{J(pk)}$ = 135°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 135°C. $T_{J(pk)}$ may be calculated from the data in Figure 20. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by the secondary breakdown.

FIGURE 20 — THERMAL RESPONSE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 f = \frac{t_1}{t_p}$

PEAK PULSE POWER = P_p

A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 20 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 20 by the steady state value $\theta_{JC}(\infty)$.

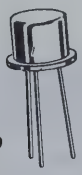
Example:
The 2N4402 is dissipating 2.0 watts under the following conditions: t_1 = 1.0 ms, t_p = 5.0 ms. (D = 0.2)

Using Figure 20, at a pulse width of 1.0 ms and D = 0.2, the reading of r (t) is 0.27.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_p \times \theta_{JC}(\infty) = 0.27 \times 2000 \times 0.137 = 74.0°C$$

2N4404 (SILICON)
2N4405



CASE 79
(TO-39)

PNP silicon annular transistors designed for general-purpose amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	25	°C/W
Thermal Resistance, Junction to Ambient (Lead Length 1/4")	θ_{JA}	140	°C/W

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON

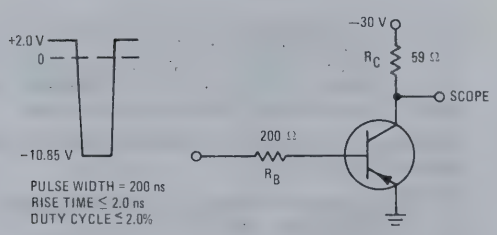
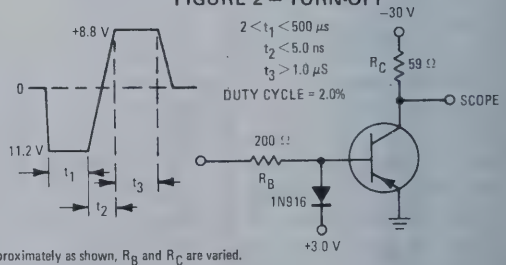


FIGURE 2 – TURN-OFF



To obtain data for curves, voltage levels are approximately as shown, R_B and R_C are varied.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	80	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	80	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	-	25	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	25	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N4404		30	-	
	2N4405		75	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N4404		40	-	
	2N4405		100	-	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)*	2N4404		40	120	
	2N4405		100	300	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)*	2N4404		15	-	
	2N4405		25	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			-	0.15	
(I_C = 150 mAdc, I_B = 15 mAdc)*			-	0.2	
(I_C = 500 mAdc, I_B = 50 mAdc)*			-	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			-	0.8	
(I_C = 500 mAdc, I_B = 50 mAdc)*			0.85	1.2	
Base-Emitter On Voltage* (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$*	-	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	600	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	-	10	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	-	75	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc,	t_d	-	15	ns
Rise Time	I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figure 1)	t_r	-	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc,	t_s	-	175	ns
Fall Time	I_{B1} = I_{B2} = 50 mAdc) (Figure 2)	t_f	-	35	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TRANSIENT CHARACTERISTICS

——— 25°C – – – 100°C

FIGURE 3 – CAPACITANCES

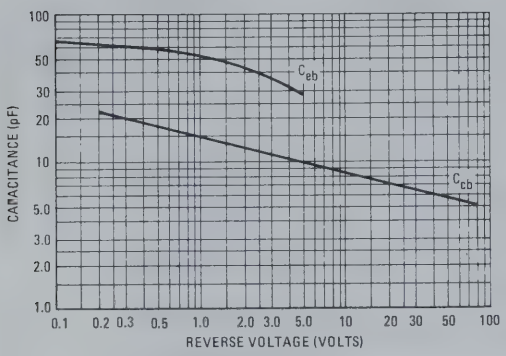


FIGURE 4 -- CHARGE DATA

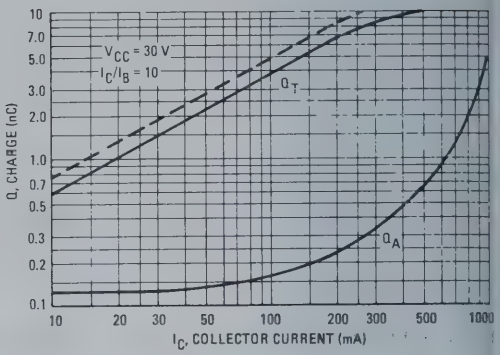


FIGURE 5 – DELAY TIME

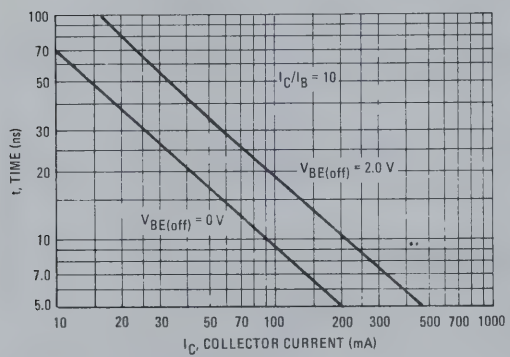


FIGURE 6 – RISE TIME

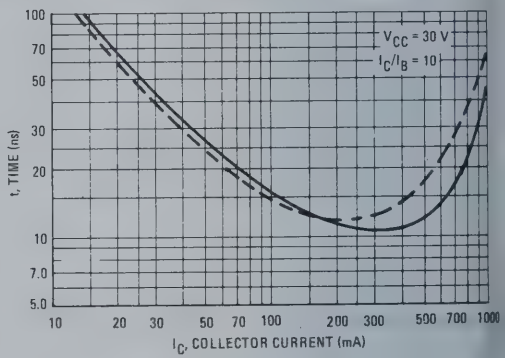


FIGURE 7 – STORAGE TIME

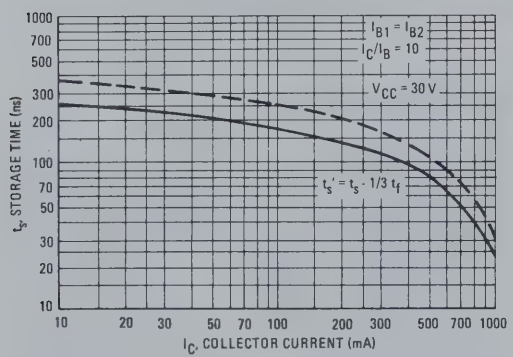
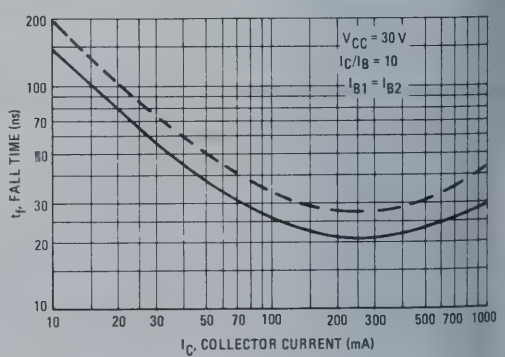


FIGURE 8 – FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 9 – FREQUENCY EFFECTS

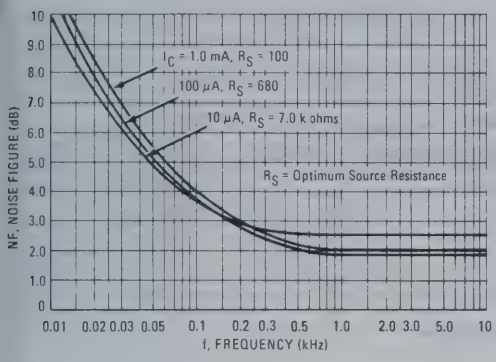
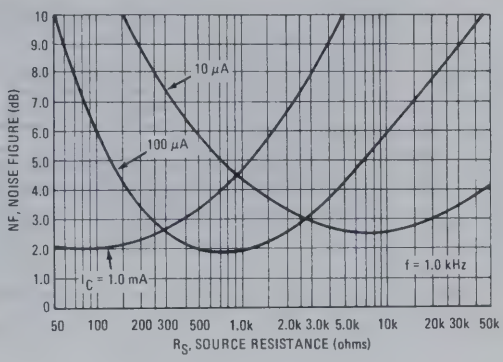


FIGURE 10 – SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number – the same units were used to develop curves on each graph.

FIGURE 11 – CURRENT GAIN

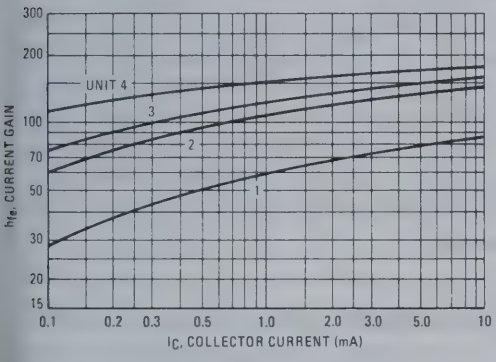


FIGURE 12 – INPUT IMPEDANCE

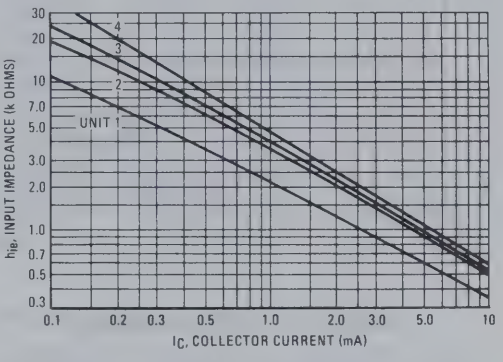


FIGURE 13 – VOLTAGE FEEDBACK RATIO

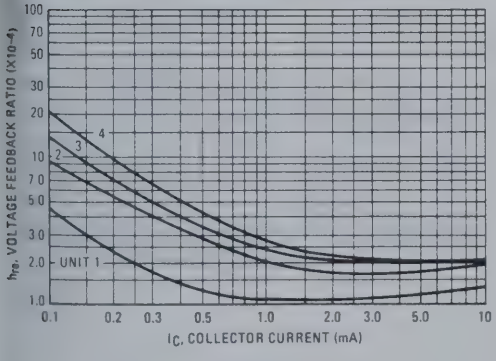
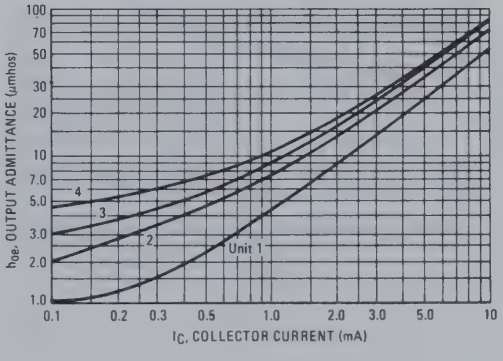


FIGURE 14 – OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN

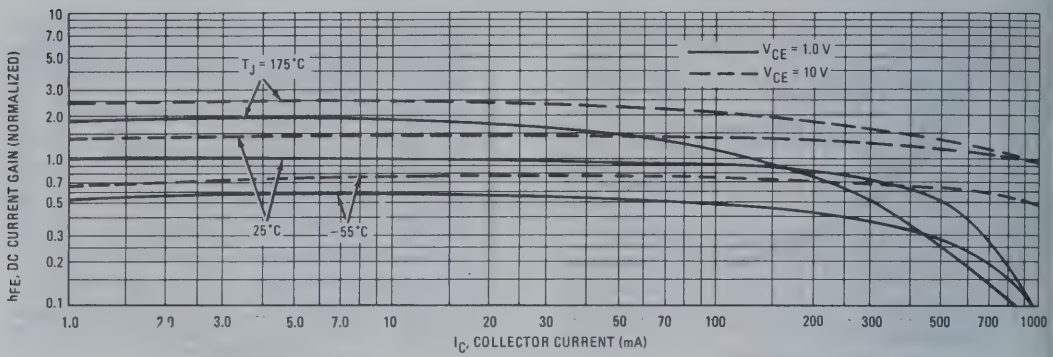


FIGURE 16 – COLLECTOR SATURATION REGION

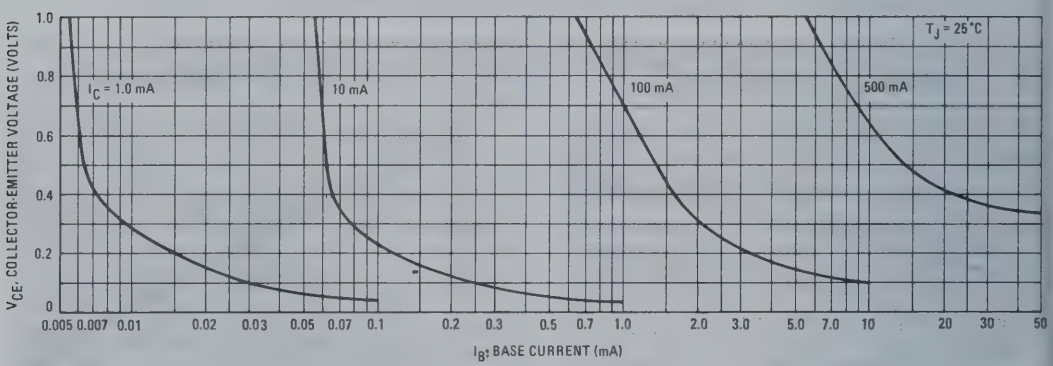


FIGURE 17 – "ON" VOLTAGES

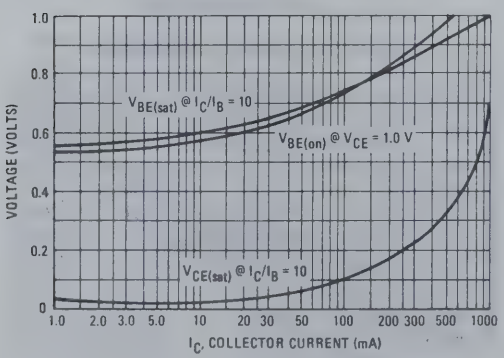
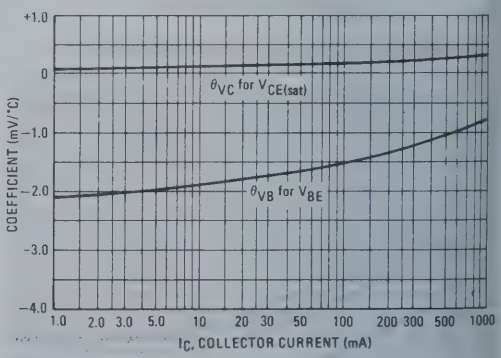
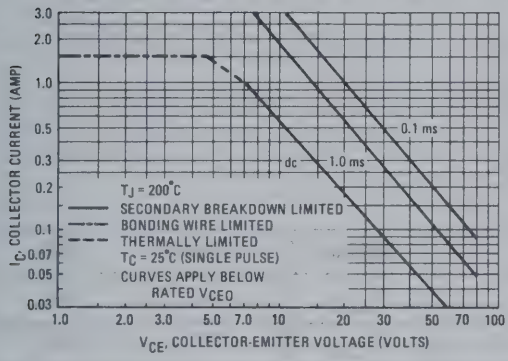


FIGURE 18 – TEMPERATURE COEFFICIENTS



RATINGS AND THERMAL DATA

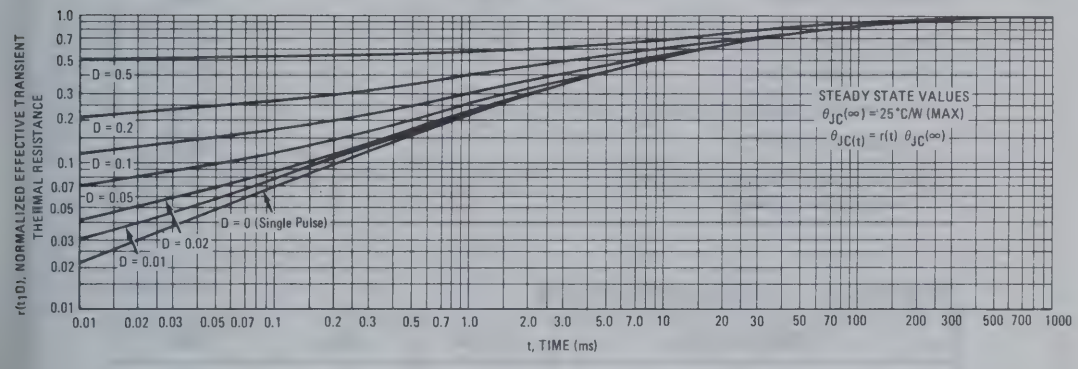
FIGURE 19 – SAFE OPERATING AREA



The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

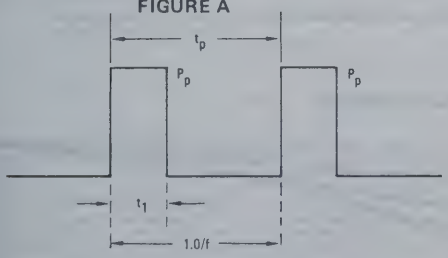
The data of Figure 19 is based upon $T_{J(pk)}$ = 200°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 20. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

FIGURE 20 – THERMAL RESPONSE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 f = \frac{t_1}{t_p}$

PEAK PULSE POWER = P_p

A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 20 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 20 by the steady state value $\theta_{JC}(\infty)$.

Example:

If the 2N4404 is dissipating 8.0 watts peak under the following conditions: t_1 = 1.0 ms, t_p = 5.0 ms, (D = 0.2), find ΔT.

Using Figure 20 at a pulse width of 1.0 ms and D = 0.2, the reading of $r(t_1D)$ is 0.4.

The peak rise in junction temperature above case temperature is, therefore, $\Delta T = r(t_1D) \times P_p \times \theta_{JC}(\infty) = 0.4 \times 8.0 \times 25 = 80°C$.

2N4406 (SILICON)
2N4407



CASE 79
(TO-39)

PNP silicon annular transistors designed for general-purpose amplifier and switching applications.

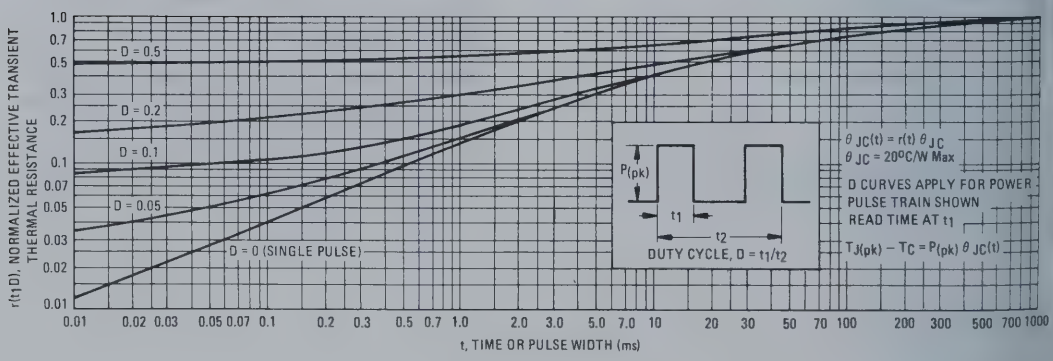
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.75 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	20	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	140	°C/W

FIGURE 1 - THERMAL RESPONSE



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	80	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	80	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	-	25	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	25	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N4406	h_{FE}*	30	-	-
	2N4407		80	-	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N4406		25	100	
	2N4407		75	225	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N4406		20	-	
	2N4407		35	-	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	2N4406		10	-	
	2N4407		15	-	
(I_C = 1.5 Adc, V_{CE} = 5.0 Vdc)	2N4406, 2N4407		10	-	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$*	-	0.2	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			-	0.4	
(I_C = 1.0 Adc, I_B = 100 mAdc)			-	0.7	
(I_C = 1.5 Adc, I_B = 150 mAdc)			-	1.5	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$*	-	0.9	Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc)			0.9	1.3	
(I_C = 1.5 Adc, I_B = 150 mAdc)			-	1.5	
Base-Emitter On Voltage* (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$*	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	150	750	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	-	15	pF
Collector-Emitter Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	-	160	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc,	t_d	-	15	ns
Rise Time	I_C = 1.0 Adc, I_{B1} = 100 mAdc) (Figure 11)	t_r	-	60	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 1.0 Adc,	t_s	-	175	ns
Fall Time	I_{B1} = I_{B2} = 100 mAdc) (Figure 12)	t_f	-	50	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

STATIC CHARACTERISTICS

FIGURE 2 - DC CURRENT GAIN

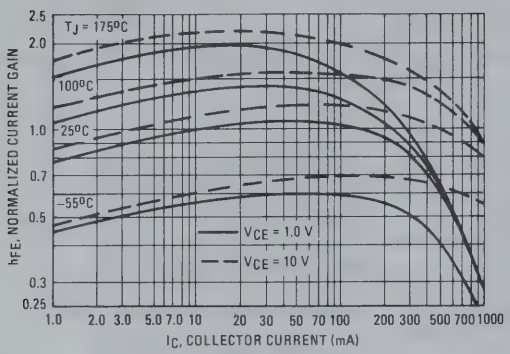


FIGURE 3 - COLLECTOR SATURATION REGION

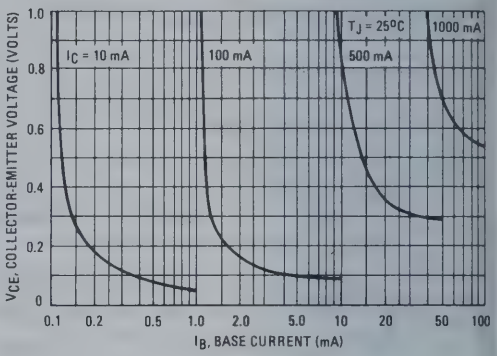


FIGURE 4 - "ON" VOLTAGES

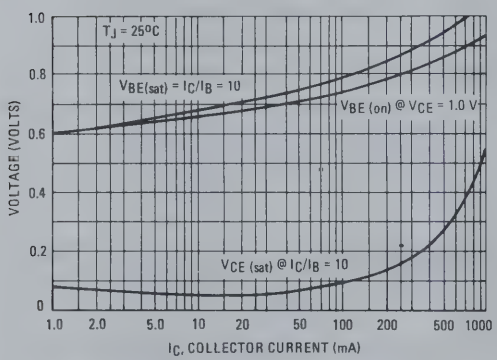


FIGURE 5 - TEMPERATURE COEFFICIENTS

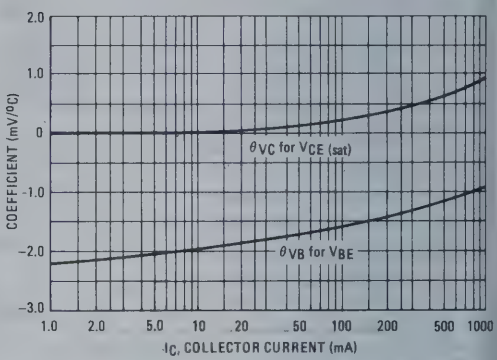
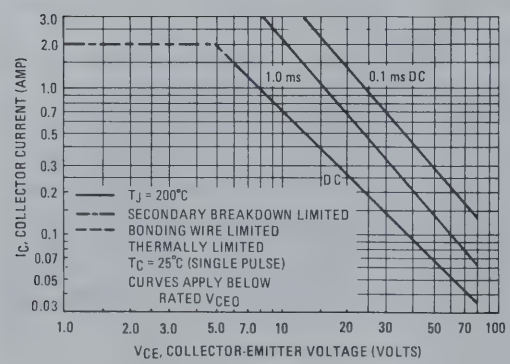


FIGURE 6 - SAFE OPERATING AREA



The safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 6 is based upon $T_{J(pk)}$ = 200°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leqq$ 200°C. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TRANSIENT CHARACTERISTICS

——— 25°C — — — 100°C

FIGURE 7 - CAPACITANCES

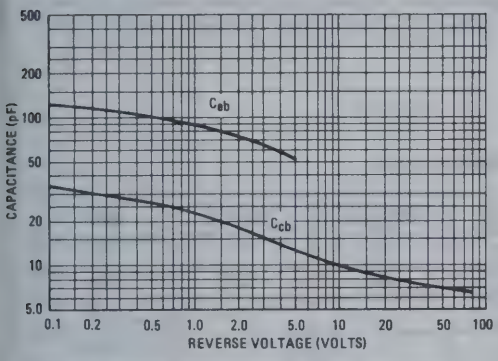


FIGURE 8 - CHARGE DATA

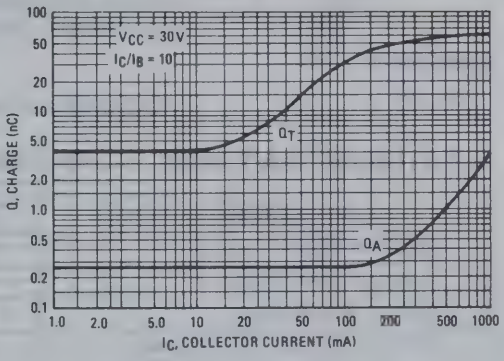


FIGURE 9 - TURN-ON TIME

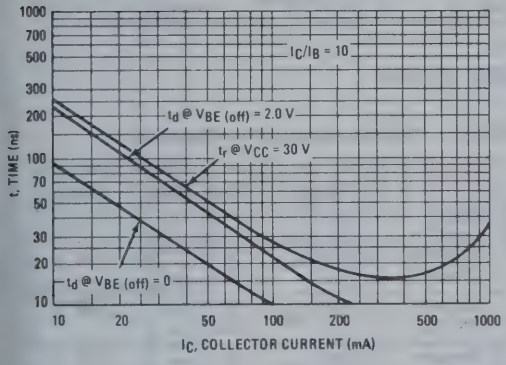
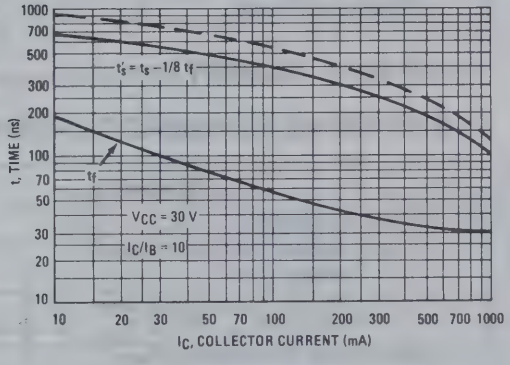


FIGURE 10 - TURN-OFF TIME



SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 11 - TURN-ON TIME

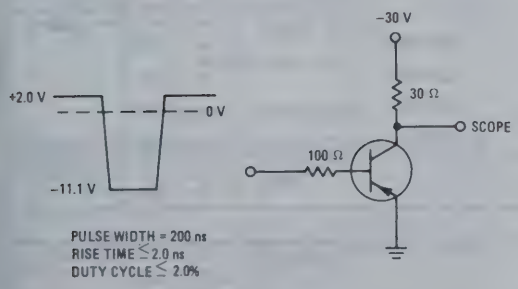
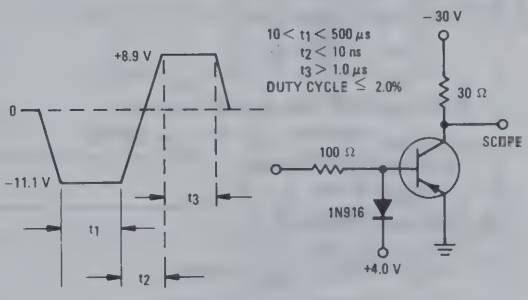


FIGURE 12 - TURN-OFF TIME



2N4409 (SILICON)
2N4410



CASE 29(1)
(TO-92)

NPN silicon epitaxial transistors designed for driving neon display tubes. Features one-piece, injection-molded plastic package for high reliability.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	2N4409	2N4410	Unit
Collector-Emitter Voltage	V_{CEO}	50	80	Vdc
Collector-Base Voltage	V_{CB}	80	120	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	Vdc
Collector Current - Continuous	I_C	250		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL RESISTANCE: θ_{JA} = 0.357°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	2N4409 2N4410	BV_{CEO}	50 80	— —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 500 μAdc, V_{BB} = 5 Vdc, R_{BE} = 8.2 k ohms)	2N4409 2N4410	BV_{CEX}	80 120	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_C = 0)	2N4409 2N4410	BV_{CBO}	80 120	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N4409		—	0.01	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	2N4409		—	1.0	
(V_{CB} = 100 Vdc, I_E = 0)	2N4410		—	0.01	
(V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C)	2N4410		—	1.0	
Emitter Cutoff Current (V_{BE} = 4 Vdc, I_C = 0)		I_{EBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 1 mAdc, V_{CE} = 1 Vdc)			60	400	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)			60	—	
Collector-Emitter Saturation Voltage (I_C = 1 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	—	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 1 mAdc, I_B = 0.1 mAdc)		$V_{BE(sat)}$	—	0.8	Vdc
Base-Emitter On Voltage (I_C = 1 mAdc, V_{CE} = 5 Vdc)		$V_{BE(on)}$	—	0.8	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)	f_T	60	300	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz, emitter guarded)	C_{cb}	—	12	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz, collector guarded)	C_{eb}	—	50	pF

TYPICAL DC CHARACTERISTICS

FIGURE 1 — CURRENT GAIN

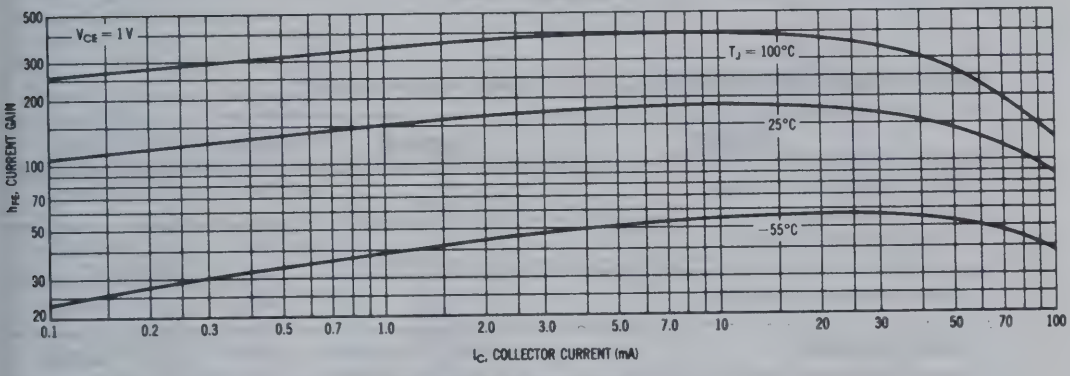


FIGURE 2 — SATURATION VOLTAGES

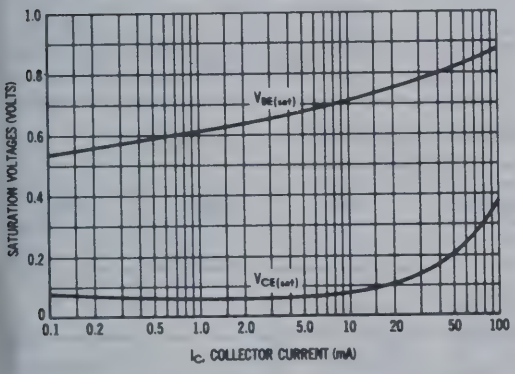


FIGURE 3 — TEMPERATURE COEFFICIENTS

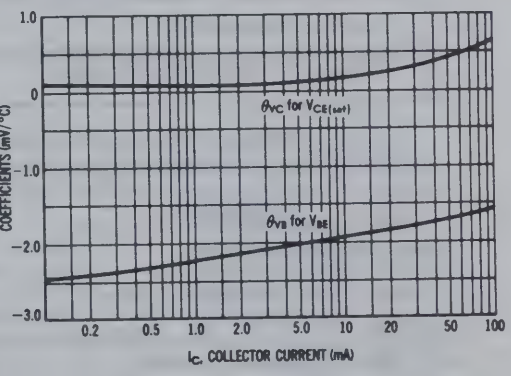


FIGURE 4 — CUTOFF CURRENT

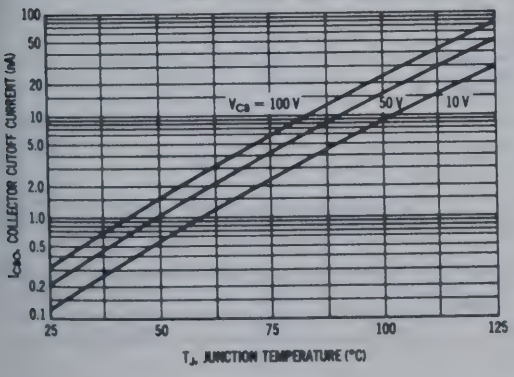
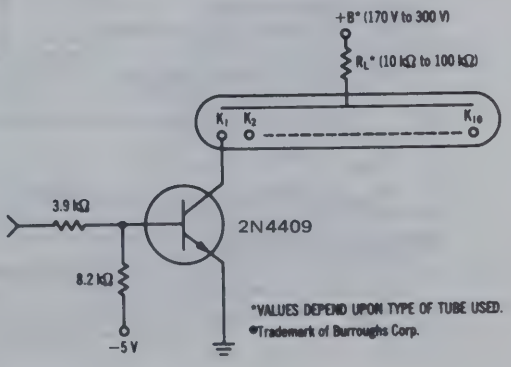


FIGURE 5 — TYPICAL NIXIE® DRIVER APPLICATION



*VALUES DEPEND UPON TYPE OF TUBE USED.
®Trademark of Burroughs Corp.

2N4416 (SILICON)



Silicon N-channel junction field-effect transistor designed for VHF/UHF amplifier applications.

CASE 20 (1)
(TO-72)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A @ 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = -1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	-	Vdc
Gate-Source Cutoff Voltage (I_D = 1.0 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	-	6.0	Vdc
Gate-Source Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)	V_{GS}	1.0	5.5	Vdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)	$V_{GS(f)}$	-	1.0	Vdc
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0) (V_{GS} = -20 Vdc, V_{DS} = 0, T_A = +150°C)	I_{GSS}	- -	100 200	pAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	5.0	15	mAdc

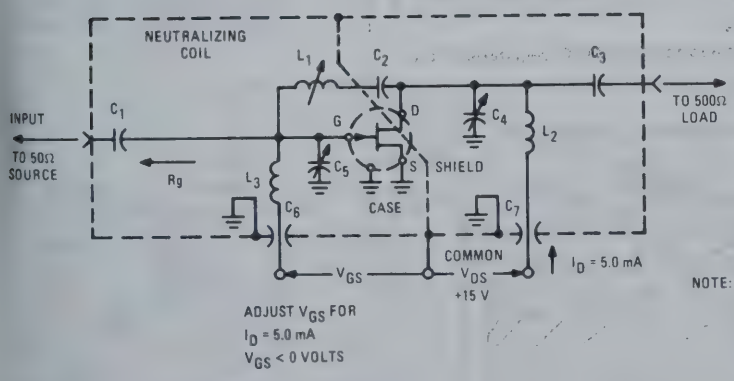
2N4416 (continued)

SMALL-SIGNAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Forward Transfer Admittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{fs}^*\|$	4500	7500	μmhos
Real Part of Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	$RE(y_{fs})$	4000	-	μmhos
Real Part of Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	$RE(y_{is})$	- -	100 1000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	-	50	μmhos
Real Part of Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	$RE(y_{os})$	- -	75 100	μmhos
Imaginary Part of Input Susceptance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	$IM(y_{is})$	- -	2500 10,000	μmhos
Imaginary Part of Output Susceptance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	$IM(y_{os})$	- -	1000 4000	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	4.0	pF
Common-Source Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{osp}	-	2.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	0.8	pF
Common-Source Spot Noise Figure (Figure 1) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, R_g ~1000 ohms, f = 100 MHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, R_g ~1000 ohms, f = 400 MHz)	NF	- -	2.0 4.0	dB
Small-Signal Power Gain (Figure 1) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 100 MHz) (V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 400 MHz)	G_{ps}	18 10	- -	dB

* Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

FIGURE 1 – 100 MHz & 400 MHz NEUTRALIZED AMPLIFIER



Reference Designation	VALUE	
	100 MHZ	400 MHz
C_1	7.0 pF	1.8 pF
C_2	1000 pF	17 pF
C_3	3.0 pF	1.0 pF
C_4	1-12 pF	0.8-8.0 pF
C_5	1-12 pF	0.8-8.0 pF
C_6	0.0015 μF	0.001 μF
C_7	0.0015 μF	0.001 μF
L_1	3.0 μH*	0.2 μH**
L_2	0.15 μH*	0.03 μH**
L_3	0.14 μH*	0.022 μH**

NOTE: The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

* L_1 17 turns, (approx. – depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L_2 4 1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I.D. (AIR CORE).

L_3 3 1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I.D. (AIR CORE).

** L_1 6 turns, (approx. – depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L_2 1 turn, AWG #16 enameled copper wire, 3/8" I.D. (AIR CORE).

L_3 1/2 turn, AWG #16 enameled copper wire, 1/4" I.D. (AIR CORE).

2N4427 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

- Current-Gain—Bandwidth Product —
  f_T = 500 MHz (Min) @ I_C = 50 mAdc
- Power Gain —
  G_{pe} = 10 dB (Min) @ V_{CE} = 12 Vdc
- 1 Watt Minimum Power Output @ f = 175 MHz
- Multiple-Emitter Construction for Excellent High-Frequency Performance

NPN SILICON RF POWER TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	2.0	Vdc
Collector Current — Continuous	I_C	400	mAdc
Base Current — Continuous	I_B	400	mAdc
** Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to + 200	°C

*Indicates JEDEC Registered Data
**Motorola guarantees this data in additon to JEDEC registered Data

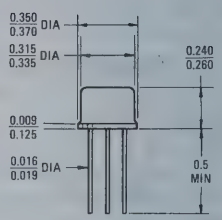
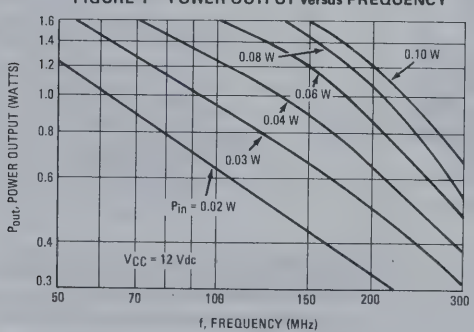
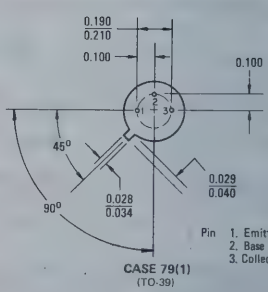


FIGURE 1 — POWER OUTPUT versus FREQUENCY



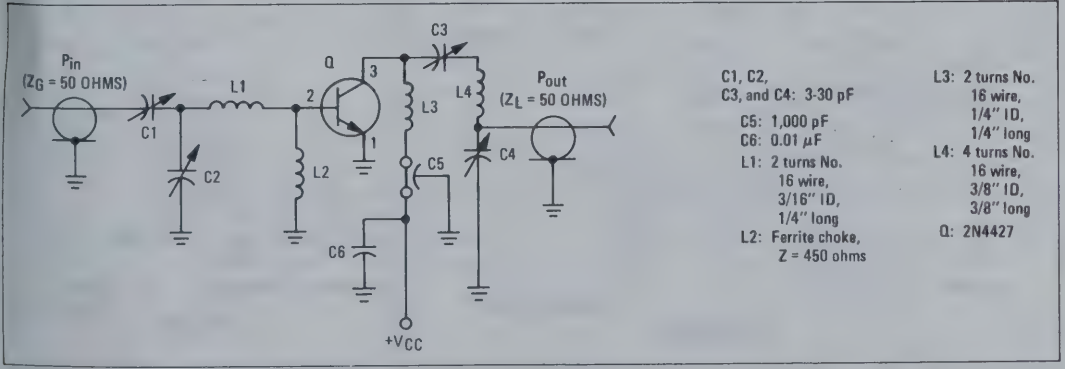


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**				
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	20	–	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, R_{BE} = 10 ohms)	$V_{CER(sus)}$	40	–	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, I_B = 0)	I_{CEO}	–	0.02	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = –1.5 Vdc) (V_{CE} = 12 Vdc, V_{BE} = –1.5 Vdc, T_C = +150°C)	I_{CEV}	– –	0.1 5.0	mAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	mAdc
***ON CHARACTERISTICS**				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc) (I_C = 360 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10 5.0	200 –	–
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	–	0.5	Vdc
***DYNAMIC CHARACTERISTICS**				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	–	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	4.0	pF
FUNCTIONAL TEST				
*Power Input (Figure 1) (P_{out} = 1.0 W, Z_S = 50 Ohms, V_{CC} = 12 Vdc, f = 175 MHz)	P_{in}	–	100	mW
Common-Emitter Amplifier Power Gain (P_{in} = 100 mW, Z_S = 50 Ohms, V_{CC} = 12 Vdc, f = 175 MHz)	G_{pe}	10	–	dB
*Collector Efficiency (Figure 1) (P_{out} = 1.0 W, Z_S = 50 Ohms, V_{CC} = 12 Vdc, f = 175 MHz)	η	50	–	%

*Indicates JEDEC Registered Data

FIGURE 1 – 175 MHz RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST



C1, C2, C3, and C4: 3-30 pF
C5: 1,000 pF
C6: 0.01 μF
L1: 2 turns No. 16 wire, 3/16" ID, 1/4" long
L2: Ferrite choke, Z = 450 ohms
L3: 2 turns No. 16 wire, 1/4" ID, 1/4" long
L4: 4 turns No. 16 wire, 3/8" ID, 3/8" long
Q: 2N4427

2N4428 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed primarily for use in large signal VHF and UHF amplifier output stages in military and industrial communications applications.

- High Power Output — P_{out} = 0.75 Watt with 10 dB Gain @ f = 500 MHz
- High Current-Gain—Bandwidth Product — f_T = 1000 MHz (Typ) @ I_C = 50 mAdc
- Multiple Emitter Construction for Excellent High Frequency Performance

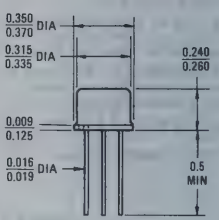
NPN SILICON RF POWER TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current — Continuous	I_C	425	mAdc
Base Current — Continuous	I_B	150	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg} *	-65 to +200	°C

*Indicates JEDEC Registered Data.



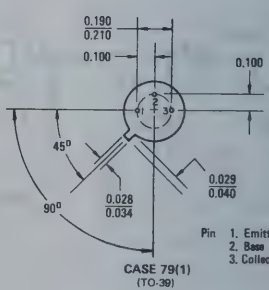
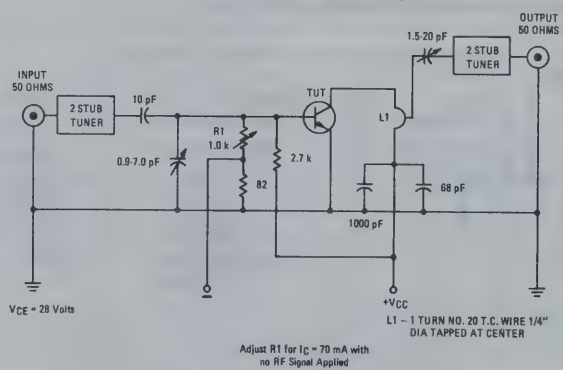


FIGURE 1 — 500 MHz TEST CIRCUIT



*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 20 mAdc, I_B = 0)	$V_{CEO(sus)}$	35	–	–	Vdc
Collector-Emitter Sustaining Voltage (I_C = 20 mAdc, R_{BE} = 10 ohms)	$V_{CER(sus)}$	55	–	–	Vdc
Collector Cutoff Current (V_{CE} = 55 Vdc, V_{BE} = -1.5 Vdc)	I_{CEX}	–	–	1.0	mAdc
Emitter Cutoff Current (V_{EB} = 3.5 Vdc, I_C = 0)	I_{EBO}	–	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	–	200	–
(I_C = 400 mAdc, V_{CE} = 5.0 Vdc)		5.0	–	–	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	700	1000	–	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	1.2	3.5	pF
FUNCTIONAL TEST					
Power Input (Figure 1) (P_{out} = 750 mW, V_{CE} = 28 Vdc, R_S = 50 Ohms, f = 500 MHz)	P_{in}	–	–	75	mW
Collector Efficiency (Figure 1) (P_{out} = 750 mW, V_{CE} = 28 Vdc, R_S = 50 Ohms, f = 500 MHz)	η	35	–	–	%

*Indicates JEDEC Registered Data.

FIGURE 2 – CURRENT-GAIN–BANDWIDTH PRODUCT

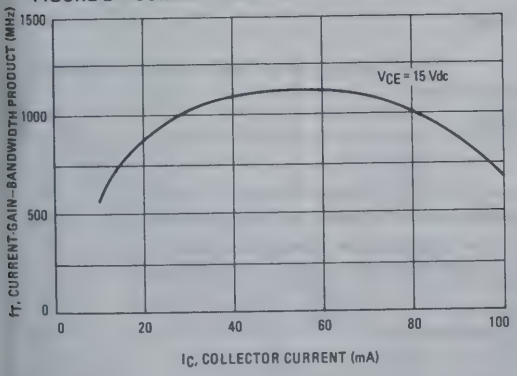
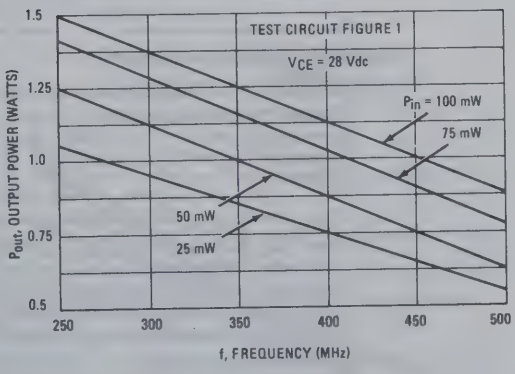
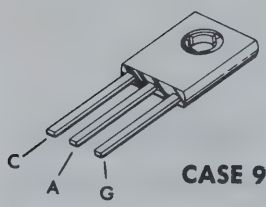


FIGURE 3 – OUTPUT POWER versus FREQUENCY



2N4441 thru 2N4444 (SILICON)



CASE 90(1)

Plastic thyristors (silicon controlled rectifiers) designed for high-volume consumer phase-control applications such as motor speed, temperature, and light controls and for switching applications in ignition and starting systems, voltage regulators, vending machines, and lamp drivers, etc.

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) 2N4441	$V_{ROM(rep)}$	50	Volts
2N4442		200	
2N4443		400	
2N4444		600	
Peak Reverse Blocking Voltage (Non-Recurrent, t = 5.0 ms (max) duration) 2N4441	$V_{ROM(non\ rep)}$	75	Volts
2N4442		300	
2N4443		500	
2N4444		700	
Forward Current RMS (All Conduction Angles)	I_f	8.0	Amps
Peak Forward Surge Current (1/2 cycle, 60 Hz, T_J = -40 to +100°C)	$I_{FM(surge)}$	80	Amps
Circuit Fusing Considerations (T_J = -40 to +100°C; t = 1.0 to 8.3 ms)	I^2t	25	A^2s
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2.0	Amps
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	10	
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Torque (6-32 screw) (Note 2)	-	12	in. lb.

1. V_{FOM} and V_{ROM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.
   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C. For optimum results, an activated flux (oxide removing) is recommended.

2N4441 thru 2N4444 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 100°C) Note 1	V_{FOM}				Volts
2N4441		50	-	-	
2N4442		200	-	-	
2N4443		400	-	-	
2N4444		500	-	-	
Peak Forward Blocking Current (Rated V_{FOM} @ T_J = 100°C, gate open)	I_{FOM}	-	-	2.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} @ T_J = 100°C, gate open)	I_{ROM}	-	-	2.0	mA
Forward "On" Voltage	V_F				Volts
(I_F = 5.0 A peak)		-	1.0	1.5	
(I_F = 15.7 A peak)		-	-	2.5 ‡	
Gate Trigger Current (Continuous dc) (Anode Voltage - 7.0 Vdc, R_L = 100 ohms) T_C = 25°C	I_{GT}	-	10	30	mA
T_C = -40°C		-	-	60 ‡	
Gate Trigger Voltage (Continuous dc)					Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms) T_C = 25°C	V_{GT}	-	0.7	1.5	
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms) T_C = -40°C	V_{GT}	-	-	2.5 ‡	
(Anode Voltage = Rated V_{FOM}, R_L = 100 ohms) T_J = 100°C	V_{GNT}	0.2 ‡	-	-	
Holding Current	I_{HO}				mA
(Anode Voltage = 7.0 Vdc, gate open) T_C = 25°C		-	10	40	
T_C = -40°C		-	-	70 ‡	
Turn-On Time (I_F = 5.0 A, I_{GT} = 20 mA)	t_{on}	-	1.0	-	μs
Turn-Off Time (I_F = 5.0 A, I_R = 5.0 A)	t_{off}	-	15	-	μs
(I_F = 5.0 A, I_R = 5.0 A, T_J = 100°C)		-	20	-	
Forward Voltage Application Rate (T_J = 100°C)	dv/dt	-	50	-	V/μs
Thermal Resistance, Junction to Case	θ_{JC}	-	-	2.5	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	-	40	-	°C/W

‡JEDEC registered, non-production line tests.

1. V_{FOM} and V_{ROM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.

FIGURE 1 — CURRENT DERATING — HALF WAVE

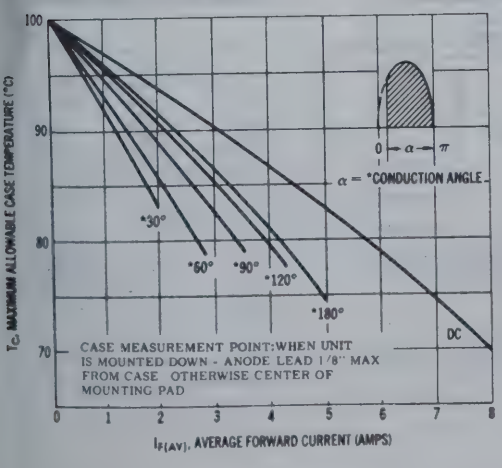
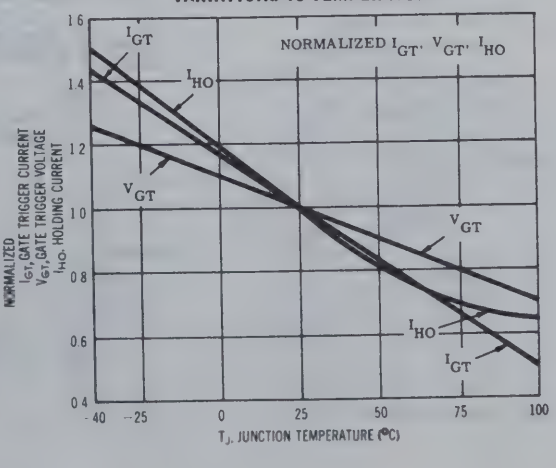
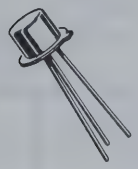


FIGURE 2 — TYPICAL PARAMETER VARIATIONS vs TEMPERATURE



2N4851 thru 2N4853 (SILICON)



CASE 22A
(TO-18 Modified)
Lead 3 connected to case

Silicon annular unijunction transistors designed for pulse and timing circuits, sensing circuits, and thyristor trigger circuits.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D*	300	mW
RMS Emitter Current	I_e	50	mA
Peak-Pulse Emitter Current **	i_e**	1.5	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage †	V_{B2B1}†	35	Volts
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Derate 3.0 mW/°C increase in ambient temperature.
** Duty cycle ≦ 1%, PRR = 10 PPS (see figure 6)
† Based upon power dissipation at T_A = 25°C

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

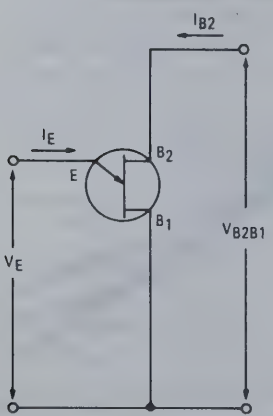


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES

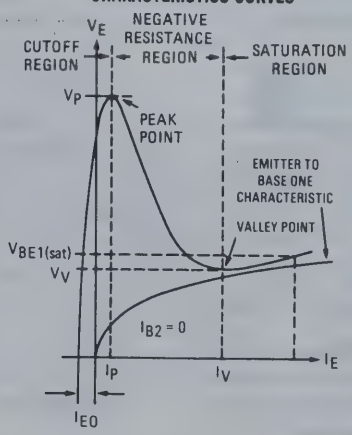
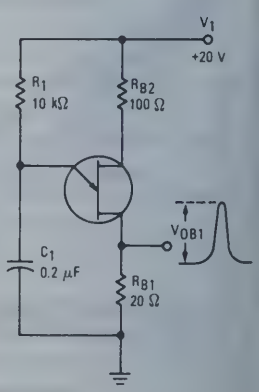


FIGURE 3 — V_{OB1} TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Figure No.	Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio* (V_{B2B1} = 10 V)	2N4851 2N4852, 2N4853	4, 8	η*	0.56 0.70	— —	0.75 0.85	—
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)		11, 12	R_{BB}	4.7	—	9.1	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65 to +125°C)		12	αR_{BB}	0.2	—	0.8	%/°C
Emitter Saturation Voltage** (V_{B2B1} = 10 V, I_E = 50 mA)			$V_{EB1(sat)}$**	—	2.5	—	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)			$I_{B2(mod)}$	—	15	—	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)	2N4851, 2N4852 2N4853	7	I_{EB2O}	— —	— —	0.1 0.05	μA
Peak-Point Emitter Current (V_{B2B1} = 25 V)	2N4851, 2N4852 2N4853	9, 10	I_P	— —	— —	2.0 0.4	μA
Valley-Point Current** (V_{B2B1} = 20 V, R_{B2} = 100 ohms)	2N4851 2N4852 2N4853	13, 14	I_V**	2.0 4.0 6.0	— — —	— — —	mA
Base-One Peak Pulse Voltage	2N4851 2N4852 2N4853	3, 17	V_{OB1}	3.0 5.0 6.0	— — —	— — —	Volts
Maximum Frequency of Oscillation		5	$f_{(max)}$	1.0	1.25	—	MHz

* η, intrinsic standoff ratio, is defined in terms of the peak-point voltage, V_P, by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is about 0.49 volt at 25 C @ I_F = 10 μA and decreases with temperature at about 2.5 mV/°C. The test circuit is shown in Figure 4. Components R_1, C_1, and the UJT form a relaxation oscillator; the remaining circuitry serves as a peak-voltage detector. The forward drop of Diode D_1 compensates for V_F. To use, the "cal" button is pushed, and R_3 is adjusted to make the current meter, M_1, read full scale. When the "cal" button is released, the value of η is read directly from the meter, if full scale on the meter reads 1.0.

** Use pulse techniques: PW = 300 μs, duty cycle ≤ 2.0% to avoid internal heating, which may result in erroneous readings.

FIGURE 4 — η TEST CIRCUIT

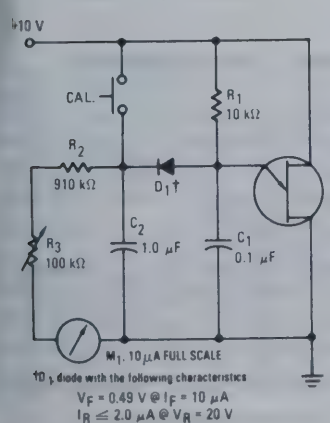


FIGURE 5 — $f_{(max)}$ TEST CIRCUIT

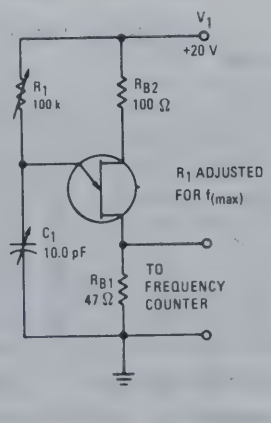
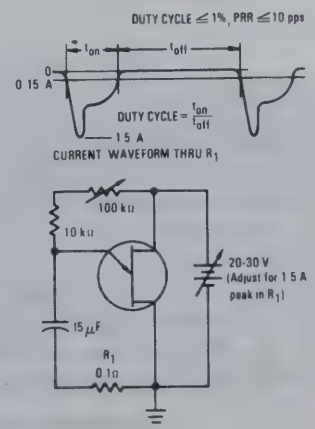


FIGURE 6 — PRR TEST CIRCUIT AND WAVEFORM



TYPICAL CHARACTERISTICS

FIGURE 7 — EMITTER REVERSE CURRENT

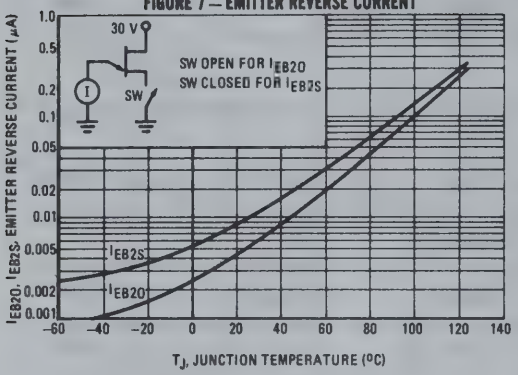
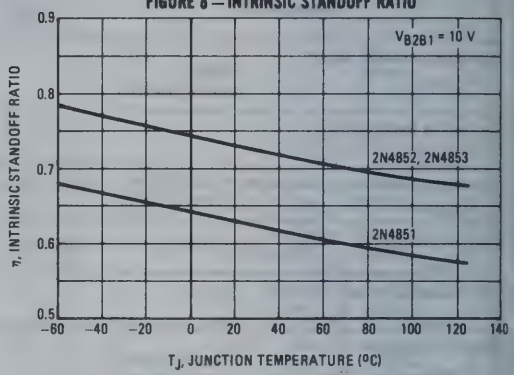


FIGURE 8 — INTRINSIC STANDOFF RATIO



PEAK POINT CURRENT

FIGURE 9 — EFFECT OF VOLTAGE

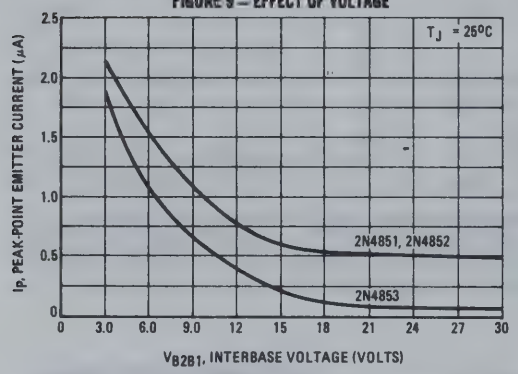
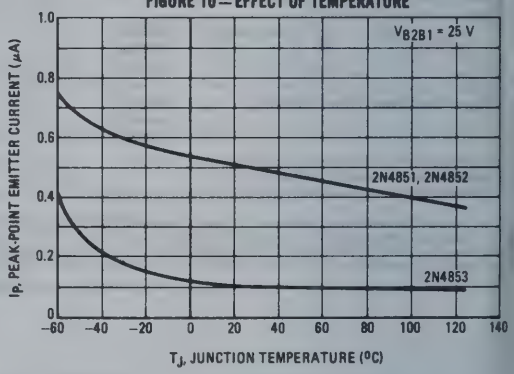


FIGURE 10 — EFFECT OF TEMPERATURE



INTERBASE RESISTANCE

FIGURE 11 — EFFECT OF VOLTAGE

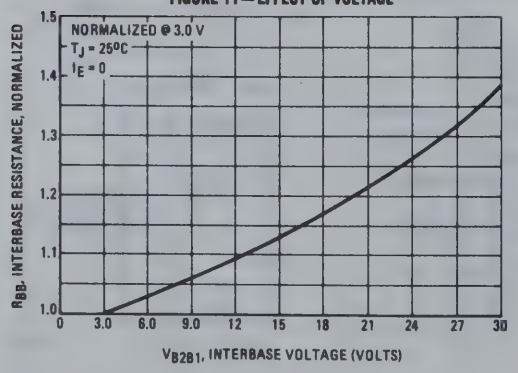
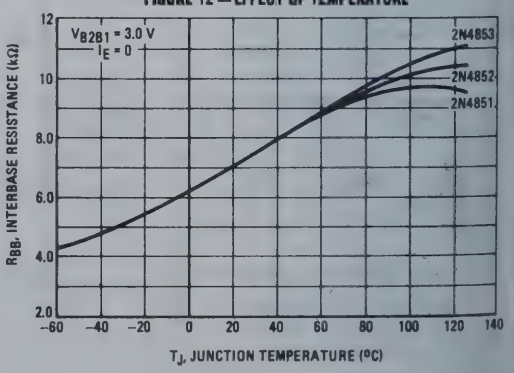


FIGURE 12 — EFFECT OF TEMPERATURE



TYPICAL CHARACTERISTICS

VALLEY CURRENT

FIGURE 13 — EFFECT OF VOLTAGE

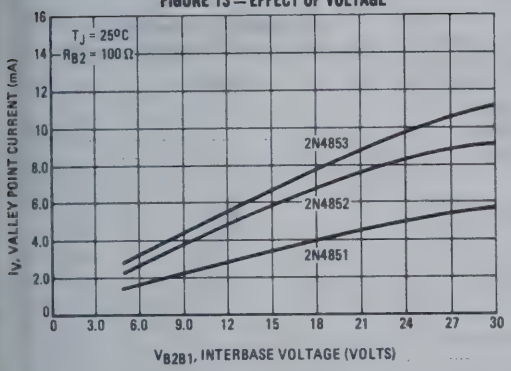
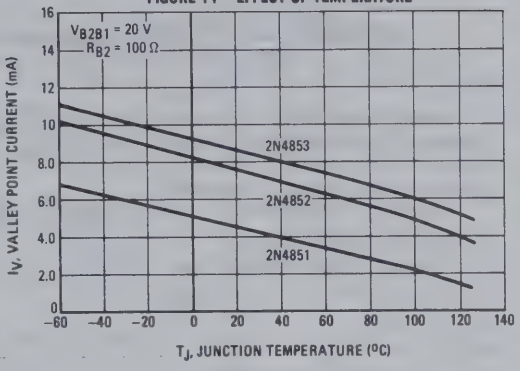


FIGURE 14 — EFFECT OF TEMPERATURE



VALLEY VOLTAGE

FIGURE 15 — EFFECT OF VOLTAGE

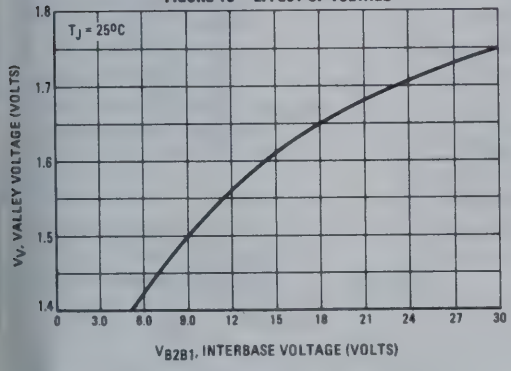


FIGURE 16 — EFFECT OF TEMPERATURE

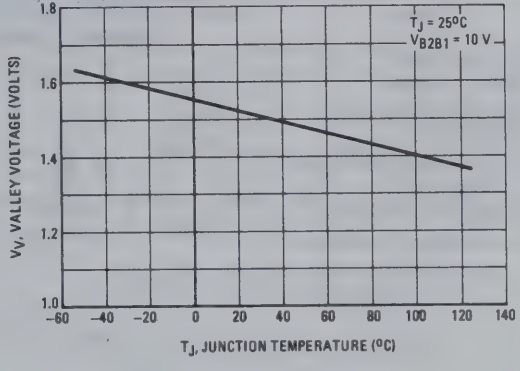
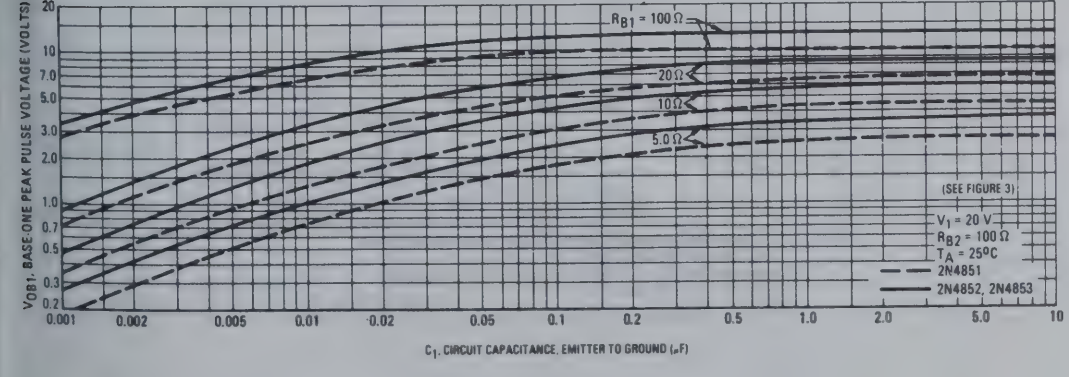


FIGURE 17 — OUTPUT VOLTAGE



2N4856, A (SILICON)
thru
2N4861, A

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) symmetrical Field-Effect transistors designed for low-power switching and chopper applications.

- Low Drain-Source "ON" Resistance –
  $r_{ds(on)}$ = 25 Ohms (Max) @ f = 1.0 kHz – 2N4856,A, 2N4859,A
- Low Drain Cutoff Current –
  $I_{D(off)}$ = 250 pAdc (Max) @ V_{DS} = 15 Vdc

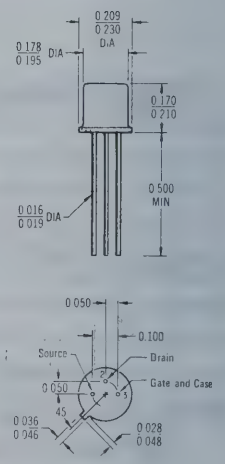
N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS
(Type A)



*MAXIMUM RATINGS

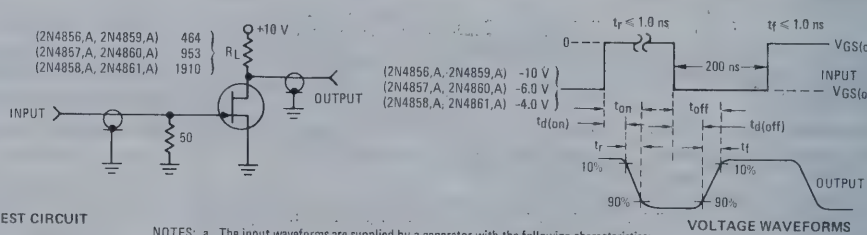
Rating	Symbol	2N4856,A 2N4857,A 2N4858,A	2N4859,A 2N4860,A 2N4861,A	Unit
Drain-Gate Voltage	V_{DG}	+40	+30	Vdc
Drain-Source Voltage	V_{DS}	+40	+30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	-40	-30	Vdc
Forward Gate Current	I_{GF}	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4		mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.



CASE 22 (4)
(TO-18)

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



NOTES: a. The input waveforms are supplied by a generator with the following characteristics:
Z_{out} = 50 ohms, Duty Cycle ≈ 2.0%.
b. Waveforms are monitored on an oscilloscope with the following characteristics:
$t_r \leq 0.75$ ns, $R_{in} \geq 1.0$ megohm, $C_{in} \leq 2.5$ pF.

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

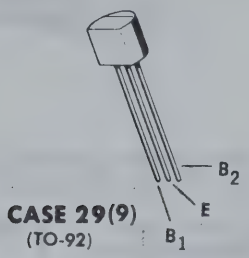
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	2N4856,A,2N4857,A,2N4858,A	$V_{(BR)GSS}$	-40	–	Vdc
	2N4859,A,2N4860,A,2N4861,A		-30	–	
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	2N4856,A,2N4859,A	$V_{GS(off)}$	-4.0	-10	Vdc
	2N4857,A,2N4860,A		-2.0	-6.0	
	2N4858,A,2N4861,A		-0.8	-4.0	
Gate Reverse Current		I_{GSS}			
(V_{GS} = -20 Vdc, V_{DS} = 0)	2N4856,A,2N4857,A,2N4858,A		–	0.25	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0)	2N4859,A,2N4860,A,2N4861,A		–	0.25	
(V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 150°C)	2N4856,A,2N4857,A,2N4858,A		–	0.5	μAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 150°C)	2N4859,A,2N4860,A,2N4861,A		–	0.5	
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = 15 Vdc, V_{GS} = -10 Vdc)			–	0.25	nAdc
(V_{DS} = 15 Vdc, V_{GS} = -10 Vdc, T_A = 150°C)				0.5	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1)	2N4856,A,2N4859,A	I_{DSS}	50	–	mAdc
(V_{DS} = 15 Vdc, V_{GS} = 0)	2N4857,A,2N4860,A		20	100	
	2N4858,A,2N4861,A		8.0	80	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 20 mAdc, V_{GS} = 0)	2N4856,A,2N4859,A		–	0.75	
(I_D = 10 mAdc, V_{GS} = 0)	2N4857,A,2N4860,A			0.5	
(I_D = 5.0 mAdc, V_{GS} = 0)	2N4858,A,2N4861,A		–	0.5	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N4856,A,2N4859,A			25	
	2N4857,A,2N4860,A		–	40	
	2N4858,A,2N4861,A		–	60	
Input Capacitance (V_{DS} = 0, V_{GS} = -10 Vdc, f = 1.0 MHz)	2N4856 thru 2N4861	C_{iss}	–	18	pF
	2N4856 A thru 2N4861 A			10	
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 0, V_{GS} = -10 Vdc, f = 1.0 MHz)	2N4856 thru 2N4861		–	8.0	
	2N4856 A,2N4859 A		–	4.0	
	2N4857 A,2N4858 A,2N4860 A,2N4861 A			3.5	
SWITCHING CHARACTERISTICS (See Figure 1) (Note 2)					
Turn-On Delay Time	Conditions for 2N4856,A, 2N4859,A:				
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = -10 Vdc)	2N4856, 2N4859	$t_{d(on)}$		6.0	ns
		2N4856A, 2N4859A			5.0	
		2N4857, 2N4860			6.0	
		2N4857A, 2N4860A			6.0	
		2N4858, 2N4861		–	10	
		2N4858A, 2N4861A			8.0	
Rise Time	Conditions for 2N4857,A, 2N4860,A:					
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = -6.0 Vdc)	2N4856,A, 2N4859,A	t_r	–	3.0	ns
		2N4857,A, 2N4860,A		–	4.0	
		2N4858, 2N4861			10	
		2N4858A, 2N4861A			8.0	
Turn-Off Time	Conditions for 2N4858,A, 2N4861,A:					
	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = -4.0 Vdc)	2N4856, 2N4859	t_{off}		25	ns
		2N4856A, 2N4859A			20	
		2N4857, 2N4860			50	
		2N4857A, 2N4860A		–	40	
		2N4858, 2N4861			100	
		2N4858A, 2N4861A		–	80	

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

Note 2: The $I_{D(on)}$ values are nominal; exact values vary slightly with transistor parameters.

2N4870 (SILICON)
2N4871



CASE 29(9)
(TO-92)

PN unijunction transistors designed for use in pulse and timing circuits, sensing circuits and thyristor trigger circuits.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D*	300	mW
RMS Emitter Current	I_e	50	mA
Peak-Pulse Emitter Current**	i_e**	1.5	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage†	V_{B2B1}†	35	Volts
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*Derate 3.0 mW/°C increase in ambient temperature.
**Duty cycle ≦ 1%, PRR = 10 PPS (see Figure 5).
†Based upon power dissipation at T_A = 25°C.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

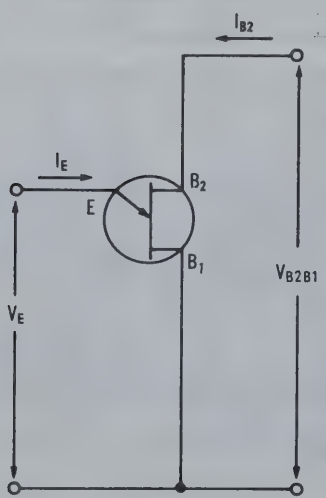
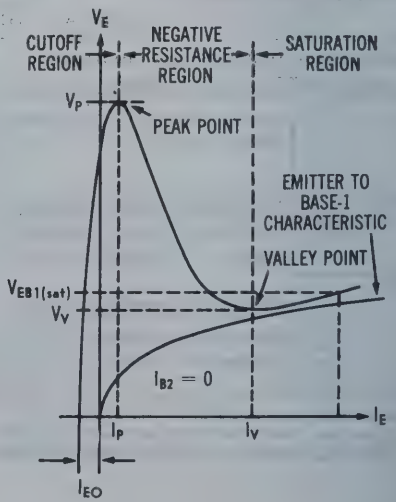


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio* (V_{B2B1} = 10 V)	2N4870 2N4871	4, 7	η*	0.56 0.70	- -	0.75 0.85	-
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)		10, 11	R_{BB}	4.0	6.0	9.1	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65 to +125°C)		11	αR_{BB}	0.10	-	0.90	%/°C
Emitter Saturation Voltage** (V_{B2B1} = 10 V, I_E = 50 mA)			$V_{EB1(sat)}$**	-	2.5	-	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)			$I_{B2(mod)}$	-	15	-	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)		6	I_{EB2O}	-	0.005	1.0	μA
Peak-Point Emitter Current (V_{B2B1} = 25 V)		8, 9	I_P	-	1.0	5.0	μA
Valley-Point Current** (V_{B2B1} = 20 V, R_{B2} = 100 ohms)	2N4870 2N4871	12, 13	I_V**	2.0 4.0	5.0 7.0	- -	mA
Base-One Peak Pulse Voltage	2N4870 2N4871	3, 16	V_{OB1}	3.0 5.0	6.0 8.0	- -	Volts

* η Intrinsic standoff ratio, is defined in terms of peak-point voltage, V_P, by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is approximately 0.49 volt at 25°C @ I_F = 10 μA and decreases with temperature at approximately 2.5 mV/°C. The test circuit is shown in Figure 4. Components R_1, C_1, and the UJT form a relaxation oscillator, the remaining circuitry serves as a peak-voltage detector. The forward drop of Diode D_1 compensates for V_F. To use, the "cal" button is pushed, and R_3 is adjusted to make the current meter, M_1, read full scale. When the "cal" button is released, the value of η is read directly from the meter, if full scale on the meter reads 1.0.

** Use pulse techniques: PW ≈ 300 μs, duty cycle ≦ 2.0% to avoid internal heating, which may result in erroneous readings.

FIGURE 3 — V_{OB1} TEST CIRCUIT

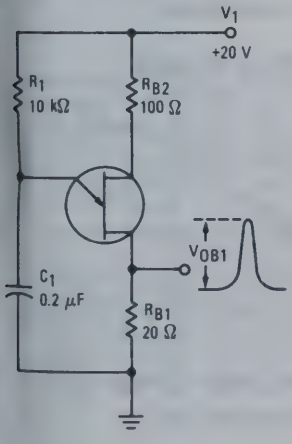
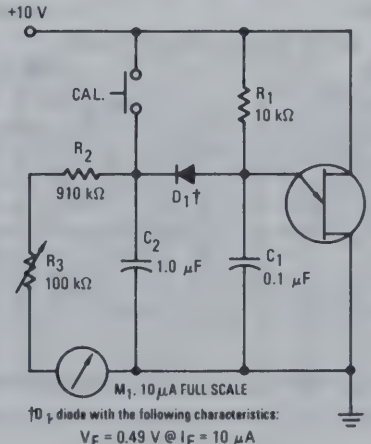
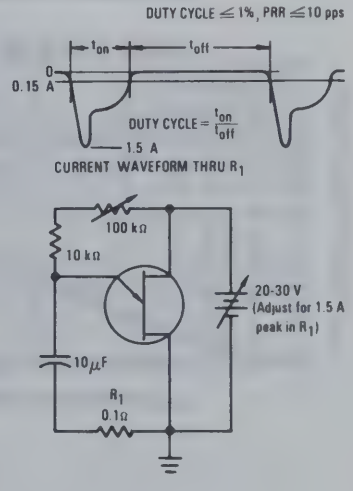


FIGURE 4 — η TEST CIRCUIT



†D1 diode with the following characteristics:
V_F = 0.49 V @ I_F = 10 μA
I_R ≦ 2.0 μA @ V_R = 20 V

FIGURE 5 — PRR TEST CIRCUIT AND WAVEFORM



TYPICAL CHARACTERISTICS

FIGURE 6 — EMITTER REVERSE CURRENT

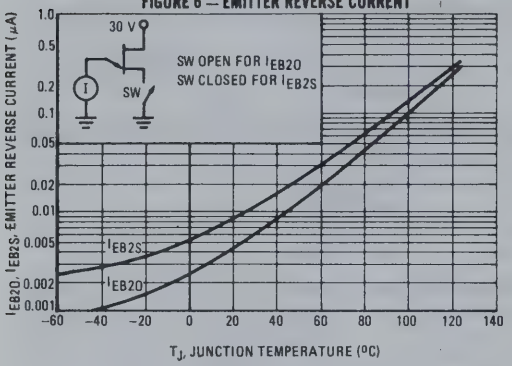
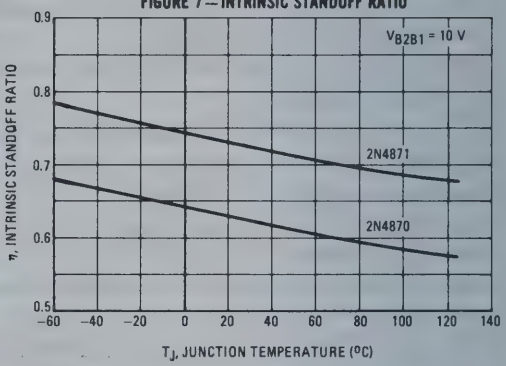


FIGURE 7 — INTRINSIC STANDOFF RATIO



PEAK POINT CURRENT

FIGURE 8 — EFFECT OF VOLTAGE

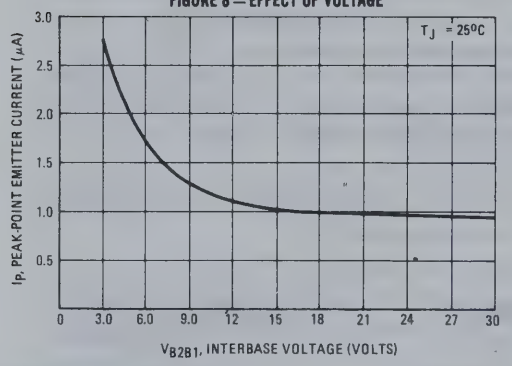
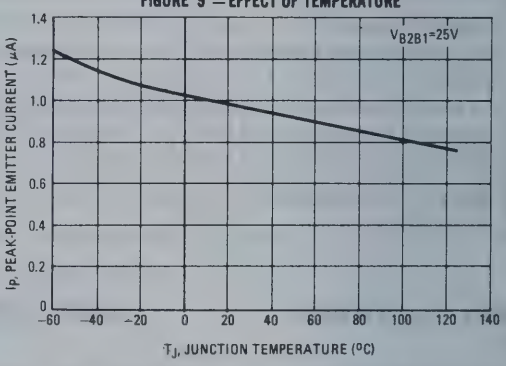


FIGURE 9 — EFFECT OF TEMPERATURE



INTERBASE RESISTANCE

FIGURE 10 — EFFECT OF VOLTAGE

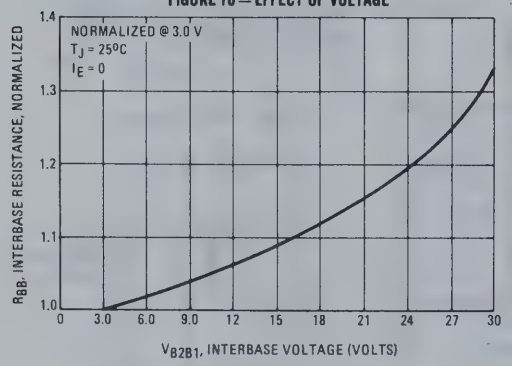
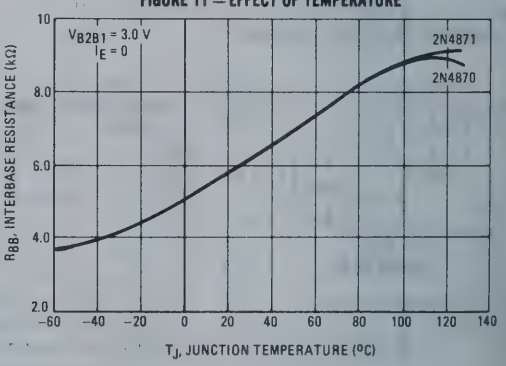


FIGURE 11 — EFFECT OF TEMPERATURE



TYPICAL CHARACTERISTICS

VALLEY CURRENT

FIGURE 12 — EFFECT OF VOLTAGE

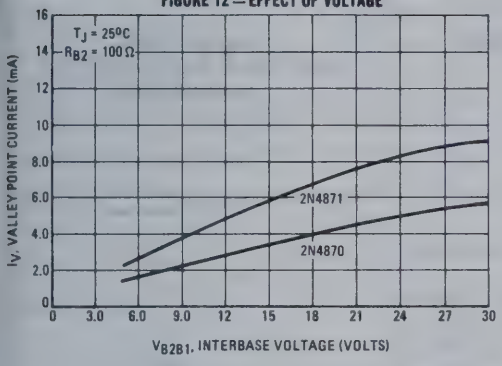
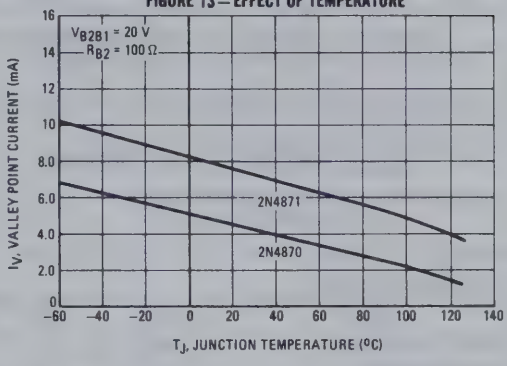


FIGURE 13 — EFFECT OF TEMPERATURE



VALLEY VOLTAGE

FIGURE 14 — EFFECT OF VOLTAGE

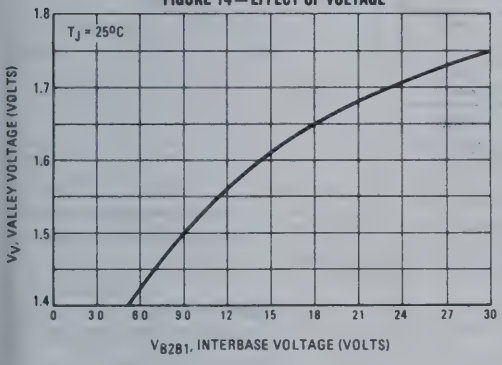


FIGURE 15 — EFFECT OF TEMPERATURE

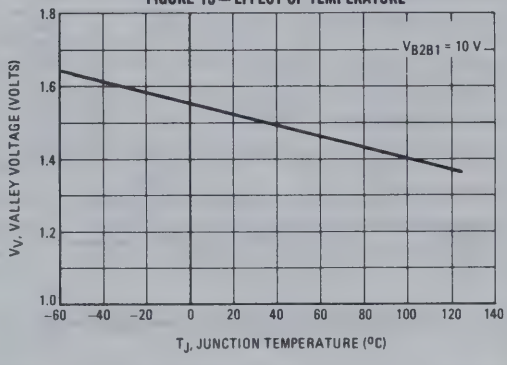
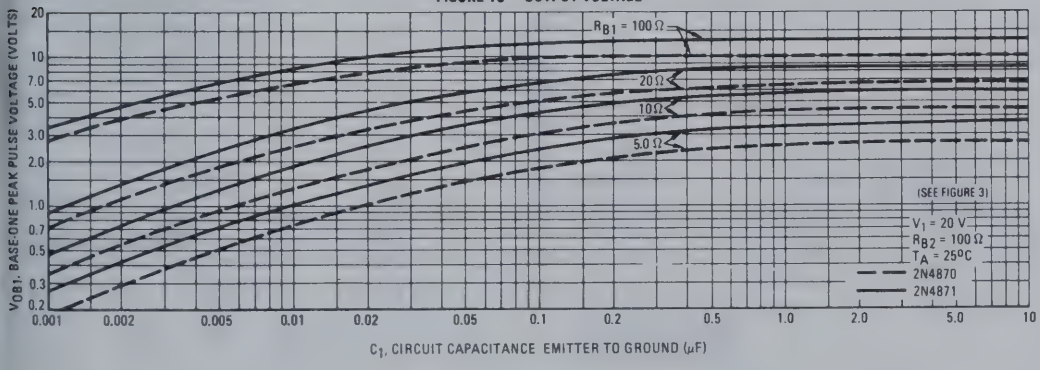


FIGURE 16 — OUTPUT VOLTAGE



2N4890 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for applications in audio-output feedback control, and general, medium-current switching and amplifier circuits.

- Direct Complement to NPN 2N3053
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.12 Vdc (Typ) @ I_C = 150 mAdc
- High Current-Gain—Bandwidth Product — f_T = 280 (Typ) @ I_C = 50 mAdc

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTOR

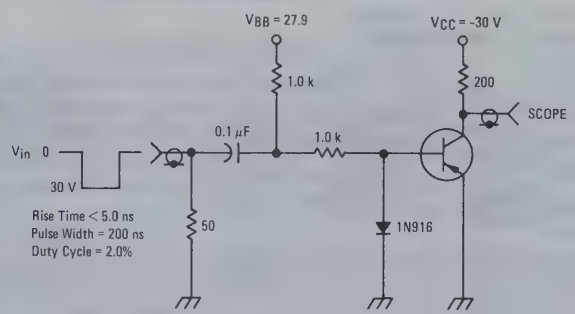


*MAXIMUM RATINGS

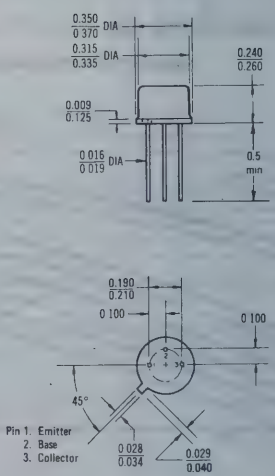
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	500 700**	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.
**Motorola Guarantees this Data in Addition to JEDEC Registered Data.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



SCOPE CHARACTERISTICS
IMPEDANCE 10 MEG MIN
CAPACITANCE 7.0 pF MAX



CASE 79 (1)
(TO-39)

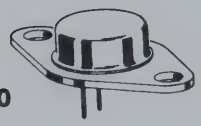
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 100 μAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, R_{BE} = 10 ohms)	BV_{CER}	50	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	I_{CEX}	–	–	0.25	μAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	I_{BL}	–	–	0.25	μAdc
ON CHARACTERISTICS					
DC Current Gain (Note 1) (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	h_{FE}	25	130	–	–
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		50	140	250	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.12	1.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	0.82	1.7	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	$V_{BE(on)}$	–	0.74	1.7	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100	280	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	9.0	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	60	80	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.8 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_d	–	15	50	ns
Rise Time		t_r	–	20	50	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 1)	t_s	–	110	200	ns
Fall Time		t_f	–	20	70	ns

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

2N4898 thru 2N4900 (SILICON)



CASE 80
(TO-66)

Medium-power PNP silicon transistors designed for driver circuits, switching, and amplifier applications. Complement to NPN 2N4910 thru 2N4912.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N4898	2N4899	2N4900	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous *	I_C*	← 1.0 →			Adc
		← 4.0 →			
Base Current	I_B	← 1.0 →			Adc
Total Device Dissipation $T_C = 25°C$	P_D	← 25 →			Watts
Derate above 25°C		← 0.143 →			W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

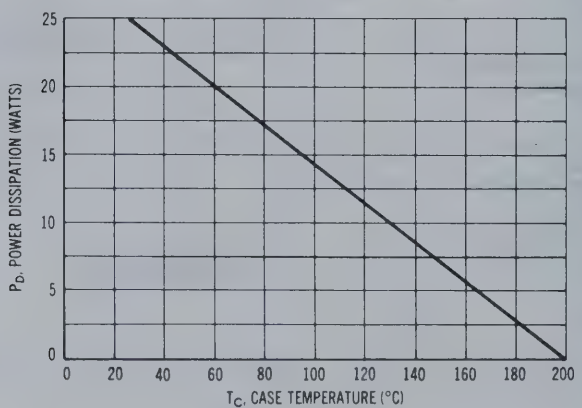
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	7.0	°C/W

* The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements.

The 4.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 0.1 Adc, I_B = 0) 2N4898	-	$BV_{CEO(sus)}$*	40	-	Vdc
2N4899			60	-	
2N4900			80	-	
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0) 2N4898		I_{CEO}	-	0.5	mAdc
(V_{CE} = 30 Vdc, I_B = 0) 2N4899			-	0.5	
(V_{CE} = 40 Vdc, I_B = 0) 2N4900			-	0.5	
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc)	12	I_{CEX}	-	0.1	mAdc
(V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	-	I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	-	I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	8	h_{FE}*	40	-	-
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			20	100	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			10	-	
Collector-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	9, 11, 13	$V_{CE(sat)}$*	-	0.6	Vdc
Base-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	11, 13	$V_{BE(sat)}$*	-	1.3	Vdc
Base-Emitter On Voltage* (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	11, 13	$V_{BE(on)}$*	-	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)	-	f_T	3.0	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	-	C_{ob}	-	100	pF
Small-Signal Current Gain (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	-	h_{fe}	25	-	-

* Pulse Test: PW ≈ 300 μs, Duty Cycle ≈ 2.0%

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

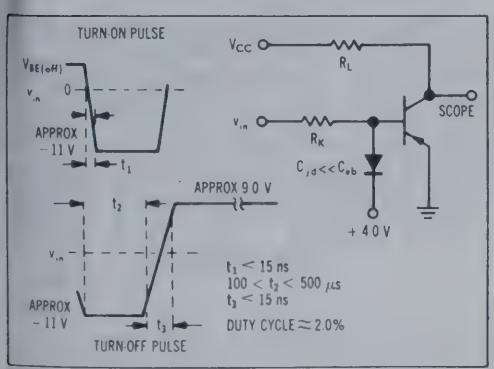


FIGURE 3 — TURN-ON TIME

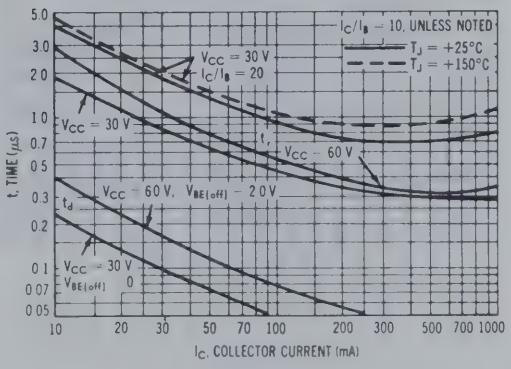


FIGURE 4 — THERMAL RESPONSE

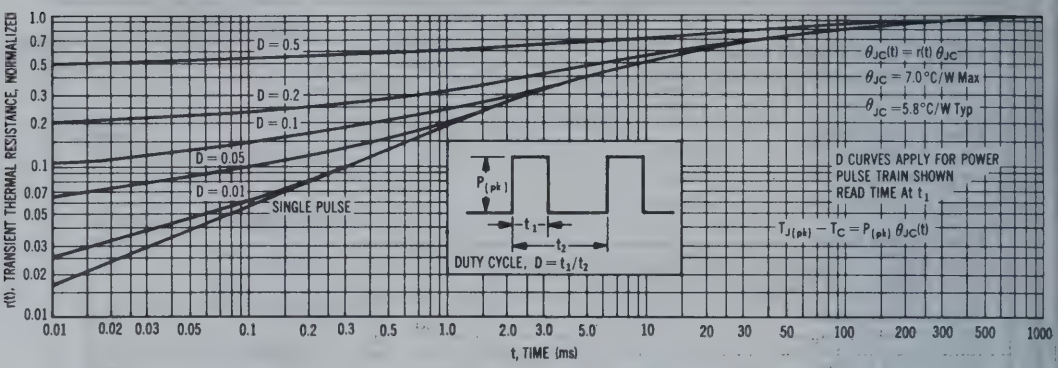
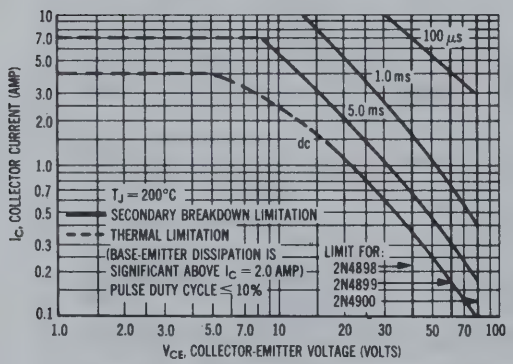


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREA



The safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor which must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 5 is based upon $T_{J(pk)} = 200°C$; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power which can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 — STORAGE TIME

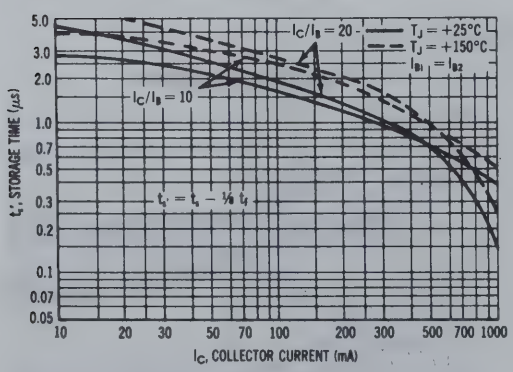


FIGURE 7 — FALL TIME

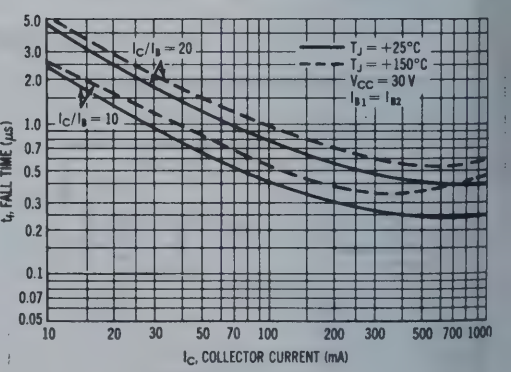


FIGURE 8 — CURRENT GAIN

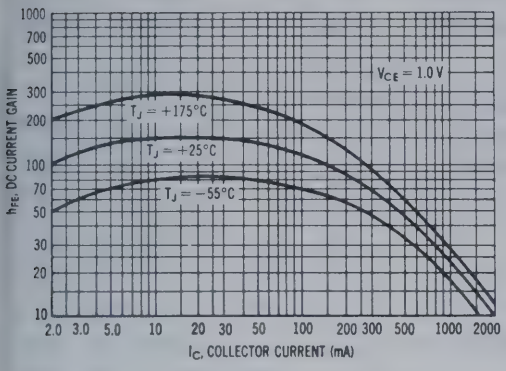


FIGURE 9 — COLLECTOR SATURATION REGION

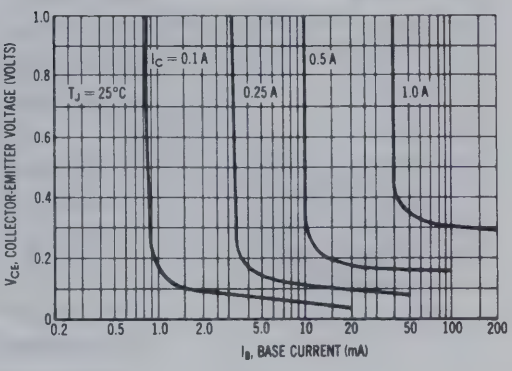


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

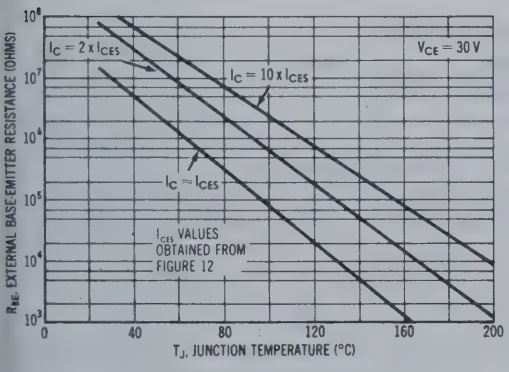


FIGURE 11 — "ON" VOLTAGE

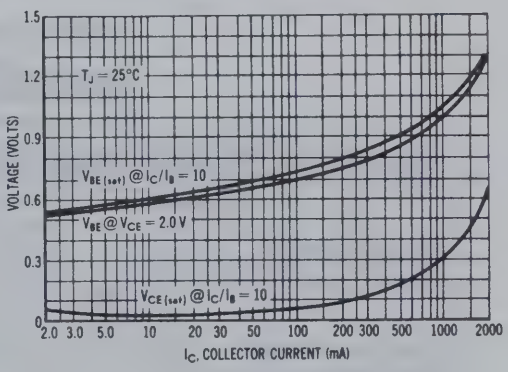


FIGURE 12 — COLLECTOR CUTOFF REGION

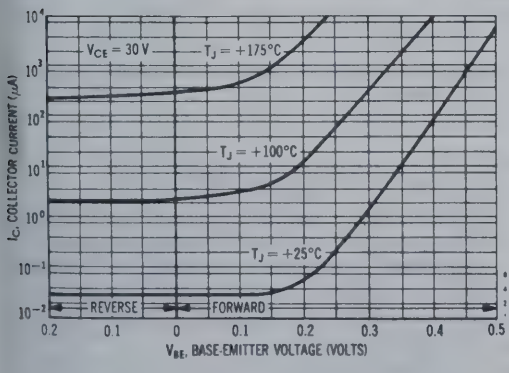
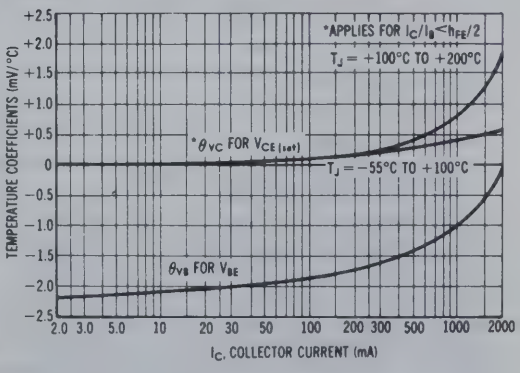
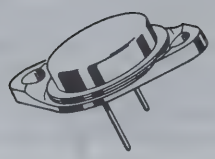


FIGURE 13 — TEMPERATURE COEFFICIENTS



2N4901 (SILICON)
2N4902
2N4903

PNP power transistors for use in power amplifier and switching circuits. Complement to NPN 2N5067, 2N5068, 2N5069.



CASE 11
(TO-3)

MAXIMUM RATINGS

Rating	Symbol	2N4901	2N4902	2N4903	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous	I_C	5.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation T_C = 25°C	P_D	87.5			Watts
Derate above 25°C		0.5			W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 0.2 Adc, I_B = 0) 2N4901 / 2N4902 / 2N4903	11	$V_{CEO(sus)}$*	40 / 60 / 80	- / - / -	Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)		I_{CEO}	-	1.0	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc) / (V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	5, 6	I_{CEX}	- / -	0.1 / 2.0	mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) / (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	1	h_{FE}*	20 / 7.0	80 / -	-
Collector-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc) / (I_C = 5.0 Adc, I_B = 1.0 Adc)	2, 3, 4	$V_{CE(sat)}$*	- / -	0.4 / 1.5	Vdc
Base-Emitter On Voltage* (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	3, 4	$V_{BE(on)}$*	-	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	-	MHz
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	-	-

* Pulse Test: PW = 300 μs, Duty Cycle ≈ 2.0%

FIGURE 1 — NORMALIZED DC CURRENT GAIN

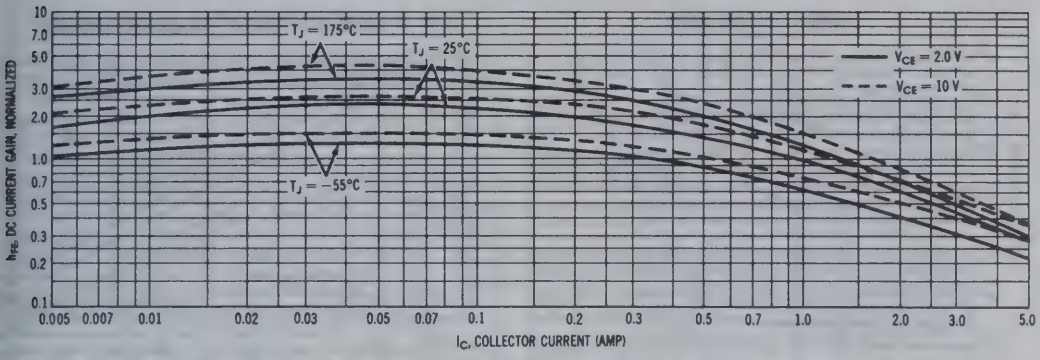


FIGURE 2 — COLLECTOR SATURATION REGION

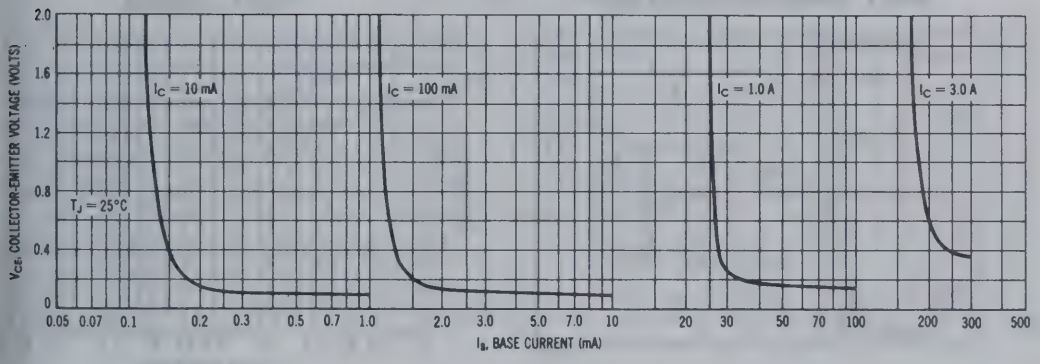


FIGURE 3 — "ON" VOLTAGE

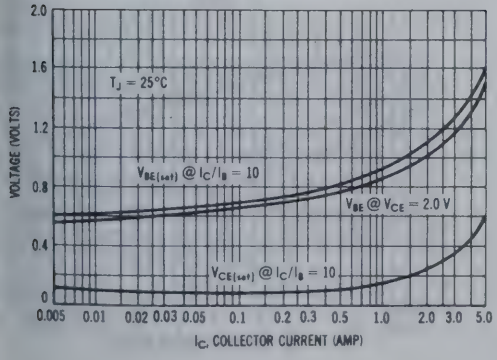
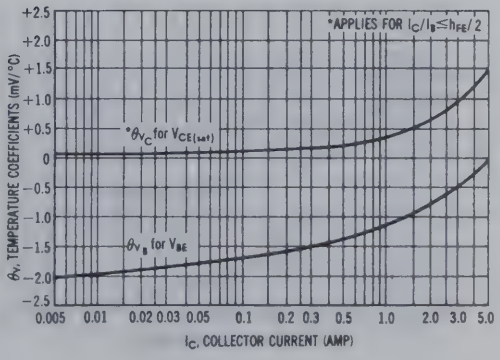


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 — CUT-OFF REGION

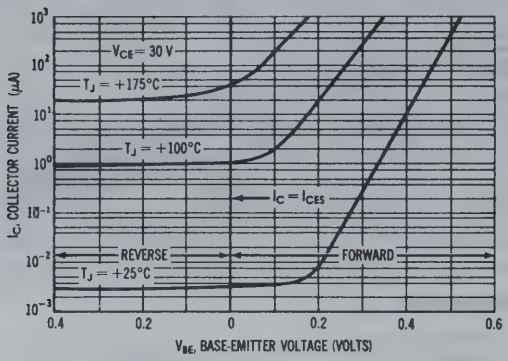


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

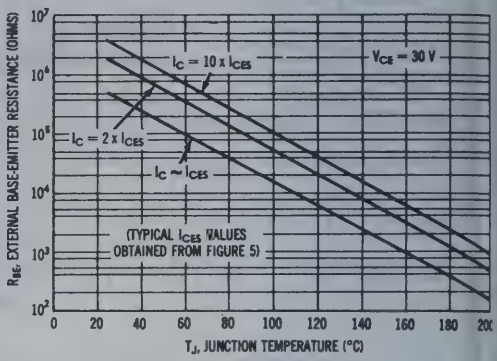


FIGURE 7 — SWITCHING TIME EQUIVALENT CIRCUIT

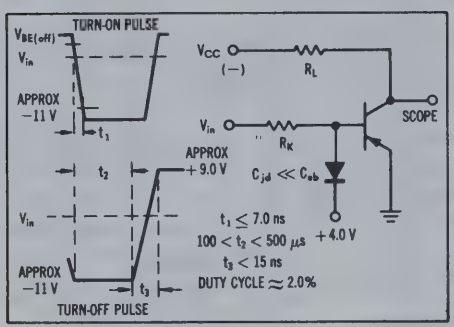


FIGURE 8 — CAPACITANCE

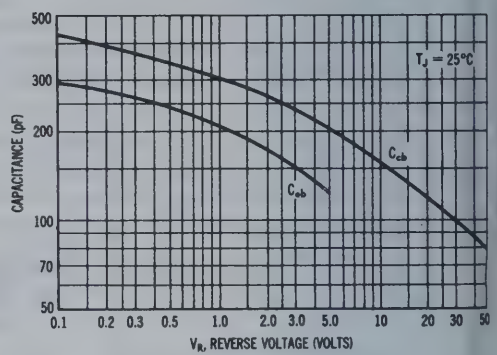


FIGURE 9 — TURN-ON TIME

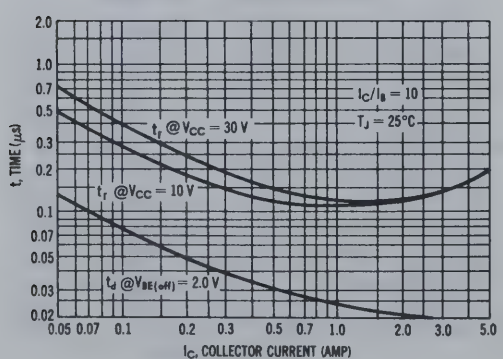
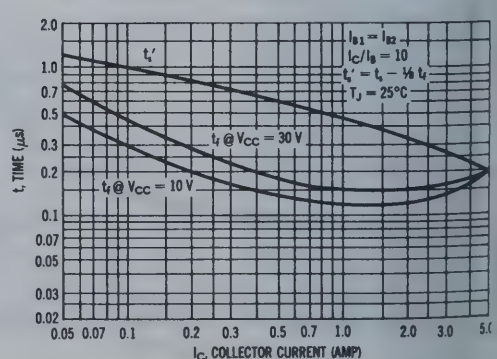
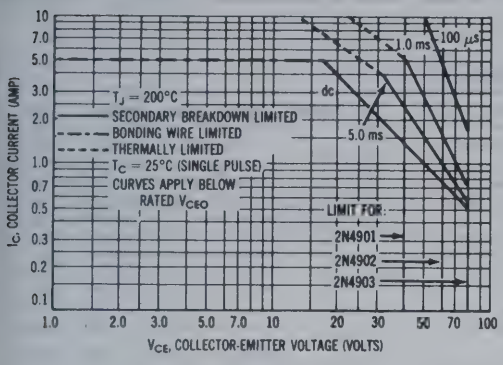


FIGURE 10 — TURN-OFF TIME



RATING AND THERMAL DATA

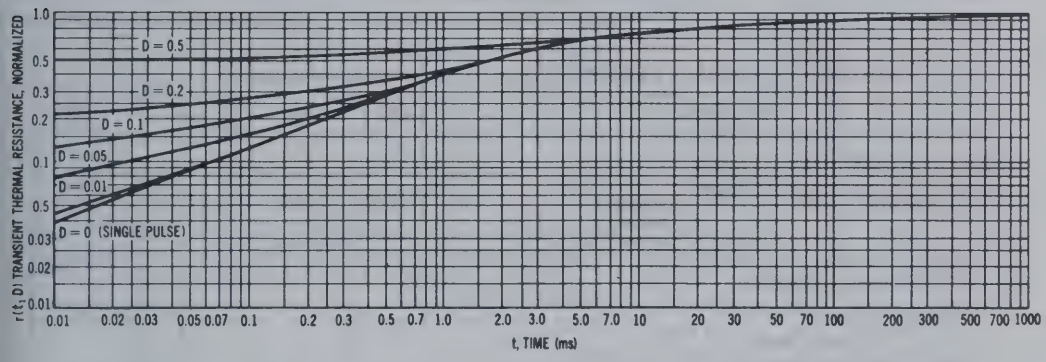
FIGURE 11 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

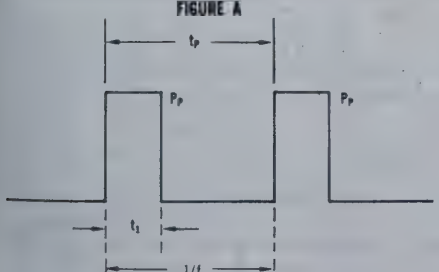
The data of Figure 11 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — TRANSIENT THERMAL RESISTANCE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 \cdot f = \frac{t_1}{t_p}$

PEAK PULSE POWER = P_p

A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC}.

Example:

The 2N4901 is dissipating 100 watts under the following conditions: t_1 = 0.1 ms, t_p = 0.5 ms. (D = 0.2)

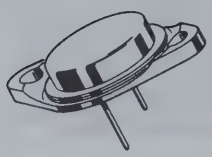
Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of r (t_1, D) is 0.27.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_p \times \theta_{JC} = 0.27 \times 100 \times 2.0 = 54°C$$

2N4904 (SILICON)
2N4905
2N4906

PNP power transistors for use in power amplifier and switching circuits. Complement to NPN 2N4913 thru 2N4915.



CASE 11
(TO-3)

MAXIMUM RATINGS

Rating	Symbol	2N4904	2N4905	2N4906	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous	I_C	5.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation $T_C = 25°C$	P_D	87.5			Watts
Derate above 25°C		0.5			W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 0.2 Adc, I_B = 0) 2N4904 / 2N4905 / 2N4906	11	$V_{CEO(sus)}$*	40 / 60 / 80	- / - / -	Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)		I_{CEO}	-	1.0	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc)	5, 6	I_{CEX}	-	0.1	mAdc
(V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)			-	2.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 2.5 Adc, V_{CE} = 2.0 Vdc)	1	h_{FE}*	25	100	-
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			7.0	-	
Collector-Emitter Saturation Voltage* (I_C = 2.5 Adc, I_B = 0.25 Adc)	2, 3, 4	$V_{CE(sat)}$*	-	1.0	Vdc
(I_C = 5.0 Adc, I_B = 1.0 Adc)			-	1.5	
Base-Emitter On Voltage* (I_C = 2.5 Adc, V_{CE} = 2.0 Vdc)	3, 4	$V_{BE(on)}$*	-	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	-	MHz
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	40	-	

* Pulse Test: PW = 300 μs, Duty Cycle ≈ 2.0%

FIGURE 1 — NORMALIZED DC CURRENT GAIN

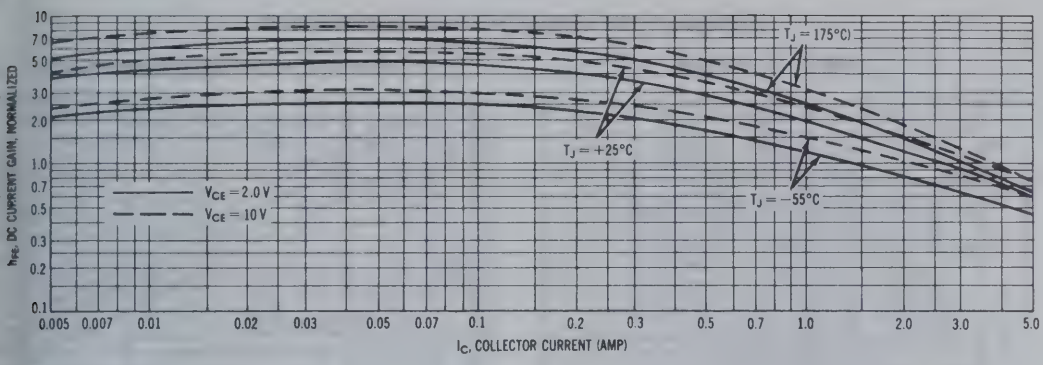


FIGURE 2 — COLLECTOR SATURATION REGION

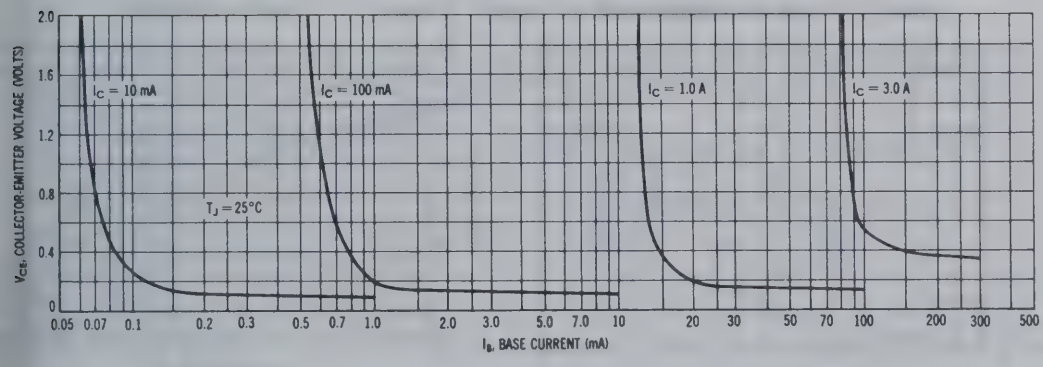


FIGURE 3 — "ON" VOLTAGE

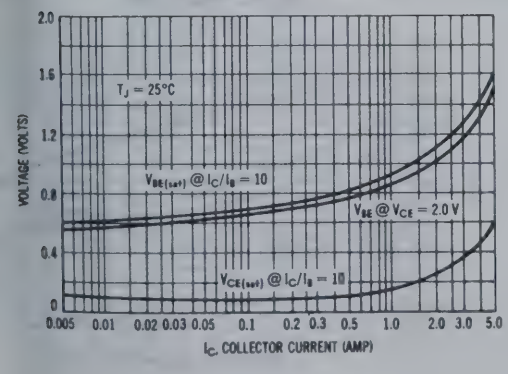
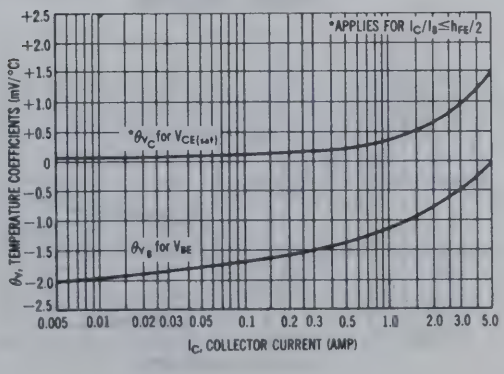


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 — CUT-OFF REGION

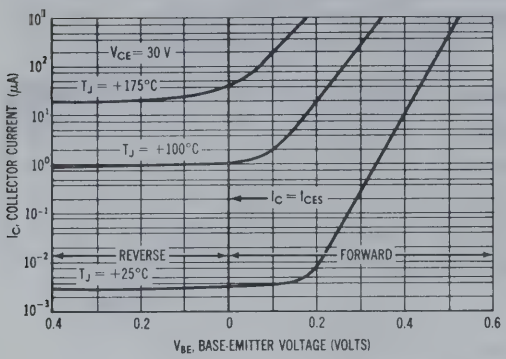


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

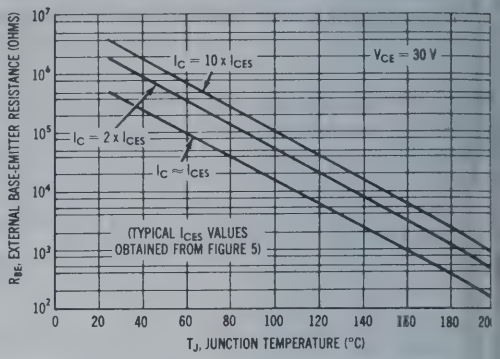


FIGURE 7 — SWITCHING TIME EQUIVALENT CIRCUIT

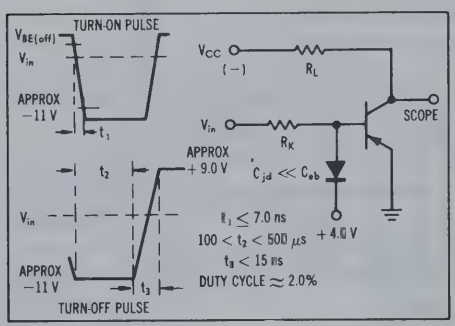


FIGURE 8 — CAPACITANCE

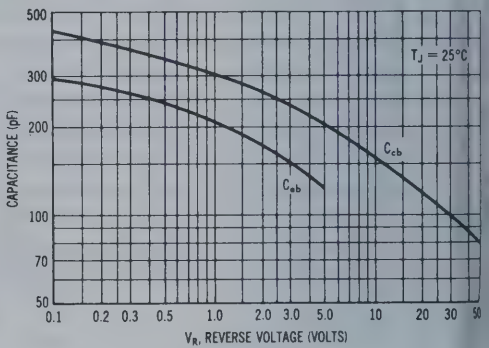


FIGURE 9 — TURN-ON TIME

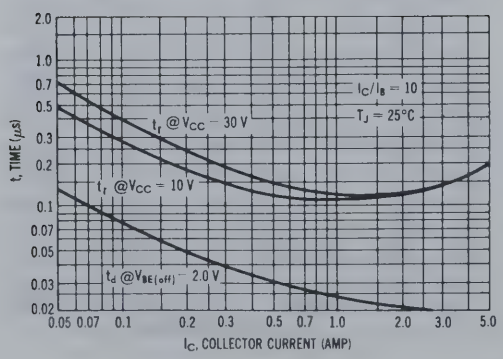
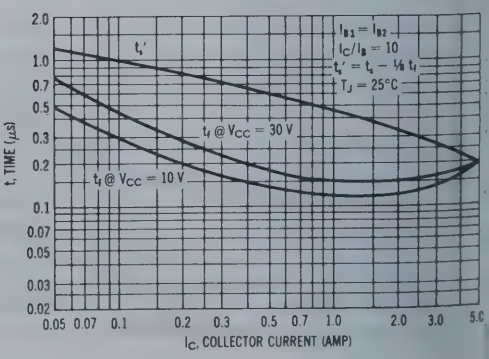
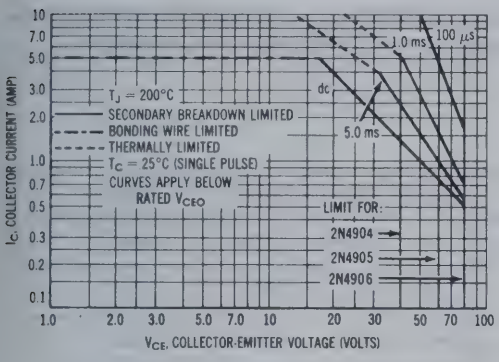


FIGURE 10 — TURN-OFF TIME



RATING AND THERMAL DATA

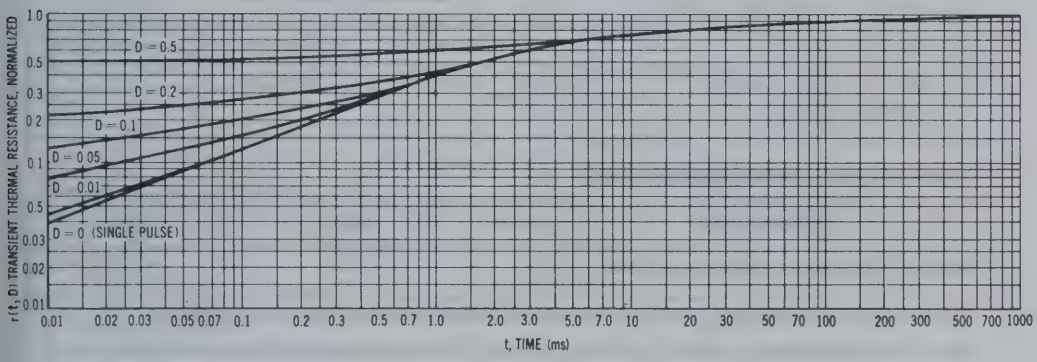
FIGURE 11 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

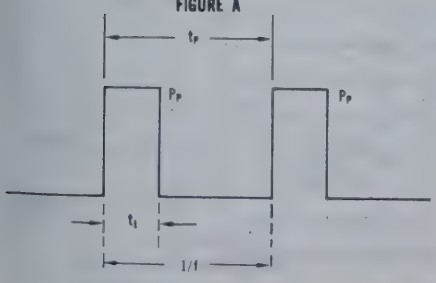
The data of Figure 11 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — TRANSIENT THERMAL RESISTANCE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 \cdot f = \frac{t_1}{t_p}$

PEAK PULSE POWER = P_p

A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC}.

Example:

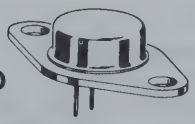
The 2N4904 is dissipating 100 watts under the following conditions: t_1 = 0.1 ms, t_p = 0.5 ms. (D = 0.2)

Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of $r(t_1, D)$ is 0.27.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_p \times \theta_{JC} = 0.27 \times 100 \times 2.0 = 54°C$$

2N4910 thru 2N4912 (SILICON)



CASE 80
(TO-66)

Medium-power NPN silicon transistors designed for driver circuits, switching, and amplifier applications. Complement to PNP 2N4898 thru 2N4900.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N4910	2N4911	2N4912	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous*	I_C*	← 1.0 → ← 4.0 →			Adc
Base Current — Continuous	I_B	← 1.0 →			Adc
Total Device Dissipation T_C = 25°C	P_D	← 25 →			Watts
Derate above 25°C		← 0.143 →			mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

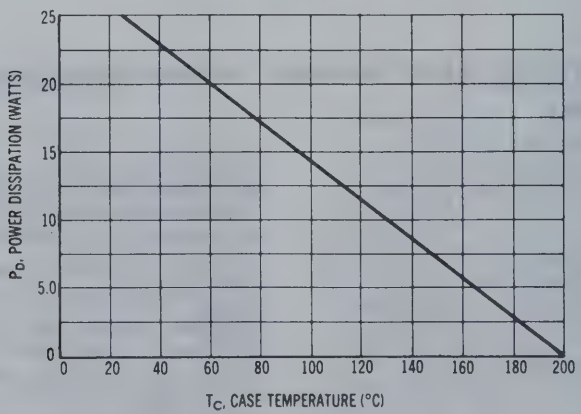
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	7.0	°C/W

* The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements.

The 4.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 0.1 Adc, I_B = 0) 2N4910	-	$BV_{CEO(sus)}$*	40	-	Vdc
2N4911			60	-	
2N4912			80	-	
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0) 2N4910	-	I_{CEO}	-	0.5	mAdc
(V_{CE} = 30 Vdc, I_B = 0) 2N4911			-	0.5	
(V_{CE} = 40 Vdc, I_B = 0) 2N4912			-	0.5	
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)	12	I_{CEX}	-	0.1	mAdc
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	-	I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	-	I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	8	h_{FE}*	40	-	-
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			20	100	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			10	-	
Collector-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	9, 11, 13	$V_{CE(sat)}$*	-	0.6	Vdc
Base-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	11, 13	$V_{BE(sat)}$*	-	1.3	Vdc
Base-Emitter On Voltage* (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	11, 13	$V_{BE(on)}$*	-	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)	-	f_T	3.0	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	-	C_{ob}	-	100	pF
Small-Signal Current Gain (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	-	h_{fe}	25	-	

* Pulse Test: PW ≈ 300 μs, Duty Cycle ≈ 2.0%

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

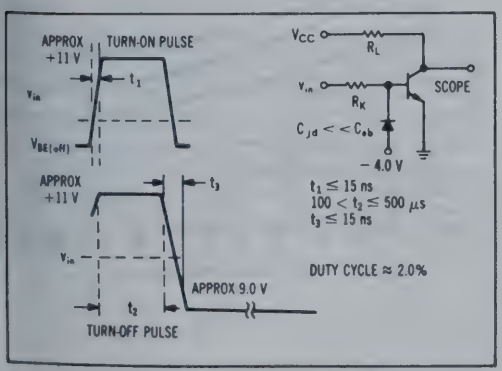


FIGURE 3 — TURN-ON TIME

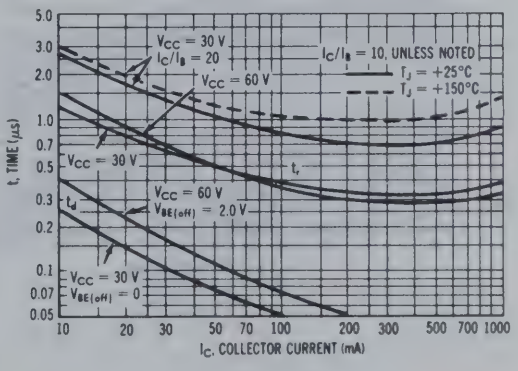


FIGURE 4 — THERMAL RESPONSE

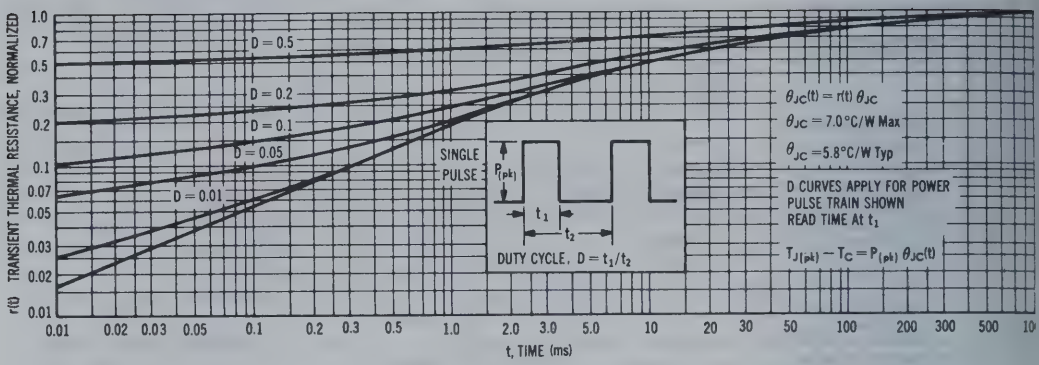
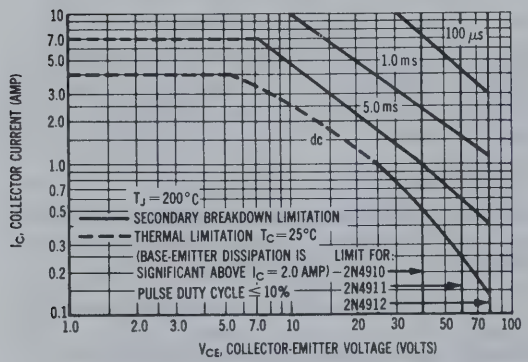


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 — STORAGE TIME

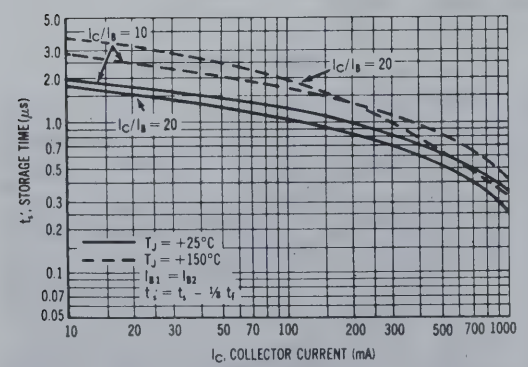
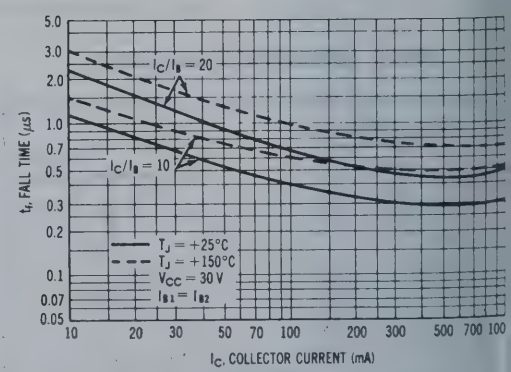


FIGURE 7 — FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 8 — CURRENT GAIN

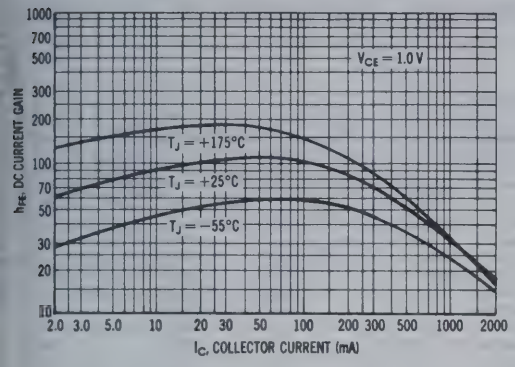


FIGURE 9 — COLLECTOR SATURATION REGION

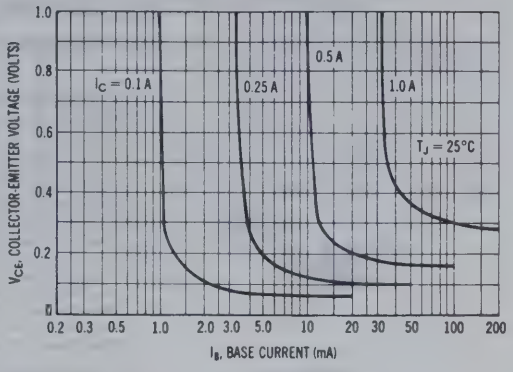


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

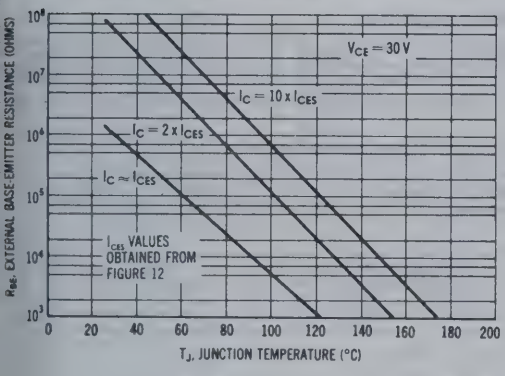


FIGURE 11 — "ON" VOLTAGE

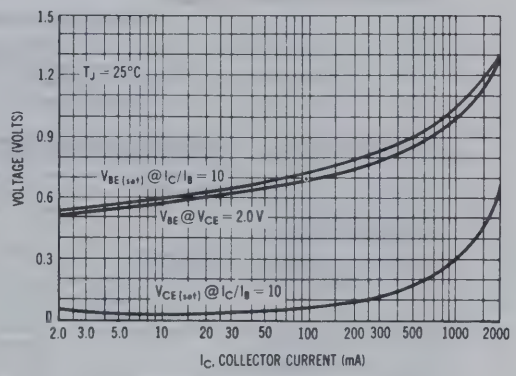


FIGURE 12 — COLLECTOR CUTOFF REGION

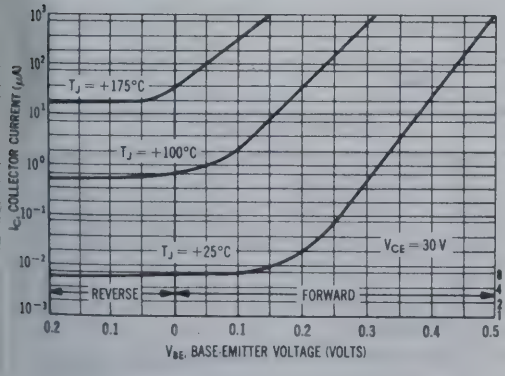
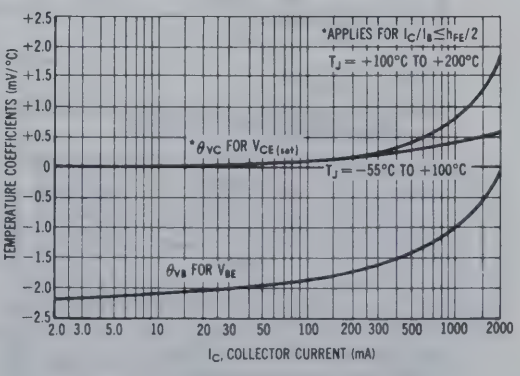
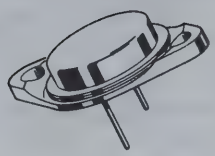


FIGURE 13 — TEMPERATURE COEFFICIENTS



2N4913 (SILICON)
2N4914
2N4915

NPN power transistors for use in power amplifier and switching circuits. Complement to PNP 2N4904 thru 2N4906.



CASE 11
(TO-3)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N4913	2N4914	2N4915	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous	I_C	5.0			Adc
Base Current - Continuous	I_B	1.0			Adc
Total Device Dissipation @ $T_C = 25°C$	P_D	87.5			Watts
Derate above 25°C		0.5			W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 0.2 Adc, I_B = 0) 2N4913	11	$BV_{CEO(sus)}$*	40	-	Vdc
2N2914			60	-	
2N4915			80	-	
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)		I_{CEO}	-	1.0	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)	5, 6	I_{CEX}	-	1.0	mAdc
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			-	2.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	5, 6	I_{CBO}	-	1.0	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 2.5 Adc, V_{CE} = 2.0 Vdc)	1	h_{FE}*	25	100	-
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			7.0	-	
Collector-Emitter Saturation Voltage* (I_C = 2.5 Adc, I_B = 250 mAdc)	2, 3, 4	$V_{CE(sat)}$*	-	1.0	Vdc
(I_C = 5.0 Adc, I_B = 1.0 Adc)			-	1.5	
Base-Emitter On Voltage* (I_C = 2.5 Adc, V_{CE} = 2.0 Vdc)	3, 4	$V_{BE(on)}$*	-	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	-	MHz
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	-	-

* Pulse Test, PW ≈ 300 μs, Duty Cycle ≈ 2.0%

FIGURE 1 — NORMALIZED DC CURRENT GAIN

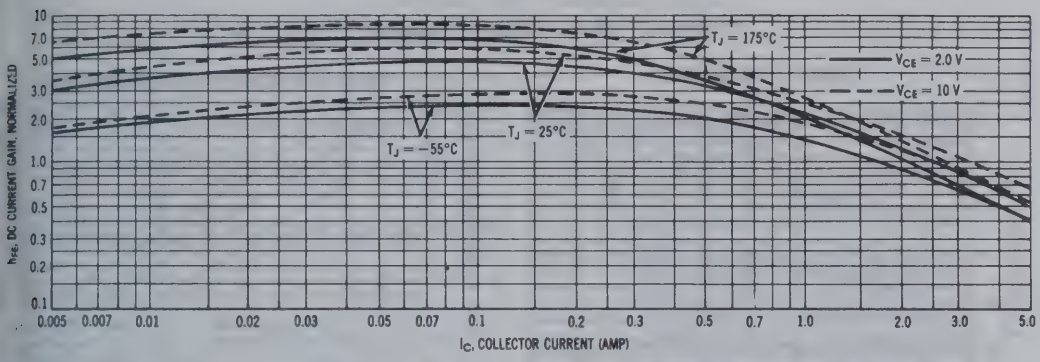


FIGURE 2 — COLLECTOR SATURATION REGION

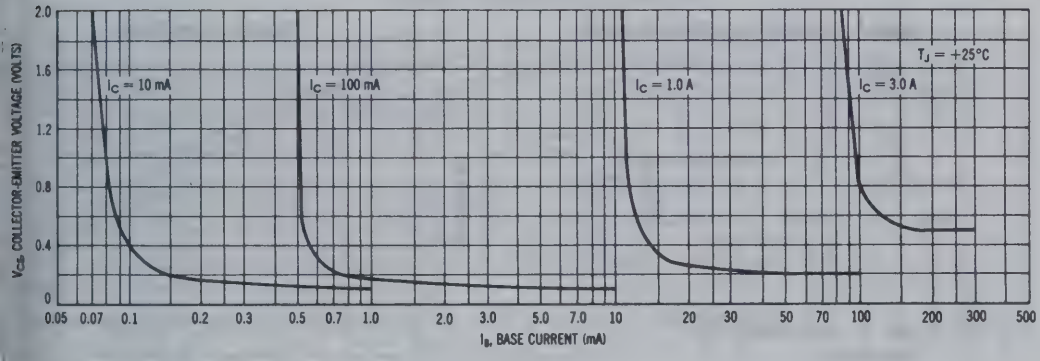


FIGURE 3 — "ON" VOLTAGES

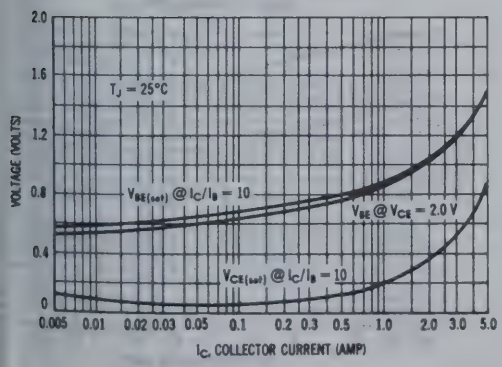
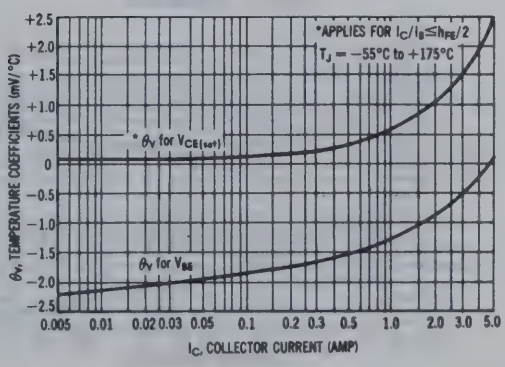


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 — CUT-OFF REGION

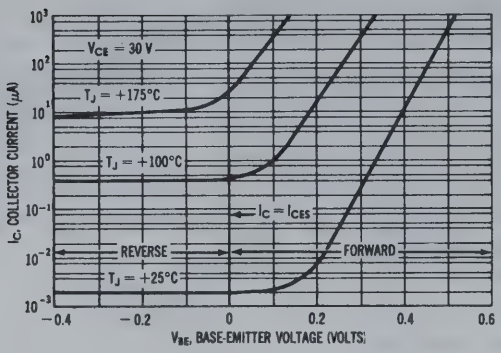


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

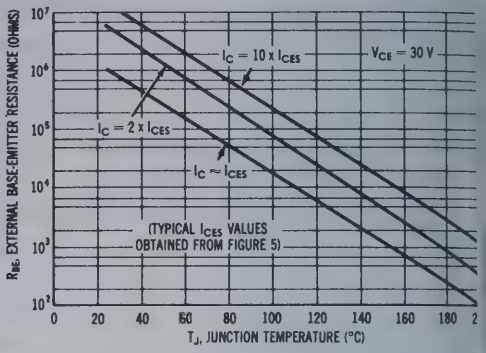


FIGURE 7 — SWITCHING TIME EQUIVALENT CIRCUIT

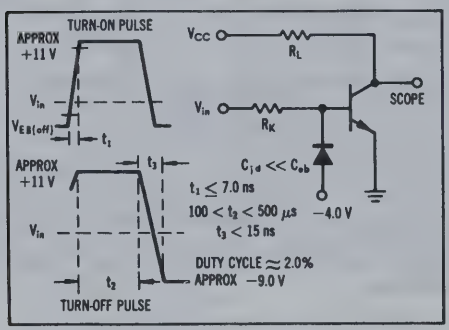


FIGURE 8 — CAPACITANCE

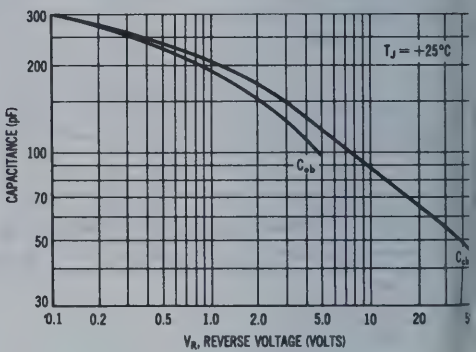


FIGURE 9 — TURN-ON TIME

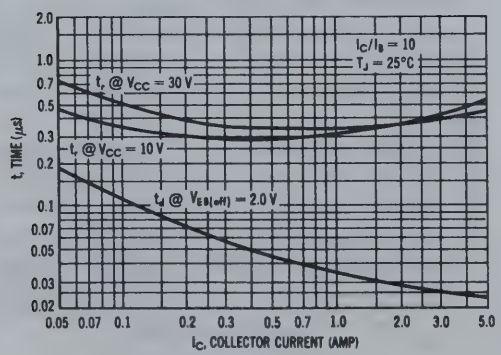
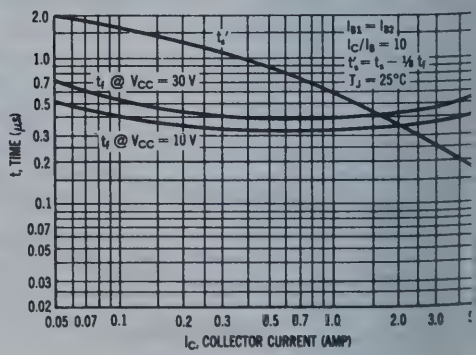
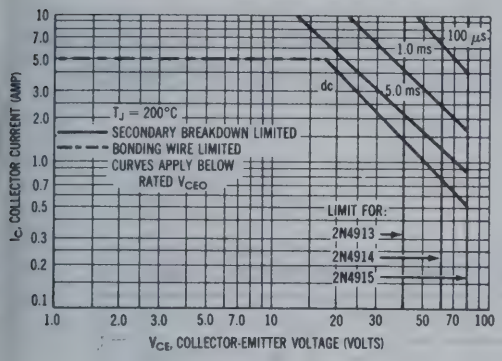


FIGURE 10 — TURN-OFF TIME



RATING AND THERMAL DATA

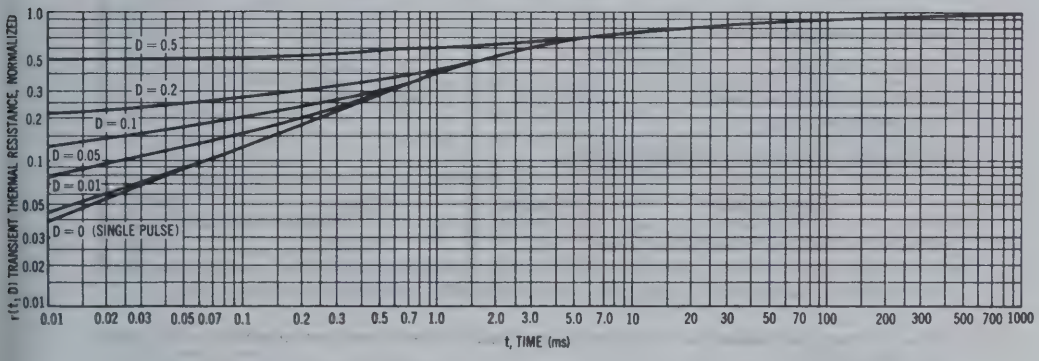
FIGURE 11 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

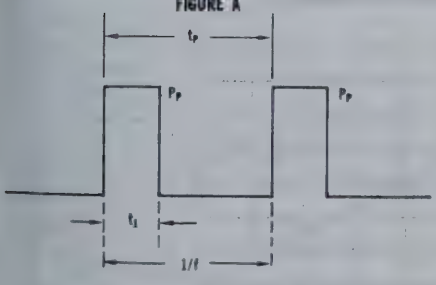
The data of Figure 11 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — TRANSIENT THERMAL RESISTANCE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 \cdot f = \frac{t_1}{t_p}$

PEAK PULSE POWER = P_p

A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC}.

Example:

The 2N4913 is dissipating 100 watts under the following conditions: t_1 = 0.1 ms, t_p = 0.5 ms. (D = 0.2)

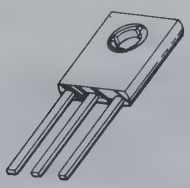
Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of r (t_1, D) is 0.28.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_p \times \theta_{JC} = 0.28 \times 100 \times 2.0 = 56°C$$

2N4918 thru 2N4920 (SILICON)

CASE 77



Medium-power plastic PNP silicon transistors designed for driver circuits, switching, and amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	2N4918	2N4919	2N4920	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous*	I_C*	1.0 3.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	30 0.24			Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			°C

THERMAL CHARACTERISTICS **

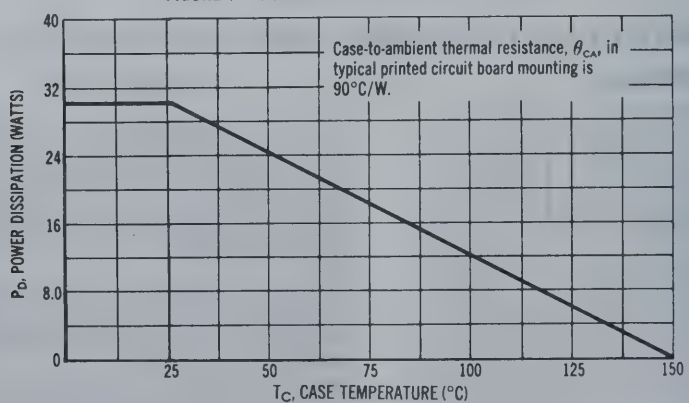
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.16	°C/W

* The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements.

The 3.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

** Recommend use of thermal compound for lowest thermal resistance.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 0.1 Adc, I_B = 0) 2N4918	-	$BV_{CEO(sus)}$*	40	-	Vdc
2N4919			60	-	
2N4920			80	-	
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	-	I_{CEO}	-	0.5	mAdc
(V_{CE} = 30 Vdc, I_B = 0)			-	0.5	
(V_{CE} = 40 Vdc, I_B = 0)			-	0.5	
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc)	12	I_{CEX}	-	0.1	mAdc
(V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)			-	0.5	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	-	I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	-	I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	8	h_{FE}*	40	-	-
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			20	100	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			10	-	
Collector-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	9, 11, 13	$V_{CE(sat)}$*	-	0.6	Vdc
Base-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	11, 13	$V_{BE(sat)}$*	-	1.3	Vdc
Base-Emitter On Voltage* (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	11, 13	$V_{BE(on)}$*	-	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)	-	f_T	3.0	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	-	C_{ob}	-	100	pF
Small-Signal Current Gain (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	-	h_{fe}	25	-	-

* Pulse Test: PW ≈ 300 μs, Duty Cycle ≈ 2.0%

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

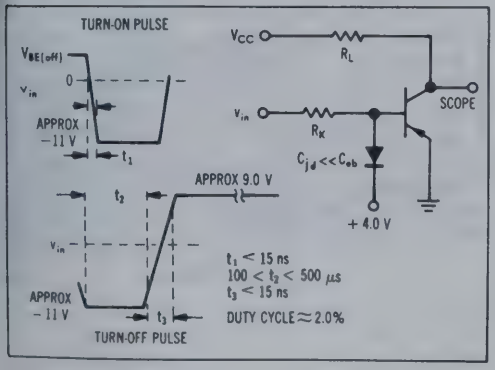


FIGURE 3 — TURN-ON TIME

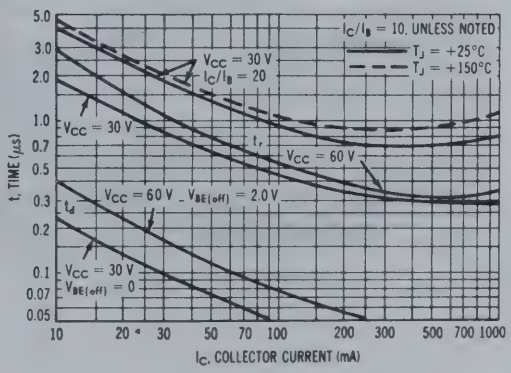


FIGURE 4 — THERMAL RESPONSE

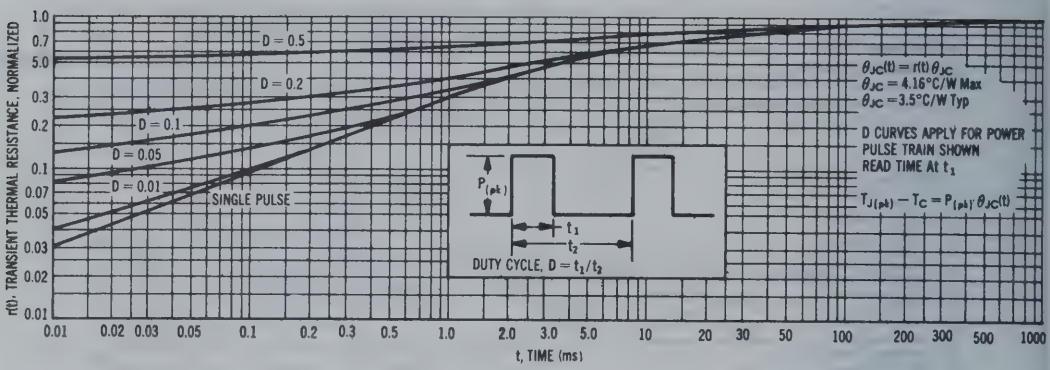
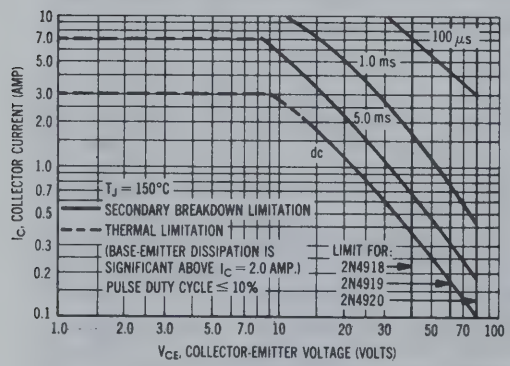


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREA



The safe operating area curves indicate I_C—V_{CE} limits of the transistor which must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 5 is based upon $T_{J(pk)} = 150°C$; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4 . At high case temperatures, thermal limitations will reduce the power which can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 — STORAGE TIME

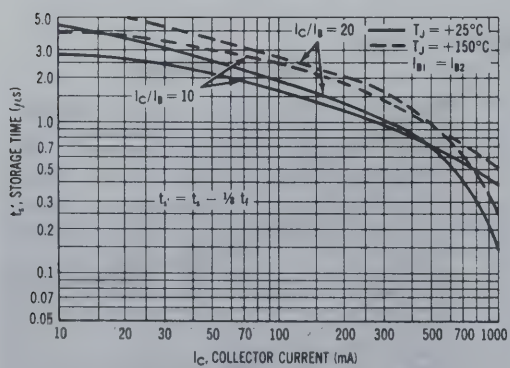
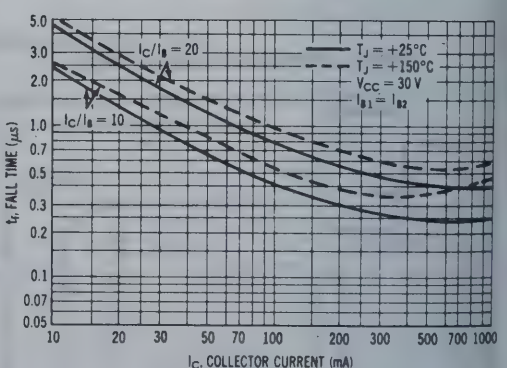


FIGURE 7 — FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 8 — CURRENT GAIN

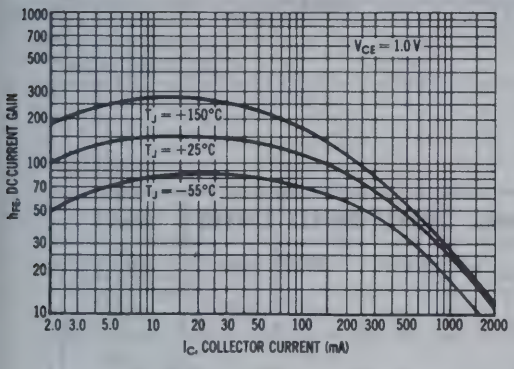


FIGURE 9 — COLLECTOR SATURATION REGION

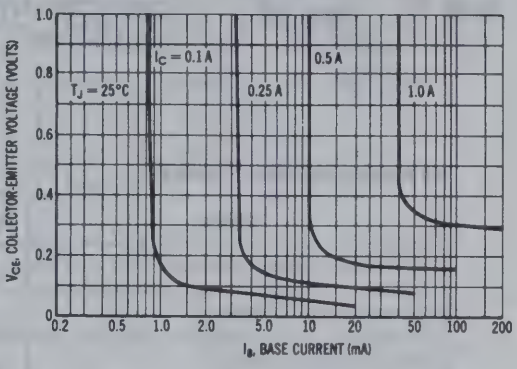


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

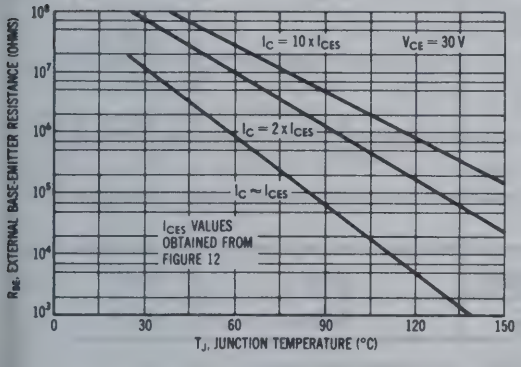


FIGURE 11 — "ON" VOLTAGE

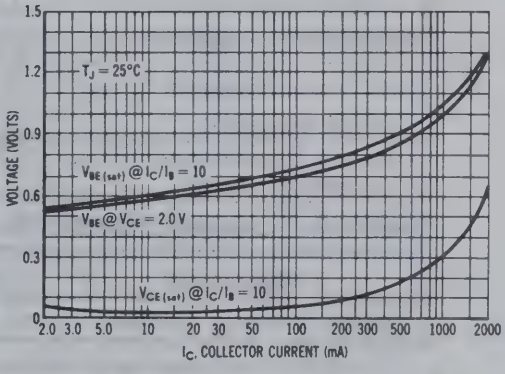


FIGURE 12 — COLLECTOR CUTOFF REGION

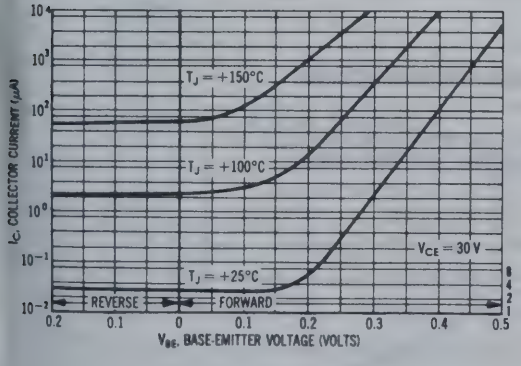
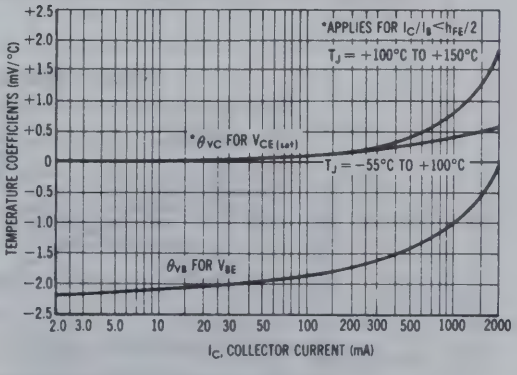
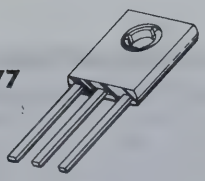


FIGURE 13 — TEMPERATURE COEFFICIENTS



2N4921 thru 2N4923 (SILICON)

CASE 77



Medium-power plastic NPN silicon transistors designed for driver circuits, switching, and amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	2N4921	2N4922	2N4923	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous*	I_C*	1.0 3.0			Adc
Base Current — Continuous	I_B	1.0			Adc
Total Device Dissipation $T_C = 25°C$ Derate above 25°C	P_D	30 0.24			Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			°C

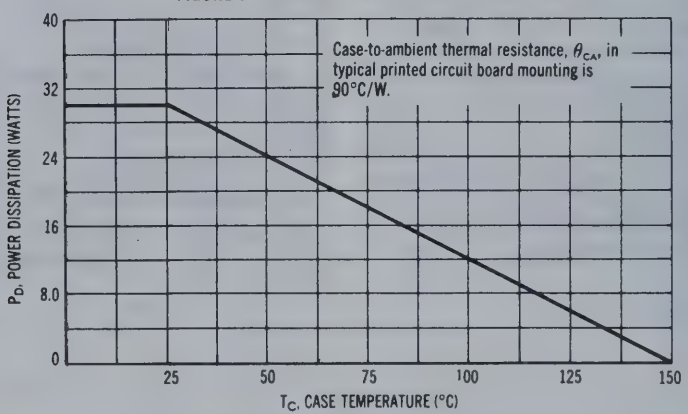
THERMAL CHARACTERISTICS **

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.16	°C/W

* The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements. The 3.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

** Recommend use of thermal compound for lowest thermal resistance.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 0.1 Adc, I_B = 0) 2N4921	-	$BV_{CEO(sus)}$*	40	-	Vdc
2N4922			60	-	
2N4923			80	-	
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0) 2N4921	-	I_{CEO}	-	0.5	mAdc
(V_{CE} = 30 Vdc, I_B = 0) 2N4922			-	0.5	
(V_{CE} = 40 Vdc, I_B = 0) 2N4923			-	0.5	
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)	12	I_{CEX}	-	0.1	mAdc
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)			-	0.5	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	-	I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	-	I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	8	h_{FE}*	40	-	-
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			20	100	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			10	-	
Collector-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	9, 11, 13	$V_{CE(sat)}$*	-	0.6	Vdc
Base-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	11, 13	$V_{BE(sat)}$*	-	1.3	Vdc
Base-Emitter On Voltage* (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	11, 13	$V_{BE(on)}$*	-	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)	-	f_T	3.0	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	-	C_{ob}	-	100	pF
Small-Signal Current Gain (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	-	h_{fe}	25	-	-

* Pulse Test: PW ≈ 300 μs, Duty Cycle ≈ 2.0%.

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

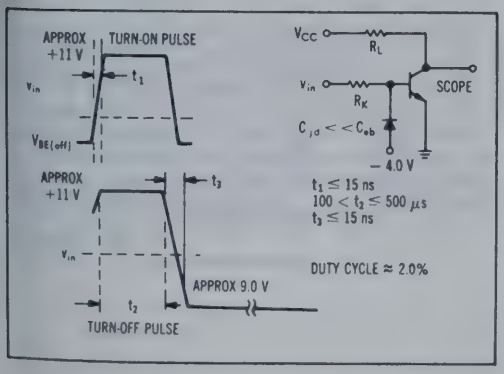


FIGURE 3 — TURN-ON TIME

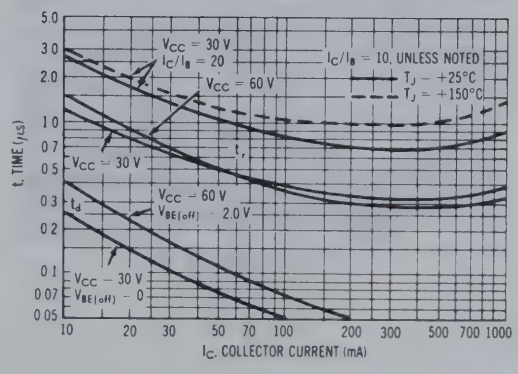


FIGURE 4 — THERMAL RESPONSE

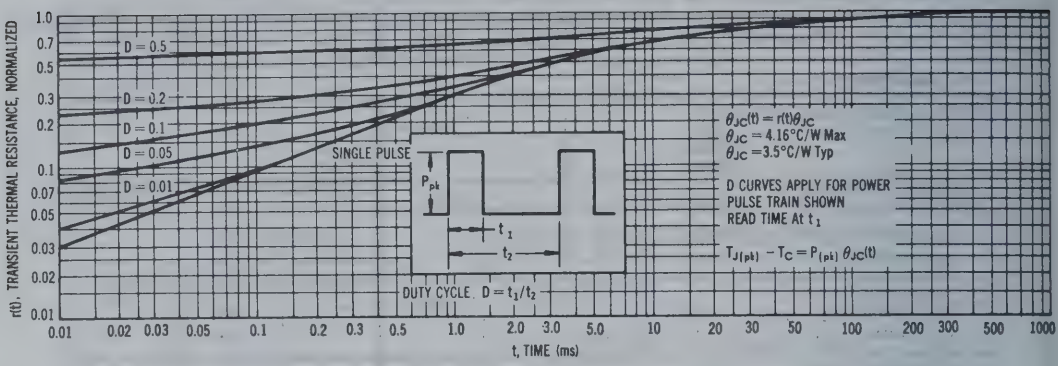
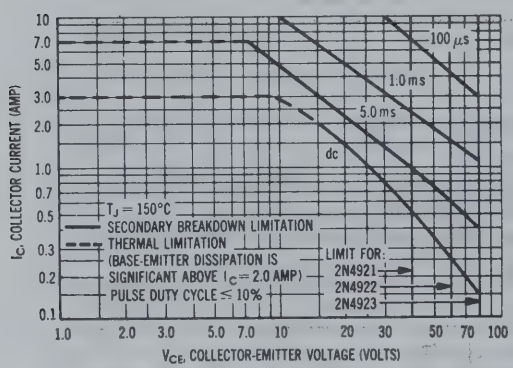


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 — STORAGE TIME

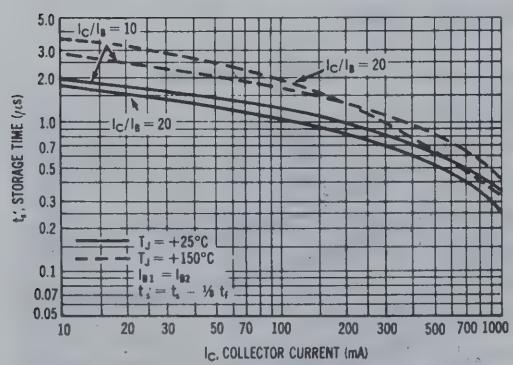


FIGURE 7 — FALL TIME

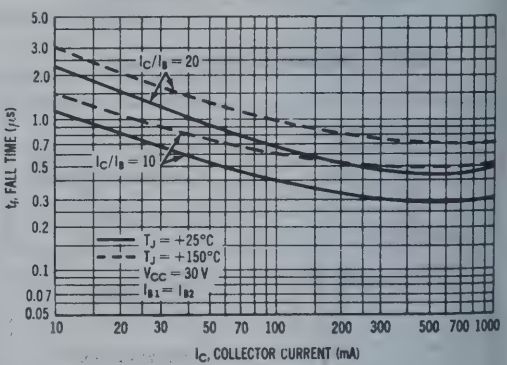


FIGURE 8 — CURRENT GAIN

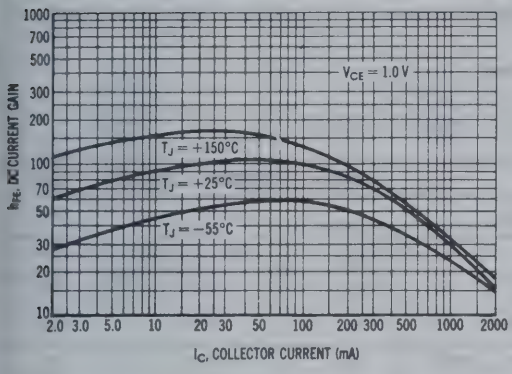


FIGURE 9 — COLLECTOR SATURATION REGION

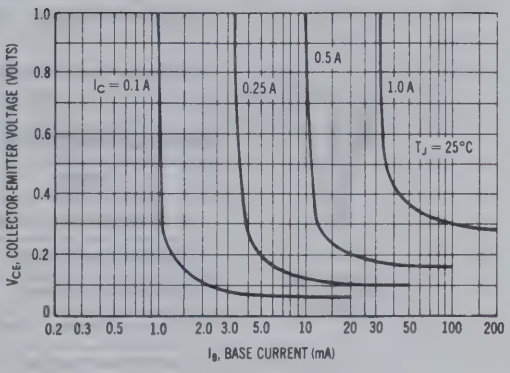


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

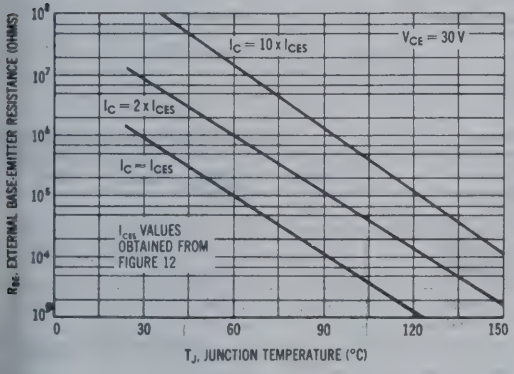


FIGURE 11 — "ON" VOLTAGE

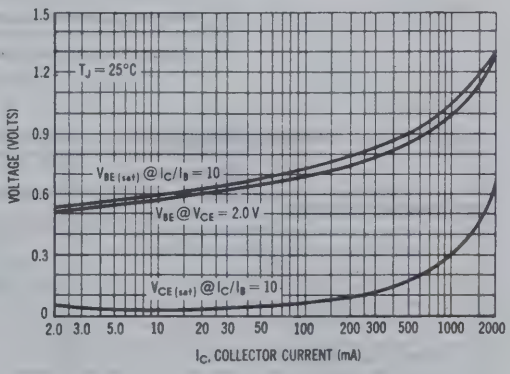


FIGURE 12 — COLLECTOR CUTOFF REGION

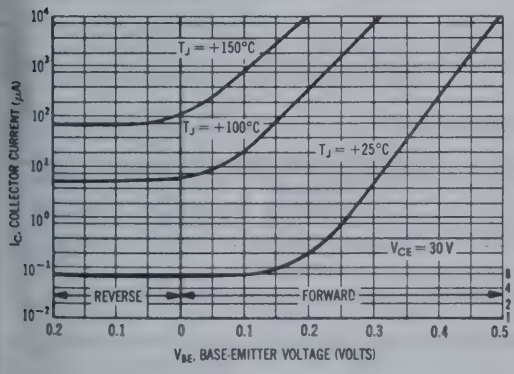
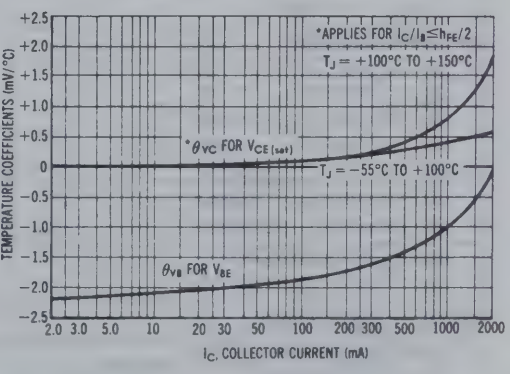


FIGURE 13 — TEMPERATURE COEFFICIENTS



2N4924 (SILICON)
2N4925

. . . NPN silicon annular transistors designed for high-voltage, high-frequency amplifier applications.

Collector connected to case



CASE 79
(TO-39)

MAXIMUM RATINGS

Rating	Symbol	2N4924	2N4925	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	Vdc
Collector-Base Voltage	V_{CB}	100	150	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	200		mAdc
Total Device Dissipation T_A = 25°C Derate above 25°C	P_D	1.0 5.71		W mW/°C
Total Device Dissipation T_C = 25°C Derate above 25°C	P_D	5.0 28.6		W mW/°C
Operating Junction Temperature Range	T_J	-65 to +175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N4924 2N4925	BV_{CEO}*	100 150	- -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_C = 0)	2N4924 2N4925	BV_{CBO}	100 150	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0)		I_{CBO}	- -	0.1 0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)		h_{FE}*	25 35 40	- - 200	-
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$*	- -	0.25 0.4	Vdc
Base-Emitter On Voltage* (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$*	-	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain - Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	100	500	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	-	10	pF
Collector-Emitter Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)		C_{eb}	-	80	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle

2N4926 (SILICON)
2N4927



CASE 79
(TO-39)

. . . NPN silicon annular transistors designed for high-voltage, high-frequency amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N4926	2N4927	Unit
Collector-Emitter Voltage	V_{CEO}	200	250	Vdc
Collector-Base Voltage	V_{CB}	200	250	Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current - Continuous	I_C	50		mAdc
Total Device Dissipation T_A = 25°C Derate above 25°C	P_D	1.0 5.71		W mW/°C
Total Device Dissipation T_C = 25°C Derate above 25°C	P_D	5.0 28.6		W mW/°C
Operating Junction Temperature Range	T_J	-65 to +175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N4926	BV_{CEO}*	200	-	Vdc
	2N4927		250	-	
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_C = 0)	2N4926	BV_{CBO}	200	-	Vdc
	2N4927		250	-	
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)	2N4926	I_{CBO}	-	0.1	μAdc
(V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C)			-	10	
(V_{CB} = 150 Vdc, I_E = 0)	2N4927		-	0.1	
(V_{CB} = 150 Vdc, I_E = 0, T_A = 100°C)			-	10	
Emitter Cutoff Current (V_{BE} = 5.0 V		I_{EBO}	-	0.1	μAdc

*Pulse Width ≦ 300 μs, Duty Cycle ≦ 1.0%

ON CHARACTERISTICS				
DC Current Gain** (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}**	10	-	-
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		15	-	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		20	200	
(I_C = 50 mAdc, V_{CE} = 20 Vdc)		20	-	
Collector-Emitter Saturation Voltage** (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$**	-	1.0	Vdc
(I_C = 30 mAdc, I_B = 3.0 mAdc)		-	2.0	
Base-Emitter Saturation Voltage** (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$**	-	1.2	Vdc
(I_C = 50 mAdc, I_B = 3.0 mAdc)			1.5	
Base-Emitter On Voltage (I_C = 30 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	-	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	30	300	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	6.0	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	75	750	k ohm
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	0.1	1.0	$X10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	25	250	-
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	5.0	50	μmhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 5.0 MHz)	$Re(h_{ie})$	4	40	ohms

** Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%

2N4928 thru 2N4931



High-voltage PNP silicon annular transistors for use in general-purpose high-voltage applications.

CASE 79
(TO-39)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N4928	2N4929	2N4930	2N4931	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Collector-Base Voltage	V_{CB}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	500	500	500	mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D	0.6	1.0	1.0	1.0	Watt
Derate above 25°C		3.4	5.71	5.71	5.71	mW/°C
Total Device Dissipation @ $T_C = 25°C$	P_D	3.0	5.0	5.0	5.0	Watt
Derate above 25°C		17.2	28.6	28.6	28.6	mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				°C

2N4928 thru 2N4931 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N4928	BV_{CEO}*	100	-	Vdc
	2N4929		150	-	
	2N4930		200	-	
	2N4931		250	-	
Collector-Base Breakdown Voltage (I_E = 0, I_C = 100 μAdc)	2N4928	BV_{CBO}	100	-	Vdc
	2N4929		150	-	
	2N4930		200	-	
	2N4931		250	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 50 Vdc, I_E = 0)	2N4928		-	0.5	
(V_{CB} = 75 Vdc, I_E = 0)	2N4929		-	0.5	
(V_{CB} = 150 Vdc, I_E = 0)	2N4930, 2N4931		-	1.0	
Emitter Cutoff Current		I_{EBO}			μAdc
(V_{BE} = 3.0 Vdc, I_C = 0)	2N4928, 2N4929		-	0.5	
(V_{BE} = 3.0 Vdc, I_C = 0)	2N4930, 2N4931		-	1.0	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	All Types		20	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)*	2N4928, 2N4929		25	200	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)*	2N4930, 2N4931		20	200	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)*	2N4928, 2N4929		20	-	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)*	2N4930, 2N4931		20	-	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	2N4928, 2N4929	$V_{CE(sat)}$*	-	0.5	Vdc
	2N4930, 2N4931		-	5.0	
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Gandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4928, 2N4929	f_T	100	1,000	MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	2N4930, 2N4931		20	200	
Collector-Base Capacitance		C_{cb}			pF
(V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	2N4928		-	6.0	
(V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	2N4929		-	10	
(V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	2N4930, 2N4931		-	20	
Emitter-Base Capacitance		C_{eb}			pF
(V_{BE} = 2.0 Vdc, I_C = 0, f = 140 kHz)	2N4928		-	40	
(V_{BE} = 1.0 Vdc, I_C = 0, f = 140 kHz)	2N4929		-	80	
(V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	2N4930, 2N4931		-	400	

*Pulse Width ≤ 300 μs: Duty Cycle ≤ 2.0%

2N4937 thru 2N4942

Dual PNP silicon annular transistors especially designed for low-level, differential amplifier applications.

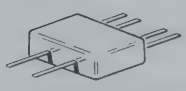


CASE 32

2N4937
2N4938
2N4939

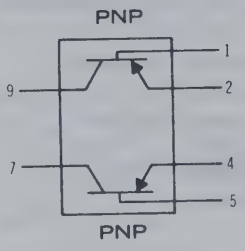


Pins 4 and 8 omitted



CASE 33
(TO-89)

2N4940
2N4941
2N4942



Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current -Continuous	I_C	50		mAdc
Base Current	I_B	10		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
Flat Pack		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40		-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50		-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0		-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	-	2.0	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	3.0	20	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc)	h_{FE}	40	-	200	-
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	-	250	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	-	250	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	400	900	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) Emitter Guarded	C_{cb}	-	3.0	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz) Collector Guarded	C_{eb}	-	7.0	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{ie}	1.0	4.0	10	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{re}	-	3.0	10	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{fe}	50	-	-	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{oe}	5.0	15	50	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 kΩ, f = 10 Hz to 15.7 kHz)	NF	-	-	4.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio* (I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc) 2N4937, 2N4940	h_{FE1}/h_{FE2}*	0.9	-	1.0	-
2N4938, 2N4941		0.8	-	1.0	
2N4939, 2N4942		-	0.7	-	
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc, T_A = -55°C to +125°C) 2N4937, 2N4940		0.85	-	1.0	
2N4938, 2N4941		0.7	-	1.0	
2N4939, 2N4942		-	0.6	-	
Base Voltage Differential (I_C = 100 μA to 1.0 mAdc, V_{CE} = 10 Vdc) 2N4937, 2N4940	$\lvert V_{BE1}-V_{BE2}\rvert$	-	-	3.0	mVdc
2N4938, 2N4941		-	-	5.0	
2N4939, 2N4942		-	5.0	-	
Base Voltage Differential Gradient (I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc, T_A = -55°C to +125°C) 2N4937, 2N4940	$\frac{\Delta\lvert V_{BE1}-V_{BE2}\rvert}{\Delta T_A}$	-	-	10	μV/°C
2N4938, 2N4941		-	-	20	
2N4939, 2N4942		-	20	-	

* The lowest h_{FE} reading is taken as h_{FE1} for this ratio

2N4948 (SILICON)
2N4949



CASE 22A
(TO-18 Modified)
(Lead 3 connected to case)

Silicon annular unijunction transistors designed for military and industrial use in pulse, timing, triggering, sensing, and oscillator circuits. The annular process provides low leakage current, fast switching and low peak-point currents as well as outstanding reliability and uniformity.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D	360*	mW
RMS Emitter Current	I_e	50	mA
Peak Pulse Emitter Current**	i_e	1.0**	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Derate 2.4 mW/°C increase in ambient temperature. Total power dissipation (available power to Emitter and Base-Two) must be limited by external circuitry. Interbase voltage (V_{B2B1}) limited by power dissipation,

$$V_{B2B1} = \sqrt{R_{BB} \cdot P_D}.$$

** Capacitance discharge current must fall to 0.37 Amp within 3.0 ms and PRR ≦ 10 PPS.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (V_{B2B1} = 10 V) Note 1	2N4948	η	0.55	-	0.82	-
	2N4949		0.74	-	0.86	
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)	2N4948, 2N4949	R_{BB}	4.0	7.0	12.0	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65°C to +100°C)		αR_{BB}	0.1	-	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA) Note 2		$V_{EB1(sat)}$	-	2.5	3.0	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	12	15	-	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)		I_{EB2O}	-	5.0	10	nA
(V_{B2E} = 30 V, I_{B1} = 0, T_A = 125°C)			-	-	1.0	μA
Peak Point Emitter Current (V_{B2B1} = 25 V)	2N4948	I_P	-	0.6	2.0	μA
	2N4949		-	0.6	1.0	
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms) Note 2	2N4948, 2N4949	I_V	2.0	4.0	-	mA
					-	
Base-One Peak Pulse Voltage (Note 3, Figure 3)	2N4949	V_{OB1}	3.0	5.0	-	Volts
	2N4948		6.0	8.0	-	
Maximum Oscillation Frequency (Figure 4)		$f_{(max)}$	-	1.25	-	MHz

NOTES

1. Intrinsic standoff ratio.
   η is defined by equation:

$$\eta = \frac{V_P - V_{(EB1)}}{V_{B2B1}}$$

Where V_p = Peak Point Emitter Voltage
V_{B2B1} = Interbase Voltage
$V_{(EB1)}$ = Emitter to Base-One Junction Diode Drop (~0.5 V @ 10 μA)

2. Use pulse techniques: PW = 300 μs duty cycle ≤2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

3. Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

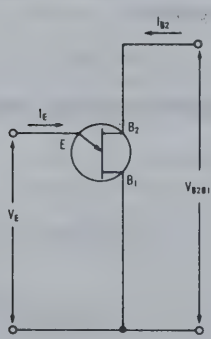


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES

(Exaggerated to Show Details)

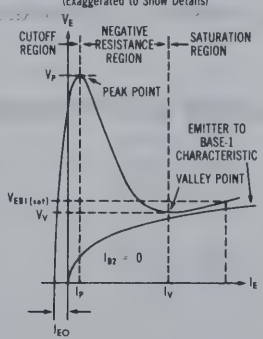


FIGURE 3 — V_{OB1} TEST CIRCUIT

(Typical Relaxation Oscillator)

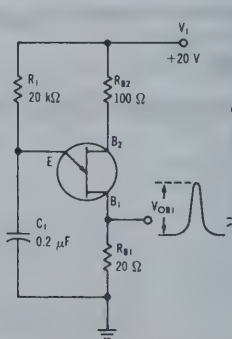
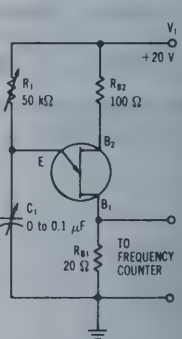


FIGURE 4 — F(max) MAXIMUM FREQUENCY TEST CIRCUIT



2N4957 (SILICON)
2N4958
2N4959

PNP silicon annular small-signal RF transistor designed for high-gain, low-noise amplifier, oscillator, and mixer applications.

CASE 20
(TO-72)



Active elements isolated from case

MAXIMUM RATINGS

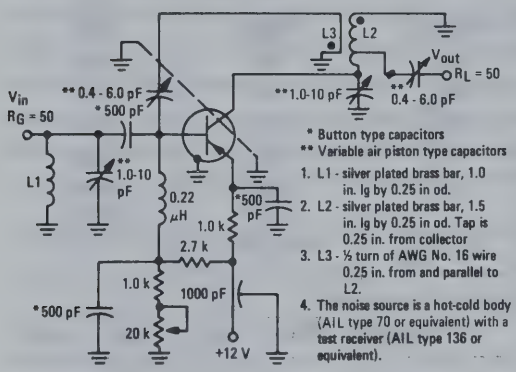
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mWatt mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	μAdc
(V_{CB} = 20 Vdc, 0, T_A = 150°C)		—	—	100	
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	40	—	—
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_E = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N4957	f_T	1200	1600	—	MHz
2N4958, 2N4959		1000	1500	—	
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	0.4	0.8	pF
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	$r_b'C_C$	—	—	8.0	ps
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz) 2N4957	NF	—	2.6	3.0	dB
2N4958		—	2.9	3.3	
Fig. 1 2N4959		—	3.2	3.8	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_G = 50 ohms, f = 1.0 GHz) 2N4957		—	5.0	—	
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz) 2N4957	G_{pe}	17	—	—	dB
2N4958		16	—	—	
2N4959		15	—	—	
(V_{CE} = 10 Vdc, I_C = 2.0 mAdc, R_G = 50 ohms, f = 1.0 GHz) 2N4957		—	13	—	

RF PERFORMANCE DATA

FIGURE 1 – NOISE FIGURE AND POWER GAIN TEST CIRCUIT



* Button type capacitors
** Variable air piston type capacitors

1. L1 - silver plated brass bar, 1.0 in. lg by 0.25 in od.
2. L2 - silver plated brass bar, 1.5 in. lg by 0.25 in od. Tap is 0.25 in. from collector
3. L3 - ½ turn of AWG No. 16 wire 0.25 in. from and parallel to L2.
4. The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

FIGURE 2 – UNILATERALIZED POWER GAIN versus FREQUENCY

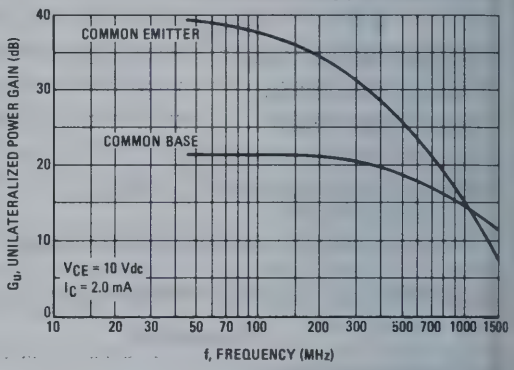


FIGURE 3 – NOISE FIGURE versus FREQUENCY

(RS & IC OPTIMIZED FOR BROAD BAND PERFORMANCE)

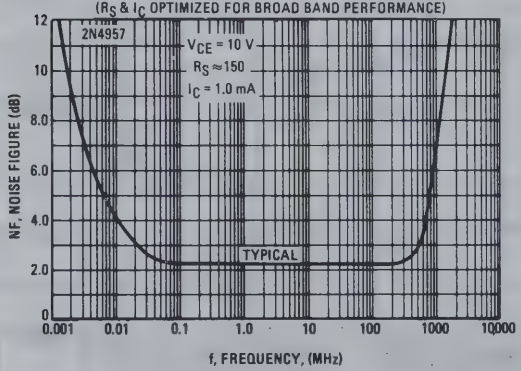


FIGURE 4 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

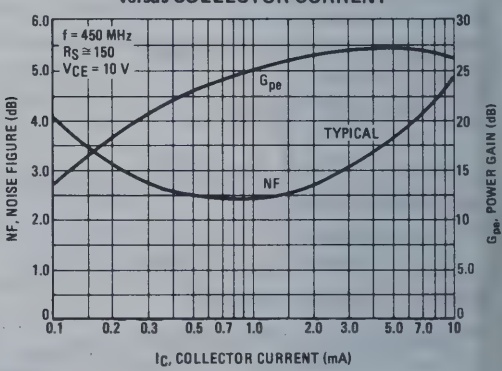


FIGURE 5 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

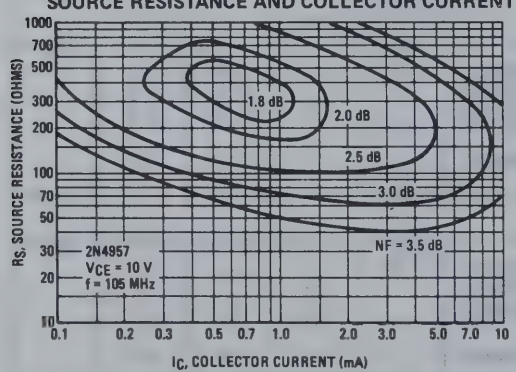
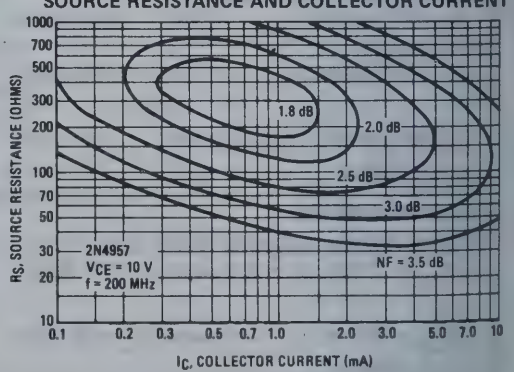


FIGURE 6 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT



COMMON EMITTER CIRCUIT DESIGN DATA

(V_{CE} = 10 Vdc, I_C = 2.0 mA)

FIGURE 7 – TRANSDUCER GAIN versus FREQUENCY

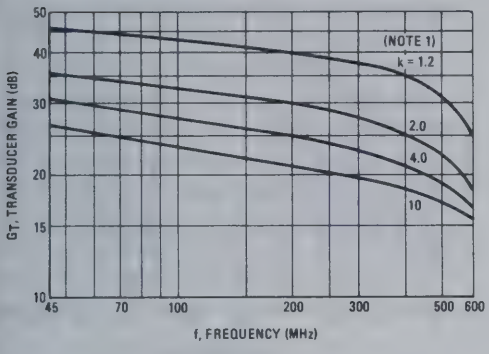


FIGURE 8 – LINVILL STABILITY FACTOR versus FREQUENCY

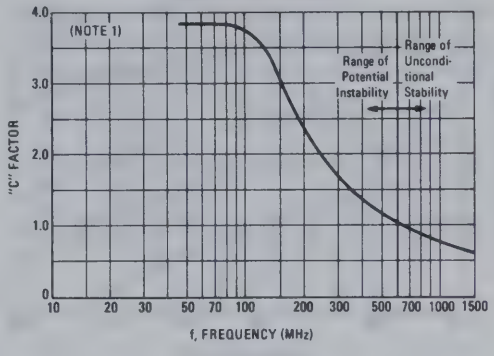


FIGURE 9 – LOAD ADMITTANCE versus FREQUENCY (REAL)

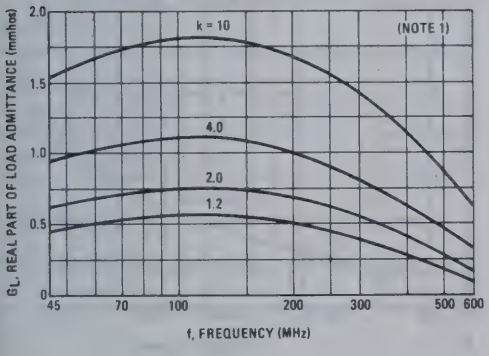


FIGURE 10 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

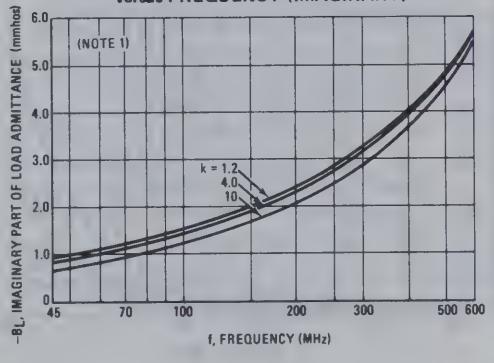


FIGURE 11 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

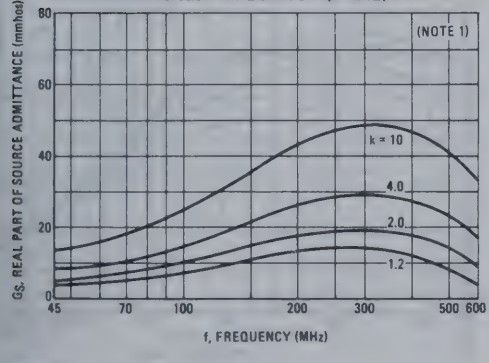
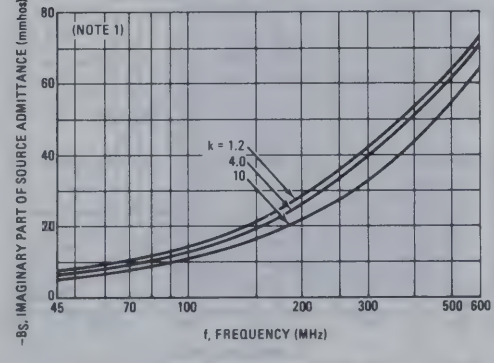


FIGURE 12 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)



NOTE 1

Figures 7 through 18 are included to assist the circuit designer in determining the stability of his particular circuit. Two stability criteria are given in these figures.

The Linvill "C" factor* is a measure of transistor stability when the input and output are terminated in the worst-case (open circuit) condition. When "C" is less than 1.0, the circuit is unconditionally stable. When "C" is greater than 1.0, the circuit is potentially unstable.

The Stern "K" factor† has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN-215.

* "Transistors and Active Circuits," Linvill and Gibbons, McGraw-Hill, 1961.

† "Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc. I.R.E., March 1967.

COMMON BASE CIRCUIT DESIGN DATA

(V_{CB} = 10 Vdc, I_C = 2.0 mA)

FIGURE 13 – TRANSDUCER GAIN versus FREQUENCY

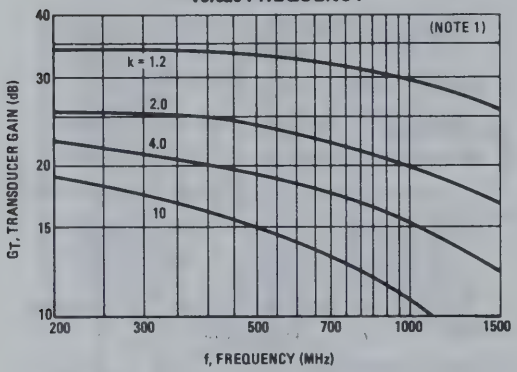


FIGURE 14 – LINVILL STABILITY FACTOR versus FREQUENCY

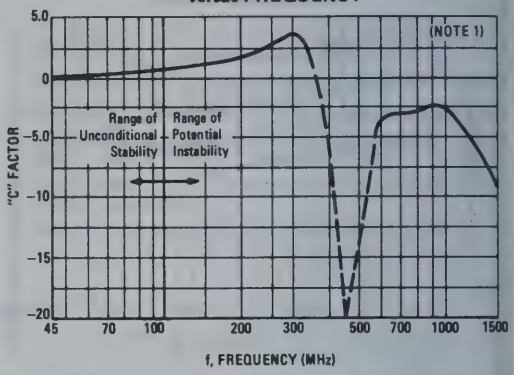


FIGURE 15 – LOAD ADMITTANCE versus FREQUENCY (REAL)

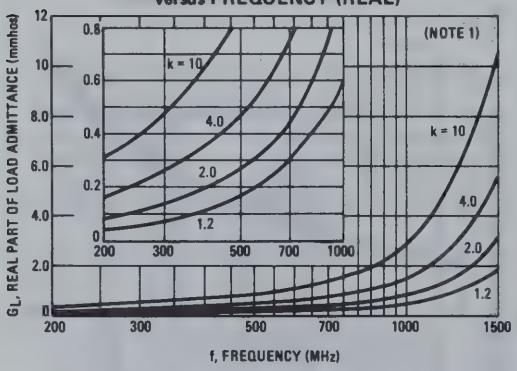


FIGURE 16 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

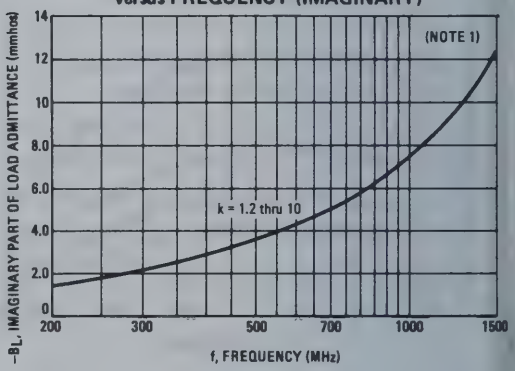


FIGURE 17 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

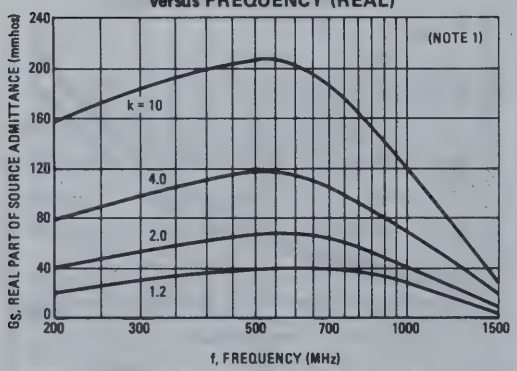


FIGURE 18 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)

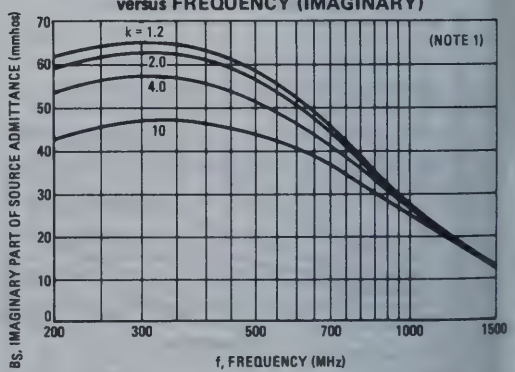


FIGURE 19 – SMALL-SIGNAL CURRENT GAIN versus FREQUENCY

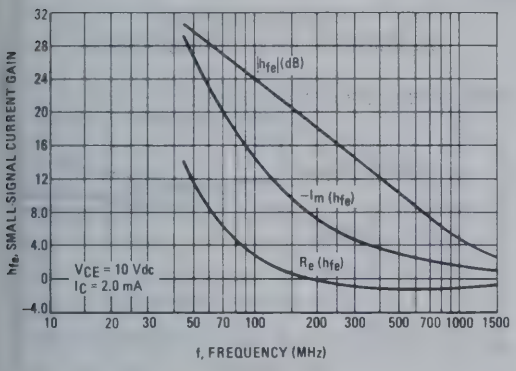


FIGURE 20 – POLAR h_{fe}

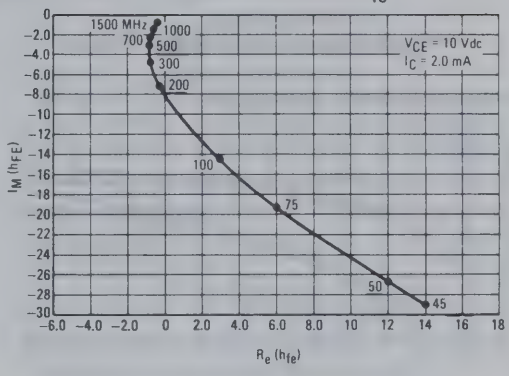


FIGURE 21 – f_T versus COLLECTOR CURRENT

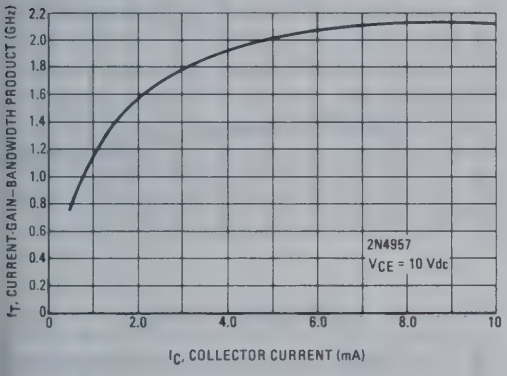


FIGURE 22 – DC CURRENT GAIN

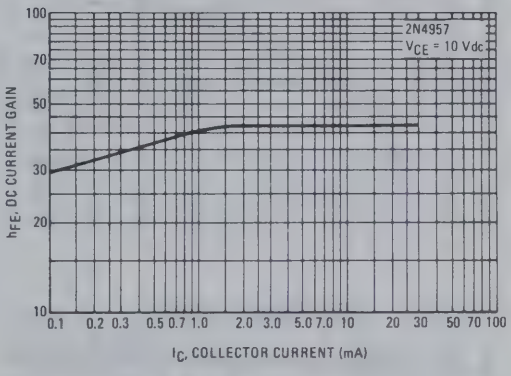


FIGURE 23 – CAPACITANCE

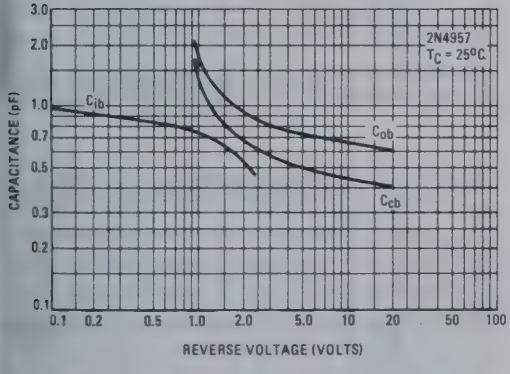
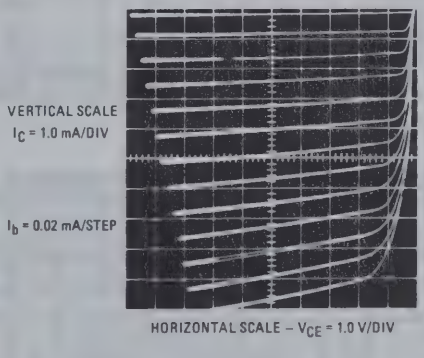


FIGURE 24 – COLLECTOR CHARACTERISTICS





Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is open.



Apply reverse bias between emitter and base and measure capacitance between these terminals. Collector is open.



Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is guarded.

Y PARAMETERS versus CURRENT

f = 450 MHz

COMMON BASE

V_{CB} = 10 Vdc ——— V_{CB} = 15 Vdc — — —

COMMON EMITTER

V_{CE} = 10 Vdc ——— V_{CE} = 15 Vdc — — —

FIGURE 25 – INPUT ADMITTANCE

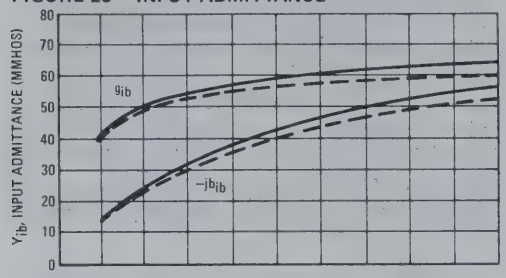


FIGURE 26 – INPUT ADMITTANCE

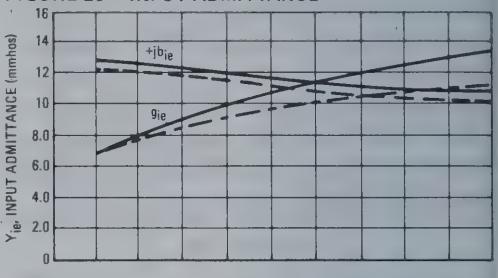


FIGURE 27 – FORWARD TRANSFER ADMITTANCE

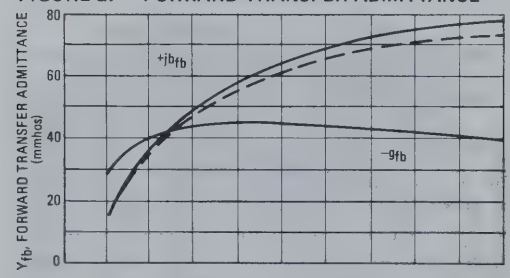


FIGURE 28 – FORWARD TRANSFER ADMITTANCE

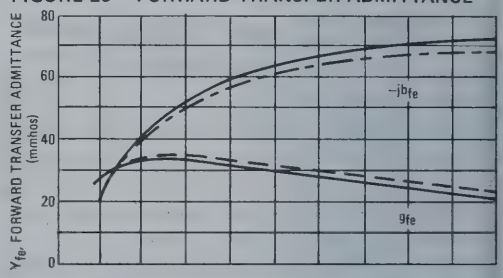


FIGURE 29 – OUTPUT ADMITTANCE

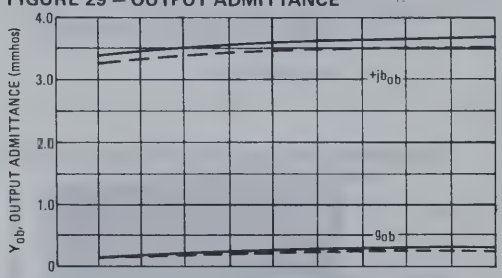


FIGURE 30 – OUTPUT ADMITTANCE

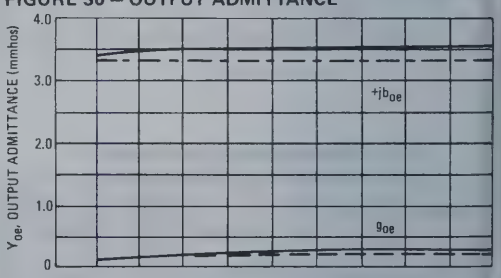


FIGURE 31 – REVERSE TRANSFER ADMITTANCE

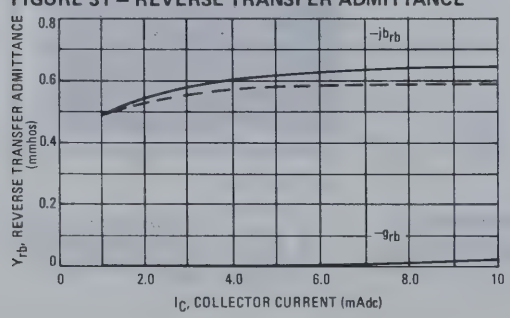
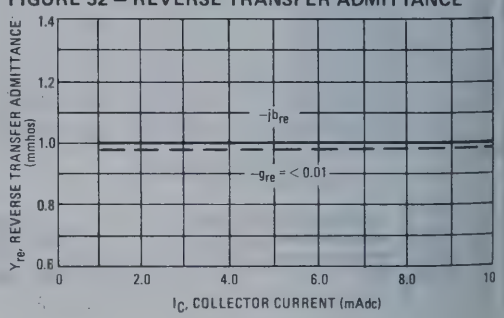


FIGURE 32 – REVERSE TRANSFER ADMITTANCE



COMMON BASE Y PARAMETER VARIATIONS

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

Y PARAMETERS versus FREQUENCY

FIGURE 33 – y_{ib} INPUT ADMITTANCE

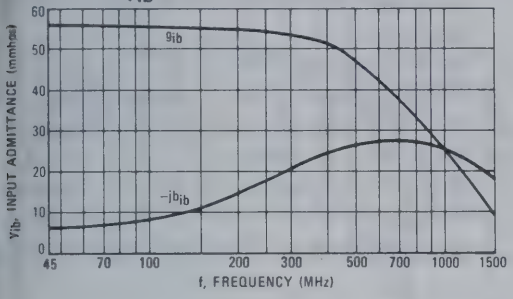


FIGURE 35 – y_{fb} FORWARD TRANSFER ADMITTANCE

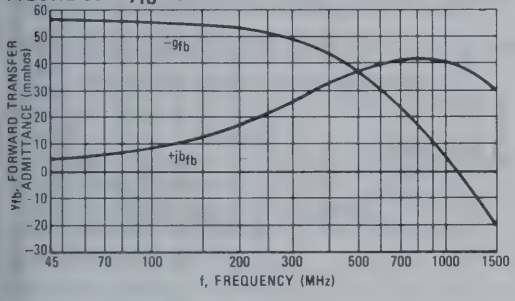


FIGURE 37 – y_{ob} OUTPUT ADMITTANCE

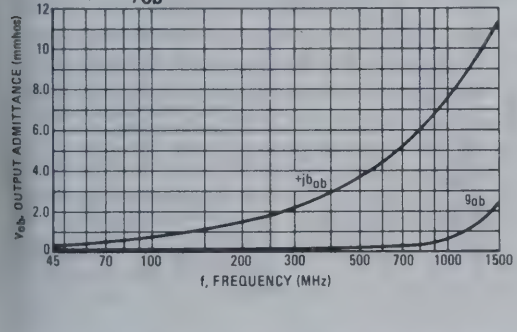
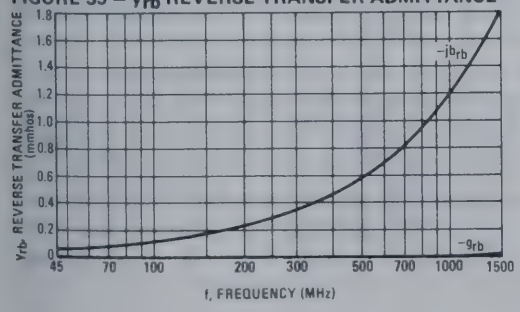


FIGURE 39 – y_{rb} REVERSE TRANSFER ADMITTANCE



POLAR Y PARAMETERS versus FREQUENCY

FIGURE 34 – y_{ib} INPUT ADMITTANCE

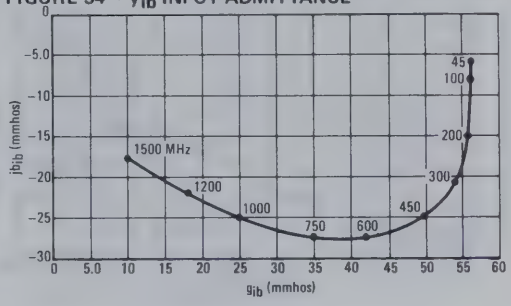


FIGURE 36 – y_{fb} FORWARD TRANSFER ADMITTANCE

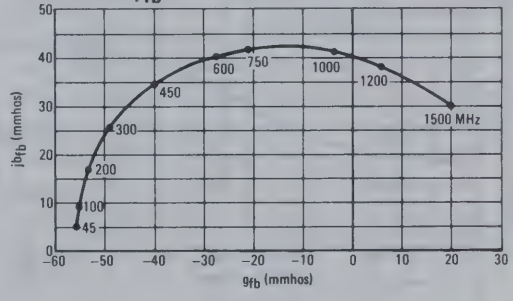


FIGURE 38 – y_{ob} OUTPUT ADMITTANCE

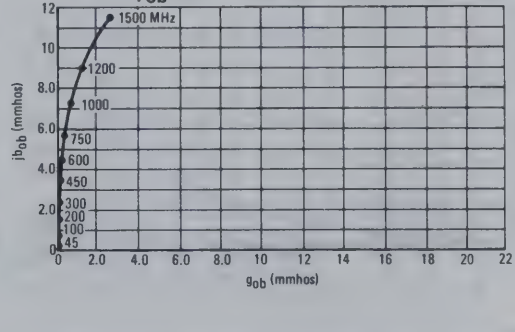
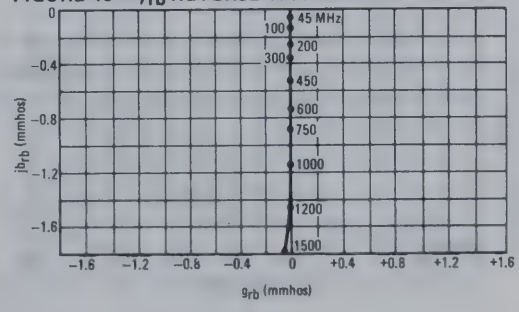


FIGURE 40 – y_{rb} REVERSE TRANSFER ADMITTANCE



COMMON EMITTER Y PARAMETER VARIATIONS

(V_{CE} = 10 Vdc, I_C = 2.0 mA)

Y PARAMETERS versus FREQUENCY

FIGURE 41 – y_{ie} INPUT ADMITTANCE

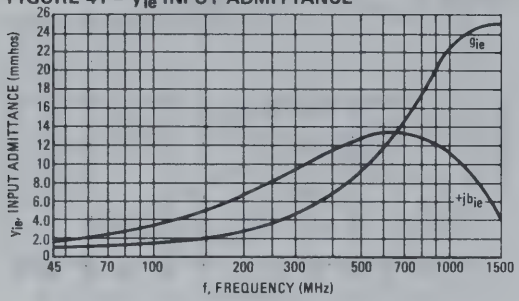


FIGURE 43 – y_{fe} FORWARD TRANSFER ADMITTANCE

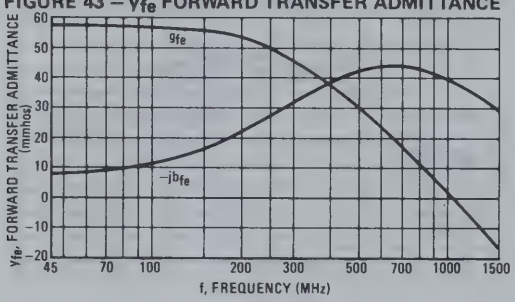


FIGURE 45 – y_{oe} OUTPUT ADMITTANCE

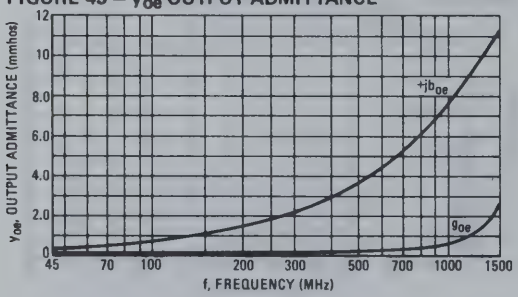
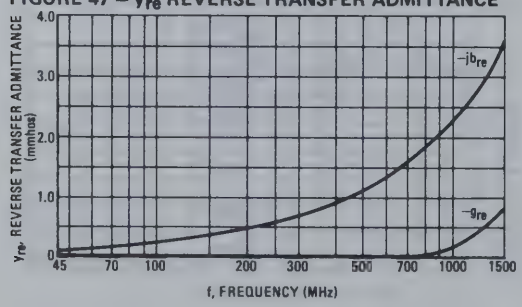


FIGURE 47 – y_{re} REVERSE TRANSFER ADMITTANCE



POLAR Y PARAMETERS versus FREQUENCY

FIGURE 42 – y_{ie} INPUT ADMITTANCE

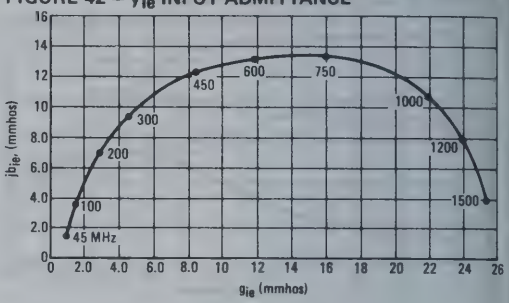


FIGURE 44 – y_{fe} FORWARD TRANSFER ADMITTANCE

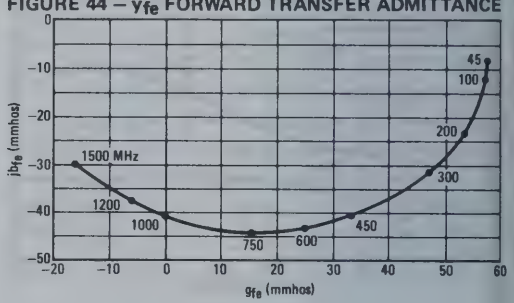


FIGURE 46 – y_{oe} OUTPUT ADMITTANCE

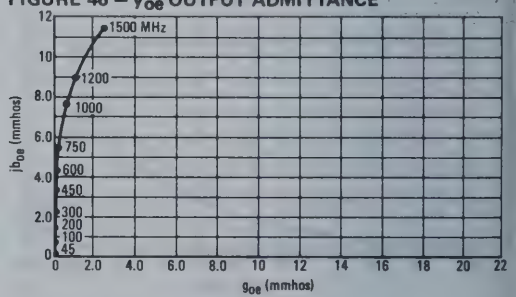
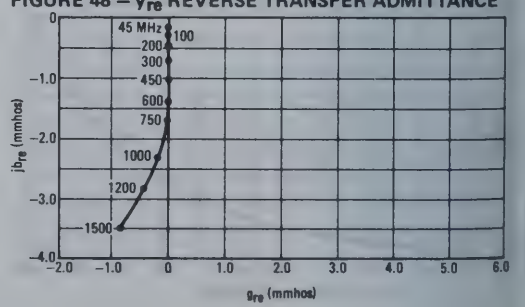


FIGURE 48 – y_{re} REVERSE TRANSFER ADMITTANCE

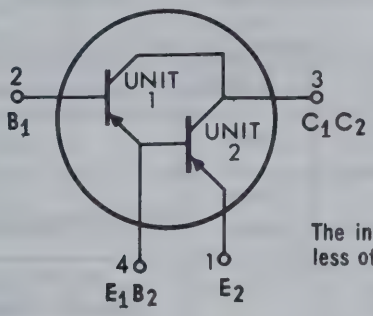


2N4974 (SILICON)
2N4975



CASE 34A
(TO-12)

PNP silicon annular darlington amplifiers contain two PNP silicon annular transistors connected as a darlington amplifier.



The input unit is identified as Unit 1 regardless of terminal numbering.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Numerical subscripts refer to unit number

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CE2}	30	Vdc
Collector-Base Voltage	V_{CB1}	40	Vdc
Emitter-Base Voltage	V_{E2B1}	10	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.5 14.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Unit
Thermal Resistance, Junction to Case Output Device Driver Device	θ_{JC}	 60 85	°C/W
Thermal Resistance, Junction to Junction	θ_{JJ}	30	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Numerical subscripts refer to unit number, lead 4 open unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage * (I_C = 10 mAdc, E_2B_1 termination open)	BV_{CE2}*	30	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	BV_{CB1O}	40	50	-	Vdc
Emitter-Base Breakdown Voltage (I_{B1} = 10 μAdc)	BV_{E2B1O}	10	12.5	-	Vdc
Collector Cutoff Current (V_{CB1} = 30 Vdc)	I_{CB1O}	-	0.5	10	nAdc
Emitter Cutoff Current (V_{E2B1} = 5.0 Vdc)	I_{E2B1O}	-	0.15	10	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				-
(I_C = 1.0 μAdc, V_{CE2} = 5.0 Vdc) 2N4974		5,000	9,000	-	
2N4975		1,000	4,000	-	
(I_C = 1.0 μAdc, V_{CE2} = 5.0 Vdc, T_A = -55°C) 2N4974		-	2,000	-	
2N4975		-	1,000	-	
(I_C = 10 μAdc, V_{CE2} = 5.0 Vdc) 2N4974		10,000	15,000	-	
2N4975		5,000	9,000		
(I_C = 10 μAdc, V_{CE2} = 5.0 Vdc, T_A = -55°C) 2N4974		-	3,500	-	
2N4975		-	2,000	-	
(I_C = 100 μAdc, V_{CE2} = 5.0 Vdc) 2N4974		20,000	30,000	-	
2N4975		10,000	20,000	-	
(I_C = 1.0 mAdc, V_{CE2} = 5.0 Vdc) 2N4974		25,000	50,000	-	
2N4975		15,000	30,000		
(I_C = 10 mAdc, V_{CE2} = 5.0 Vdc)* 2N4974		30,000	60,000	150,000	
2N4975		15,000	30,000	75,000	
(I_C = 10 mAdc, V_{CE2} = 5.0 Vdc, T_A = -55°C)* 2N4974		-	15,000	-	
2N4975		-	10,000	-	
(I_C = 100 mAdc, V_{CE2} = 5.0 Vdc)* 2N4974		25,000	50,000	-	
2N4975		15,000	30,000	-	
(I_C = 500 mAdc, V_{CE2} = 5.0 Vdc)* 2N4974		15,000	25,000	-	
2N4975		5,000	10,000	-	
(I_C = 1.0 Adc, V_{CE2} = 5.0 Vdc)* 2N4974		2,000	4,000	-	
2N4975		1,000	2,000	-	
Collector-Emitter Saturation Voltage * (I_C = 500 mAdc, I_{B1} = 1.0 mAdc)	$V_{CE2(sat)}$*	-	1.4	2.0	Vdc
Base-Emitter Voltage * (I_C = 500 mAdc, I_{B1} = 1.0 mAdc)	V_{B1E2}*	-	2.0	2.7	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE2} = 5.0 Vdc, f = 100 MHz)	f_T	175	275	-	MHz
Output Capacitance (V_{CB1} = 10 Vdc, I_{E2} = 0, f = 140 kHz)	C_{ob1}	-	4.0	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}				-
2N4974		25,000	-	-	
2N4975		15,000	-	-	
Noise Figure (I_C = 1.0 mAdc, V_{CB1} = 10 Vdc, R_S = 10 k ohms, BW = 15.7 kHz)	NF	-	3.0	6.0	dB

* Pulse Test: Pulse width ≤ 300 μs, duty cycle ≤ 2%

2N5031 (SILICON)
2N5032

NPN SILICON RF SMALL-SIGNAL TRANSISTORS

. . . designed primarily for use in high-gain, low-noise, small-signal amplifiers in military and industrial equipment. Suitable for use in video wideband and general high-frequency amplifier applications of 50 to 1000 MHz.

- Low Noise Figure –
  NF = 2.5 dB (Max) @ f = 450 MHz (2N5031)
- High Power Gain –
  G_{pe} = 17 dB (Typ) @ f = 450 MHz
- High Current-Gain–Bandwidth Product –
  f_T = 1000 MHz (Min) @ I_C = 5.0 mAdc

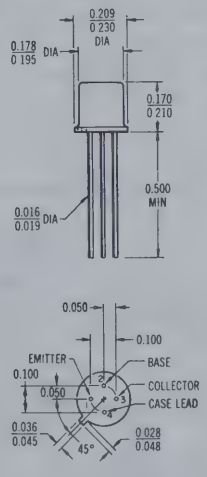
NPN SILICON RF SMALL-SIGNAL TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



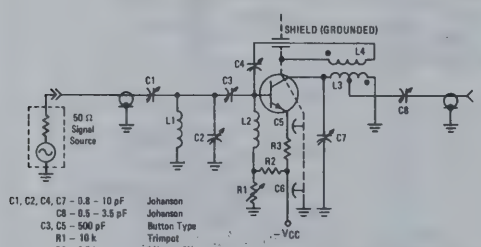
CASE 20(10)
TO-72

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	10	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)		BV_{CBO}	15	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)		BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)		I_{CBO}	–	1.0	10	nAdc
***ON CHARACTERISTICS**						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)		h_{FE}	25	–	300	–
DYNAMIC CHARACTERISTICS						
*Current-Gain–Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)		f_T	1000	–	3500	MHz
*Output Capacitance (V_{CE} = 6.0 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	1.3	1.5	pF
Collector-Base Time Constant (I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 31.8 MHz)		$r_b'C_c$	–	5.0	10	ps
*Noise Figure† (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	2N5031 2N5032	NF	– –	– –	2.5 3.0	dB
***FUNCTIONAL TEST**						
Common-Emitter Amplifier Power Gain† (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc, f = 450 MHz)		G_{pe}	14	17	25	dB

*Indicates JEDEC Registered Data.
†Tuned for Minimum Noise.

FIGURE 1 – POWER GAIN AND NOISE FIGURE TEST CIRCUIT



C1, C2, C4, C7 – 0.8 – 10 pF Johanson
C8 – 0.5 – 3.5 pF Johanson
C3, C5 – 500 pF Button Type
R1 – 10 k Trimpot
R2 – 2.7 k 1/4 watt 5%
R3 – 1.0 k 1/4 watt 5%
L1 – 1/4" Brass Rod, Solder Plated, 1-1/8" long. Placed 5/8" from the socket and in parallel with the shield, which bisects the socket. The ungrounded side is soldered directly to the ungrounded side of C2.
L2 – 0.22 μH
L3 – 1/4" Brass Rod, Solder Plated, 1-1/2" long. Placed 1/2" from the socket and in parallel with shield, which bisects the socket. The ungrounded side is soldered directly to the ungrounded side of C7. Output tap is 15/16" from ground.
L4 – 1/2 Turn #16, 5/16" above L3 and 5/8" long, (over L3).

FIGURE 2 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE

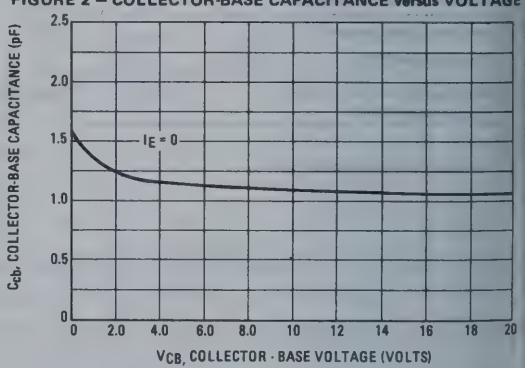


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

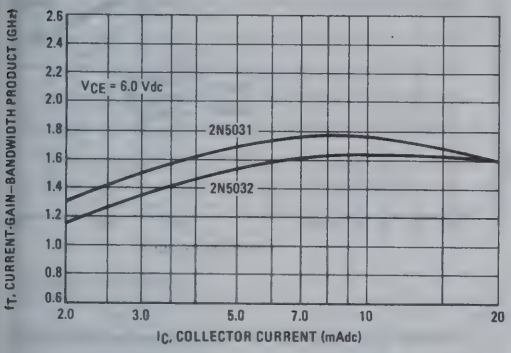


FIGURE 4 – S_{11} AND S_{22}

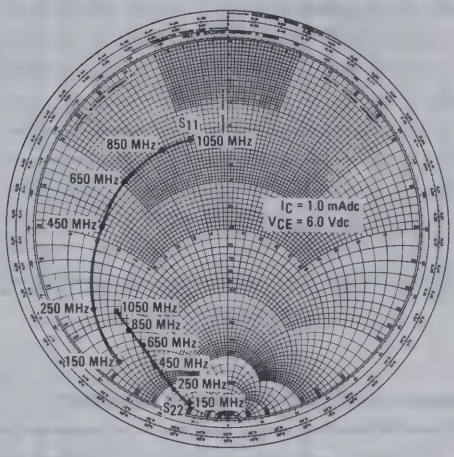


FIGURE 5 – S_{12}

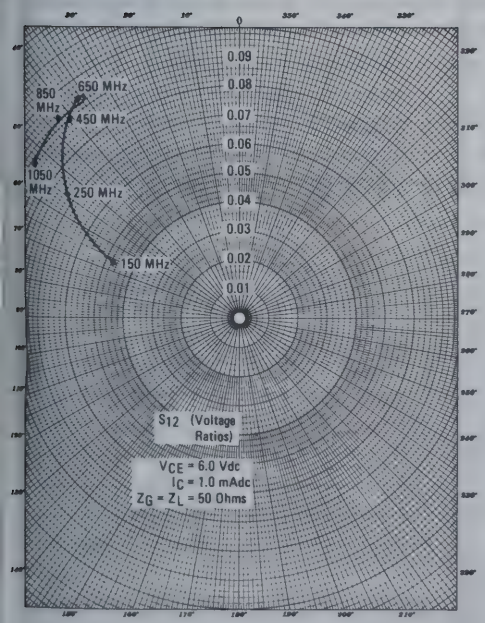


FIGURE 6 – S_{21}

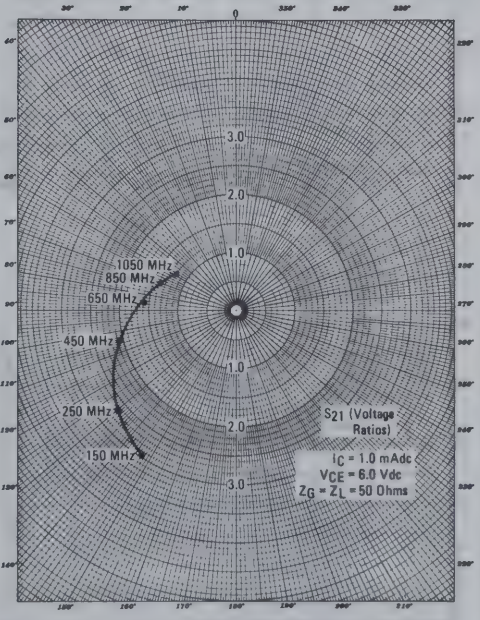


FIGURE 7 – NOISE FIGURE versus FREQUENCY

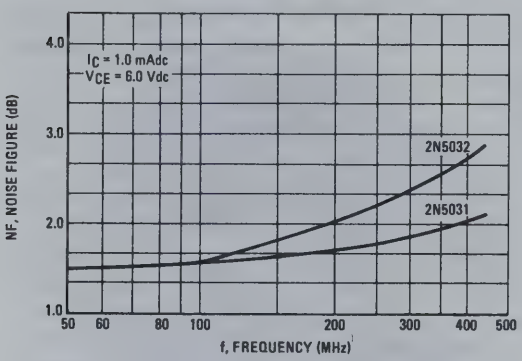


FIGURE 8 – POWER GAIN versus FREQUENCY

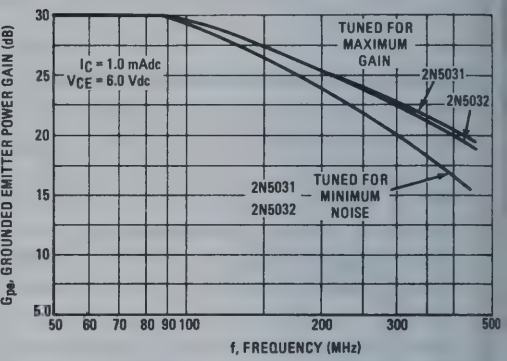


FIGURE 9 – INPUT ADMITTANCE versus FREQUENCY

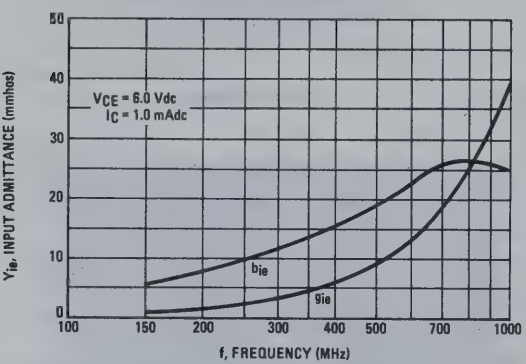


FIGURE 10 – OUTPUT ADMITTANCE versus FREQUENCY

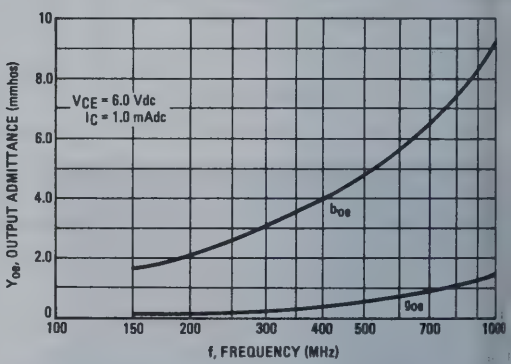


FIGURE 11 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

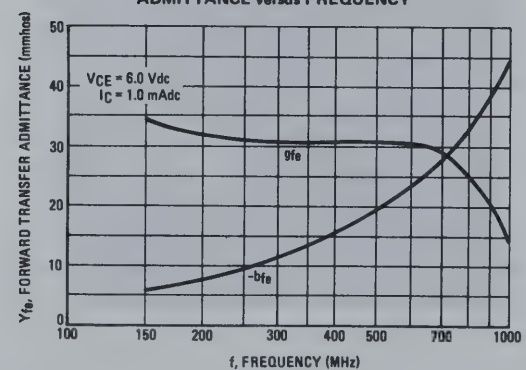
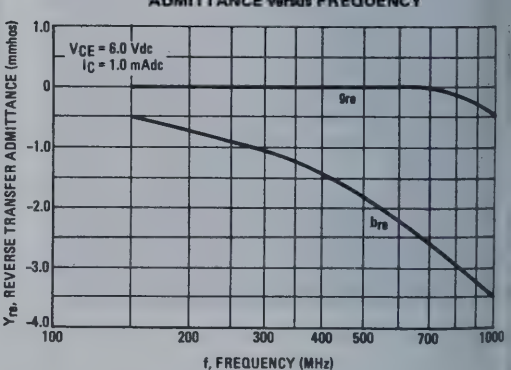


FIGURE 12 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



2N5050 (SILICON)
2N5051
2N5052

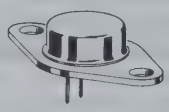
MEDIUM-POWER NPN SILICON TRANSISTORS

. . . designed for untuned amplifier and switching applications.

- High Voltage Ratings – V_{CEO} = 125, 150 and 200 Vdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 0.75 Adc
- Packaged in the Compact, High Efficiency TO-66 Case

2 AMPERE POWER TRANSISTORS NPN SILICON

125-200 VOLTS
40 WATTS



*MAXIMUM RATINGS

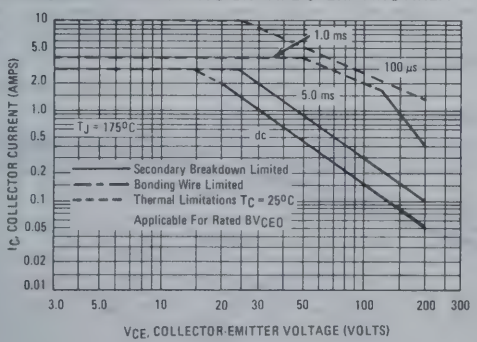
Rating	Symbol	2N5050	2N5051	2N5052	Unit
Collector-Emitter Voltage	V_{CEO}	125	150	200	Vdc
Collector-Base Voltage	V_{CB}	125	150	200	Vdc
Emitter-Base Voltage	V_{EB}	6.0			Vdc
Collector Current – Continuous	I_C	2.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 0.266			Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +175			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C

*THERMAL CHARACTERISTICS

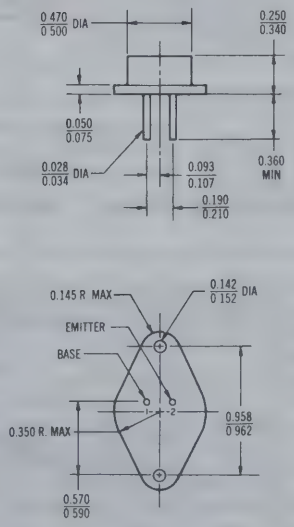
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.76	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



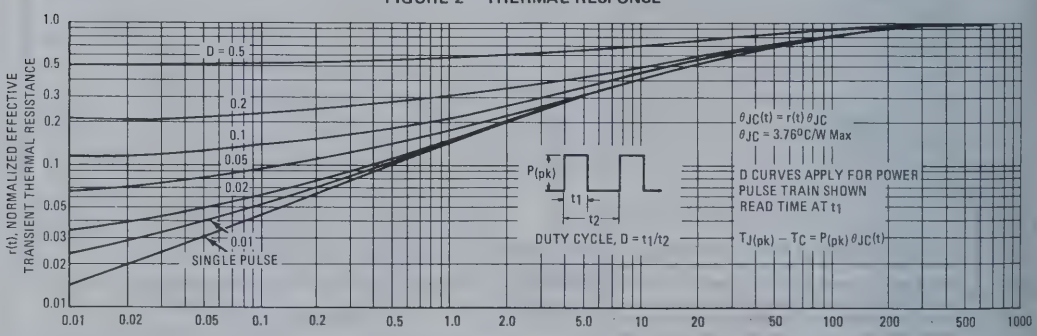
CASE 80
TO-66
Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

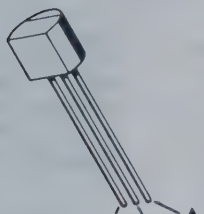
Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N5050		125	–	
	2N5051		150	–	
	2N5052		200	–	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 62.5 Vdc, I_B = 0)	2N5050		–	0.1	
(V_{CE} = 75 Vdc, I_B = 0)	2N5051		–	0.1	
(V_{CE} = 100 Vdc, I_B = 0)	2N5052		–	0.1	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)			–	0.5	
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			–	5.0	
Emitter-Base Cutoff Current		I_{EBO}	–	0.1	mAdc
(V_{BE} = 6.0 Vdc, I_C = 0)					
***ON CHARACTERISTICS**					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 0.75 Adc, V_{CE} = 5.0 Vdc)			25	100	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			25	–	
(I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 0.75 Adc, I_B = 0.1 Adc)			–	1.0	
(I_C = 2.0 Adc, I_B = 0.4 Adc)			–	5.0	
Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$	–	1.2	Vdc
(I_C = 0.75 Adc, V_{CE} = 5.0 Vdc)					
***DYNAMIC CHARACTERISTICS**					
Current-Gain–Bandwidth Product		f_T	10	–	MHz
(I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)					
Small-Signal Current Gain		h_{fe}	25	–	–
(I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)					
Common Base Output Capacitance		C_{ob}	–	250	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)					
***SWITCHING CHARACTERISTICS**					
Rise Time	(V_{CC} = 120 Vdc, I_C = 750 mAdc, R_L = 150 Ohms, I_{B1} = I_{B2} = 100 mAdc)	t_r	–	300	ns
Storage Time		t_s	–	3.5	μs
Fall Time		t_f	–	1.2	μs

*Indicates JEDEC Registered Data. Note 1: Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 2 – THERMAL RESPONSE



2N5060 thru 2N5064 (SILICON)



CASE 29 (10)
(TO-92)

PNPN plastic thyristors (silicon controlled rectifiers) designed for operation in low voltage mA/μA switching and detection circuits.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) 2N5060 2N5061 2N5062 2N5063 2N5064	$V_{RXM(rep)}$	 30 60 100 150 200	Volt
Forward Current RMS	I_f	0.8	Amp
Peak Surge Current (One Cycle, 60 Hz) No Repetition until Thermal Equilibrium is Restored	$I_{FM(surge)}$	6.0	Amp
Peak Gate Power - Forward	P_{GFM}	0.1	Watt
Average Gate Power - Forward	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current - Forward (300 μs, 120 PPS)	I_{GFM}	1.0	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	5.0 5.0	Volt
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Lead Solder Temperature (>1/16" from case, 10 sec. max)		+230	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Characteristic		Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1)	2N5060	V_{FXM}	30*		Volt
	2N5061		60*	-	
	2N5062		100*	-	
	2N5063		150*	-	
	2N5064		200*	-	
Peak Reverse Blocking Current (Rated V_{RXM}, T_J = 125°C)		I_{RXM}	-	50*	μA
Peak Forward Blocking Current (Rated V_{FXM}, T_J = 125°C)		I_{FXM}	-	50*	μA
Forward "On" Voltage (I_F = 1.0 A Peak)		V_F	-	1.7*	Volt
Gate Trigger Current (Note 2) (Anode Voltage = 7.0 V, R_L = 100 ohms)		I_{GT}			μAdc
(T_C = 25°C)				200	
(T_C = -65°C)			-	350*	
Gate Trigger Voltage		V_{GT}			Volt
(Anode Voltage = 7.0 V, R_L = 100 ohms, T_C = 25°C)			-	0.8	
(Anode Voltage = 7.0 V, R_L = 100 ohms, T_C = -65°C)			-	1.2*	
(Anode Voltage = Rated V_{FXM}, R_L = 100 ohms, T_J = 125°C)			0.1*	-	
Holding Current (Anode Voltage = 7.0 V) T_C = 25°C		I_{HX}		5.0	mA
T_C = -65°C				10*	
Turn-On Time		t_{on}	Circuit dependent, consult manufacturer		
Turn-Off Time		t_{off}			

*JEDEC Registered Values

Notes: 1. V_{RXM} and V_{FXM} can be applied for all types on a continuous dc basis without incurring damage.

2. R_{GK} current is not included in measurement.

Thyristor devices shall not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

Thyristor devices shall not have a positive bias applied to the gate concurrently with a negative potential applied to the anode.

FIGURE 1 — CURRENT DERATING

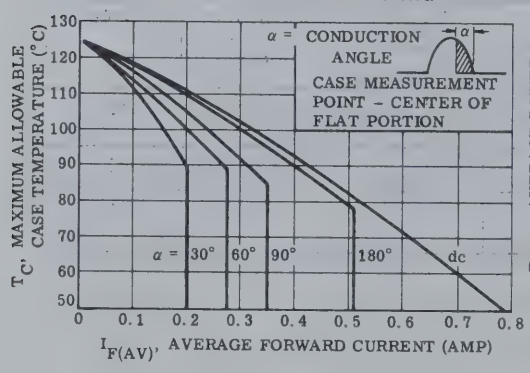
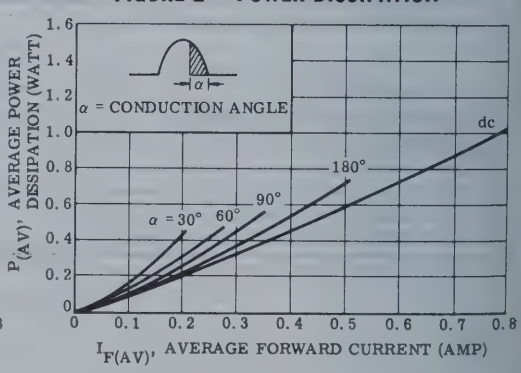
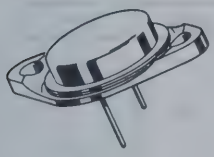


FIGURE 2 — POWER DISSIPATION



2N5067 (SILICON)
2N5068
2N5069



CASE 11
(TO-3)

NPN power transistors for use in power amplifier and switching circuits. Complement to PNP 2N4901 thru 2N4903.

MAXIMUM RATINGS

Rating	Symbol	2N5067	2N5068	2N5069	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous	I_C	5.0			Adc
Base Current - Continuous	I_B	1.0			Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	87.5 0.5			Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 0.2 Adc, I_B = 0) 2N5067 2N5068 2N5069	11	$BV_{CEO(sus)}$*	 40 60 80	 - - -	Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)		I_{CEO}	-	1.0	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	5, 6	I_{CEX}	- -	1.0 2.0	mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	5, 6	I_{CBO}	-	1.0	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	1.0	mAdc

* Pulse Test, PW ≈ 300 μs, Duty Cycle ≈ 2.0%

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain* (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	1	h_{FE}*	20	80	-
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			7.0	-	
Collector-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	2, 3, 4	$V_{CE(sat)}$*	-	0.4	Vdc
(I_C = 5.0 Adc, I_B = 1.0 Adc)			-	1.5	
Base-Emitter On Voltage* (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	3, 4	$V_{BE(on)}$*	-	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	-	MHz
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	-	-

* Pulse Test, PW ≈300 μs, Duty Cycle ≈ 2.0%

FIGURE 1 — NORMALIZED DC CURRENT GAIN

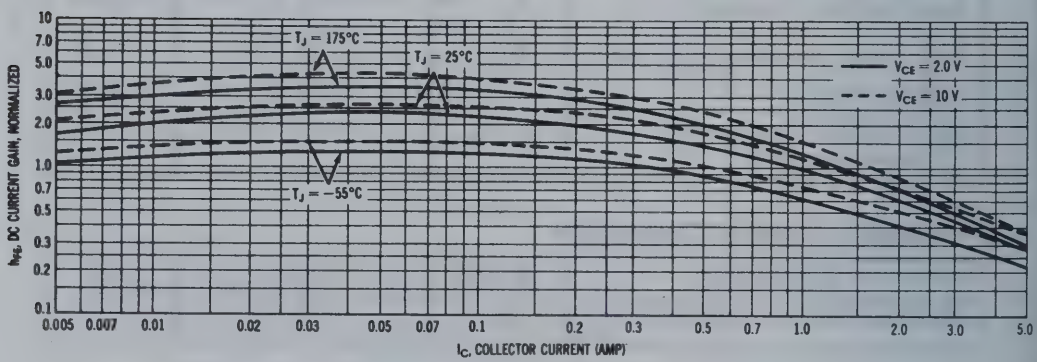


FIGURE 2 — COLLECTOR SATURATION REGION

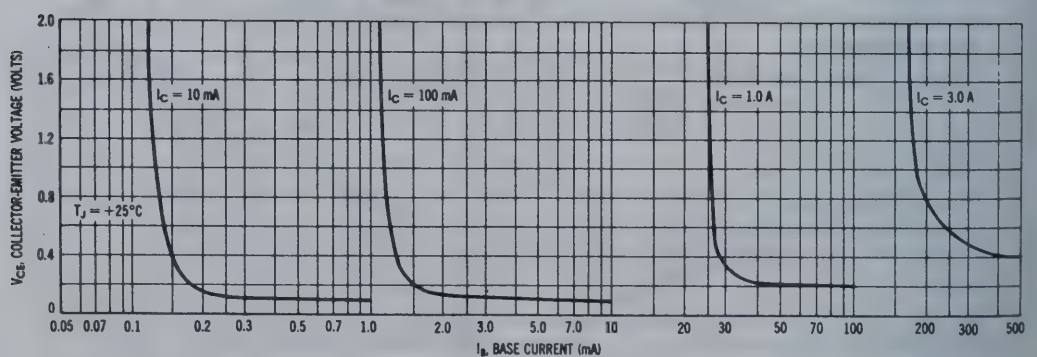


FIGURE 3 — "ON" VOLTAGES

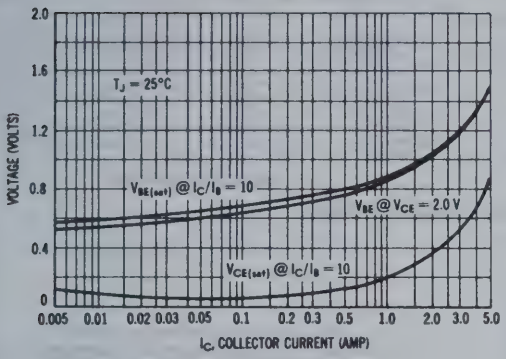
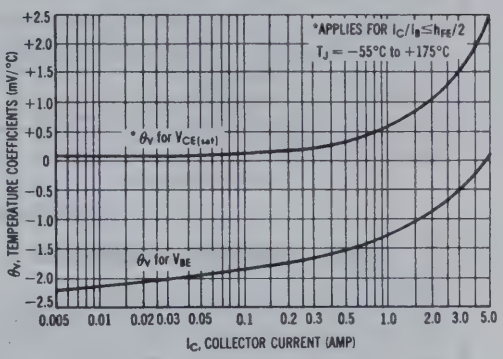


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 — CUT-OFF REGION

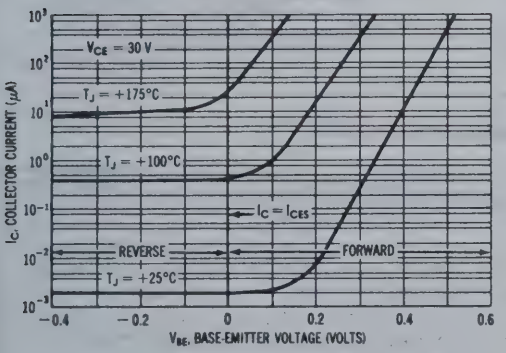


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

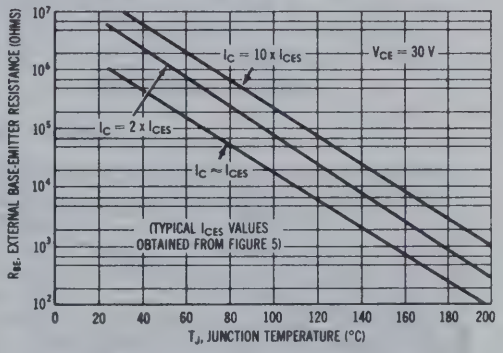


FIGURE 7 — SWITCHING TIME EQUIVALENT CIRCUIT

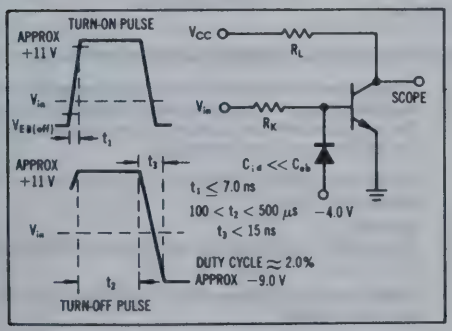


FIGURE 8 — CAPACITANCE

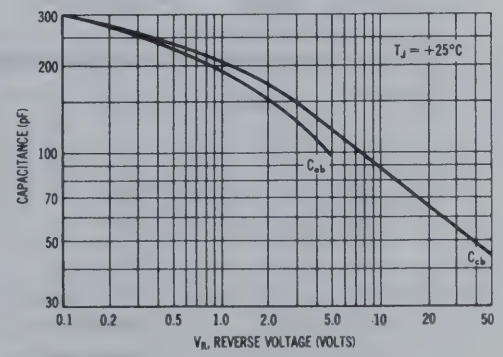


FIGURE 9 — TURN-ON TIME

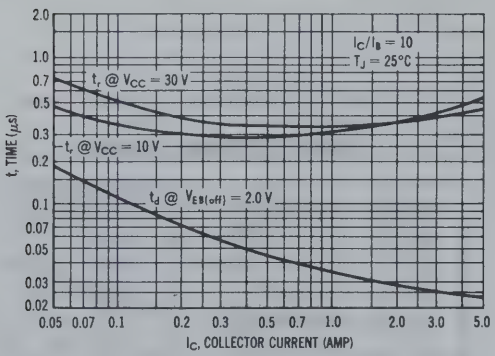
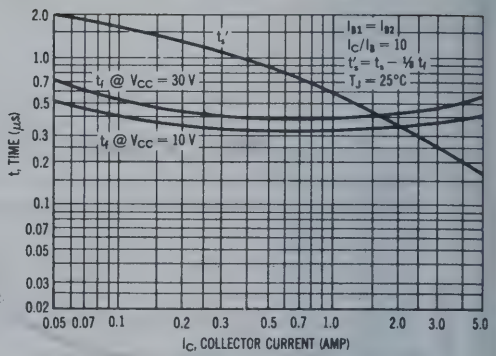
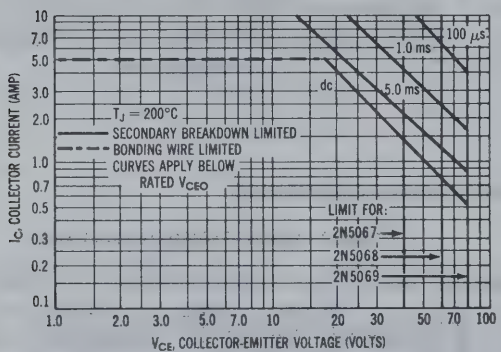


FIGURE 10 — TURN-OFF TIME



RATING AND THERMAL DATA

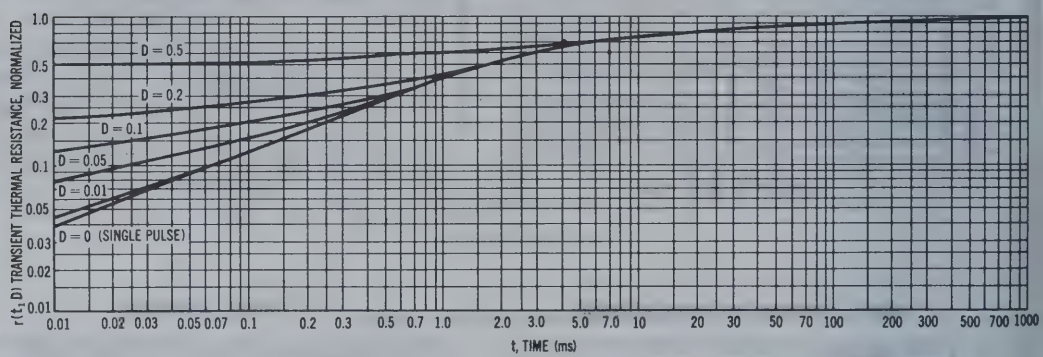
FIGURE 11 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

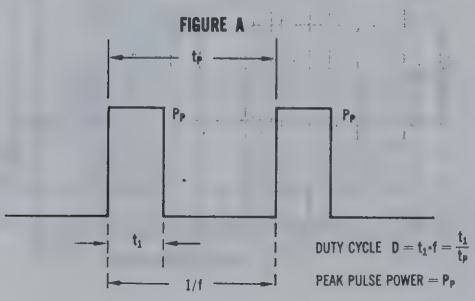
The data of Figure 11 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — TRANSIENT THERMAL RESISTANCE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC}.

Example:

The 2N5067 is dissipating 100 watts under the following conditions: $t_1 = 0.1$ ms, $t_p = 0.5$ ms. ($D = 0.2$)

Using Figure 12, at a pulse width of 0.1 ms and $D = 0.2$, the reading of $r(t_1, D)$ is 0.28.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_p \times \theta_{JC} = 0.28 \times 100 \times 2.0 = 56°C$$

2N5086 (SILICON)
2N5087



CASE 29 (1)
(TO-92)

PNP silicon annular transistors designed for low-level, low-noise amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous Peak	I_C	50 100	mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D	310	mW
Derate above 25°C		2.81	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS T_A = 25°C unless otherwise noted

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	50	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	50	-	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	-	-	10	nAdc
(V_{CB} = 35 Vdc, I_E = 0)			-	-	50	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N5086		150	-	500	
	2N5087		250	-	800	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5086		150	-	-	
	2N5087		250	-	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5086		150	-	-	
	2N5087		250	-	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	-	0.3	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc		$V_{BE(on)}$	-	-	0.85	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain – Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	2N5086	f_T	40	120	-	MHz
	2N5087		40	150	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	-	4.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N5086	h_{fe}	150	-	600	-
	2N5087		250	-	900	
Noise Figure		NF				dB
(I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz)	2N5086		-	-	3.0	
	2N5087		-	-	2.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz)	2N5086		-	1.2	3.0	
	2N5087		-	1.0	2.0	

NOISE FIGURE
V_{CE} = 5.0 Vdc, T_A = 25

FIGURE 1 – FREQUENCY EFFECTS

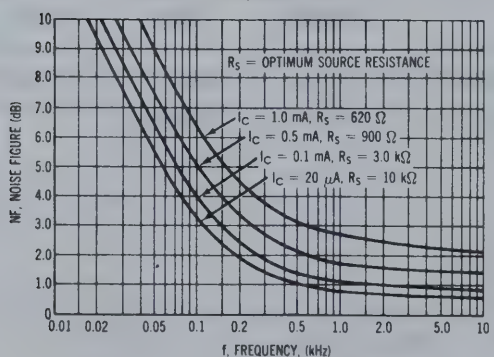
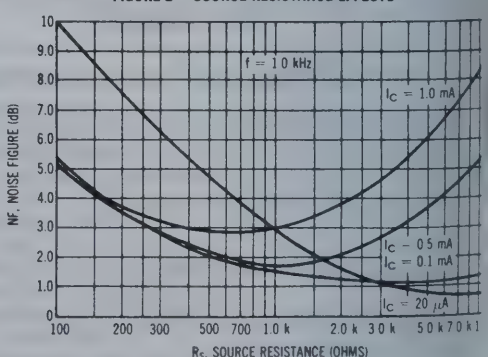


FIGURE 2 – SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C
(For Figures 3, 4, 5, 6, 8)

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number — the same units were used to develop curves on each graph.

FIGURE 3 — INPUT IMPEDANCE

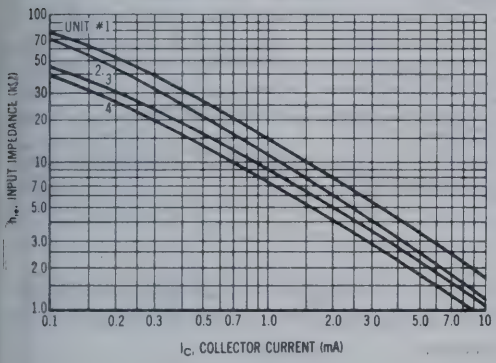


FIGURE 4 — VOLTAGE FEEDBACK RATIO

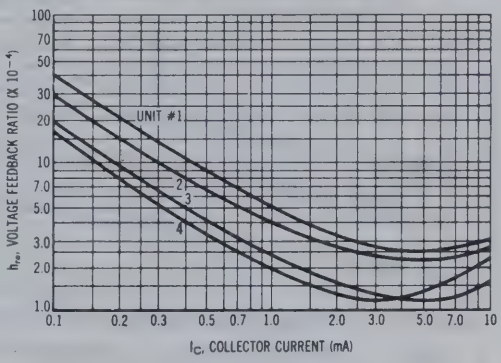


FIGURE 5 — CURRENT GAIN

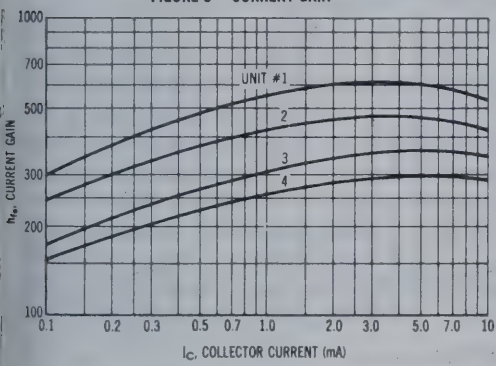


FIGURE 6 — OUTPUT ADMITTANCE

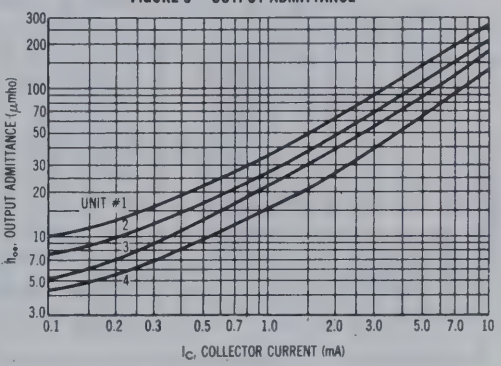


FIGURE 7 — EFFECT OF VOLTAGE

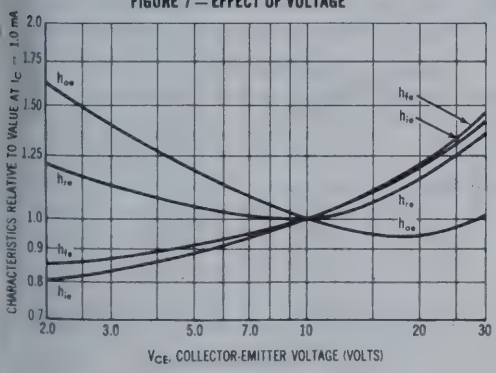


FIGURE 8 — DETERMINANT

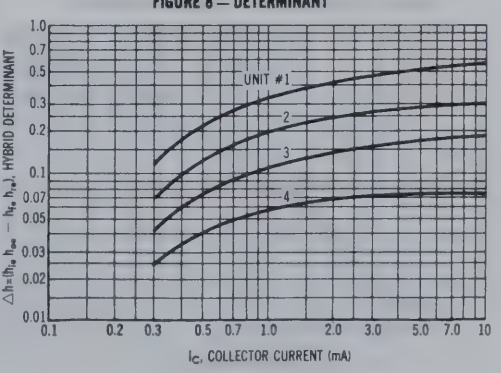


FIGURE 9 — DC CURRENT-GAIN

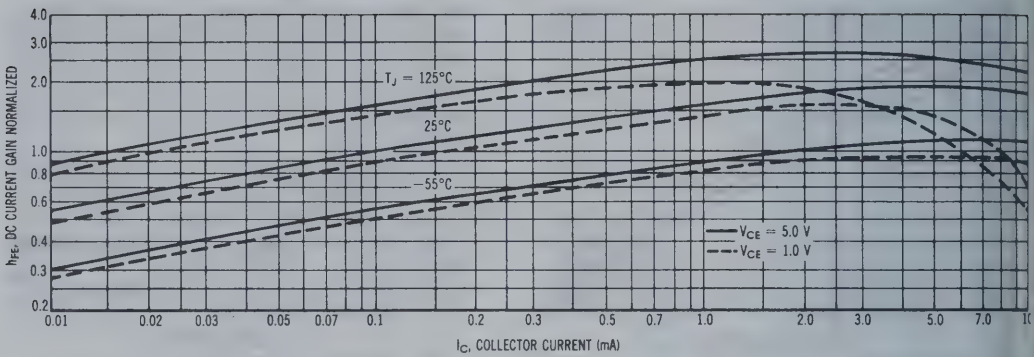


FIGURE 10 — COLLECTOR SATURATION REGION

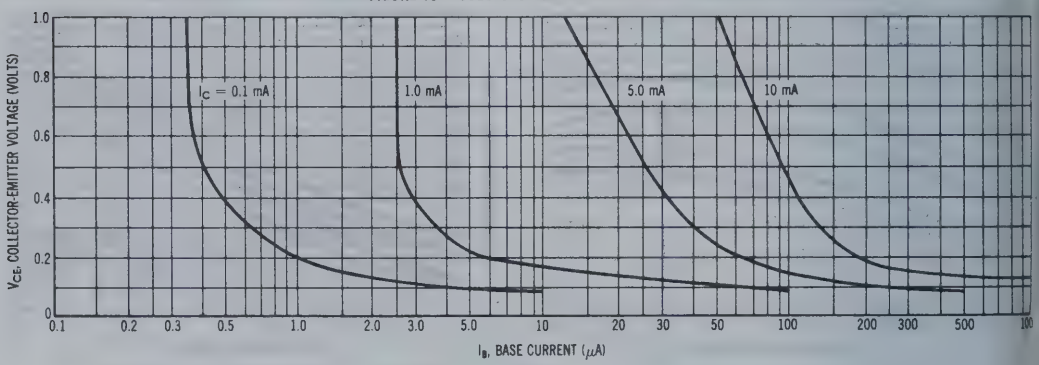


FIGURE 11 — CURRENT-GAIN — BANDWIDTH PRODUCT

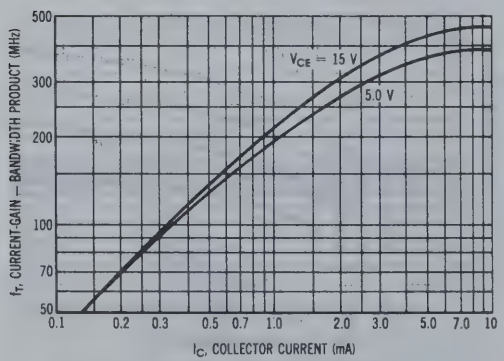
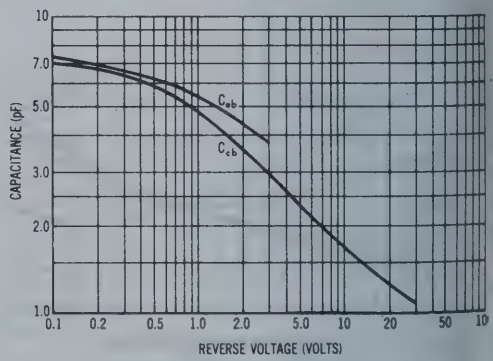


FIGURE 12 — CAPACITANCES



2N5088 (SILICON)
2N5089



CASE 29 (1)
(TO-92)

NPN silicon annular transistors designed for low-level, low-noise amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	2N5088	2N5089	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CB}	35	30	Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current	I_C	50		mAdc
Total Device Dissipation @T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	2N5088	BV_{CEO}	30	-	-	Vdc
	2N5089		25	-	-	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N5088	BV_{CBO}	35	-	-	Vdc
	2N5089		30	-	-	
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	2N5088	I_{CBO}	-	-	50	nAdc
(V_{CB} = 15 Vdc, I_E = 0)	2N5089		-	-	50	
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0)		I_{EBO}	-	-	50	nAdc
($V_{EB(off)}$ = 4.5 Vdc, I_C = 0)			-	-	100	
ON CHARACTERISTICS						
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N5088	h_{FE}	300	-	900	
	2N5089		400	-	1200	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5088		350	-	-	
	2N5089		450	-	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5088		300	-	-	
	2N5089		400	-	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	-	-	0.8	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain – Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz		f_T	50	175	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz, emitter guarded)		C_{cb}	-	1.8	4.0	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz, collector guarded)		C_{eb}	-	4.0	10	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N5088	h_{fe}	350	-	1400	-
	2N5089		450	-	1800	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz	2N5088	NF	-	-	3.0	dB
	2N5089		-	-	2.0	

NOISE FIGURE

V_{CE} = 5.0 Vdc, T_A = 25 °C

FIGURE 1 — FREQUENCY EFFECTS

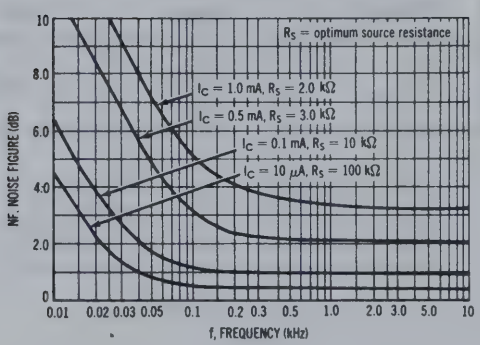
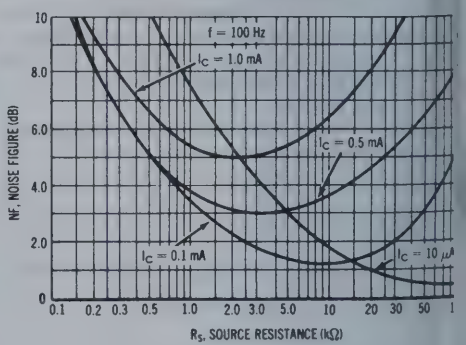


FIGURE 2 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C
(For Figures 3, 4, 5, 6, 8)

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number — the same units were used to develop curves on each graph.

FIGURE 3 — INPUT IMPEDANCE

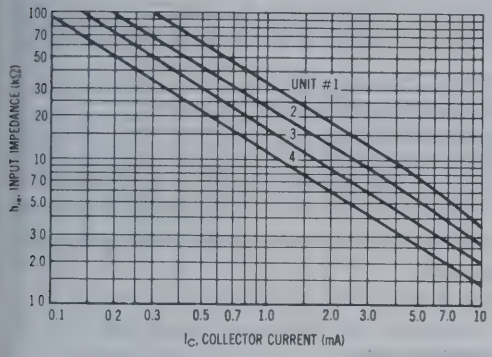


FIGURE 4 — VOLTAGE FEEDBACK RATIO

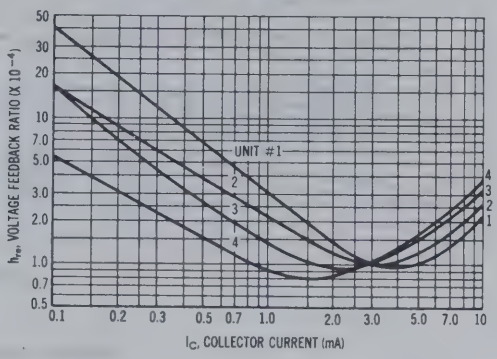


FIGURE 5 — CURRENT GAIN

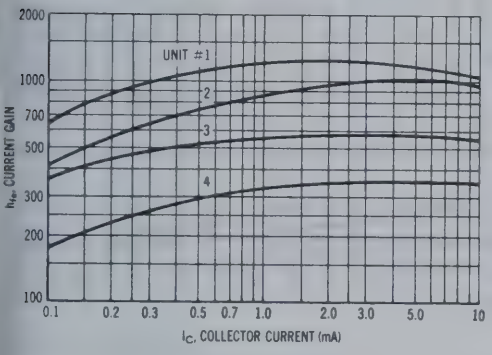


FIGURE 6 — OUTPUT ADMITTANCE

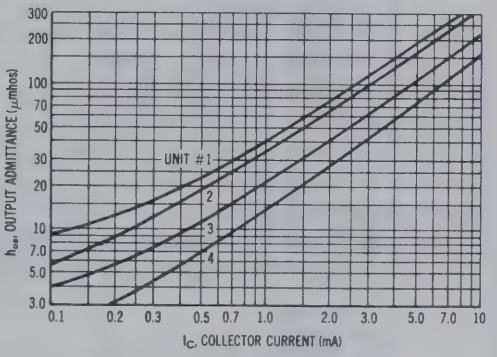


FIGURE 7 — EFFECT OF VOLTAGE

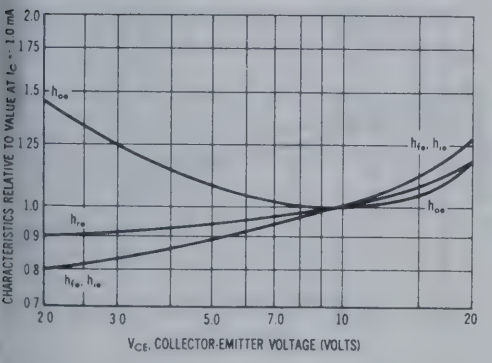


FIGURE 8 — DETERMINANT

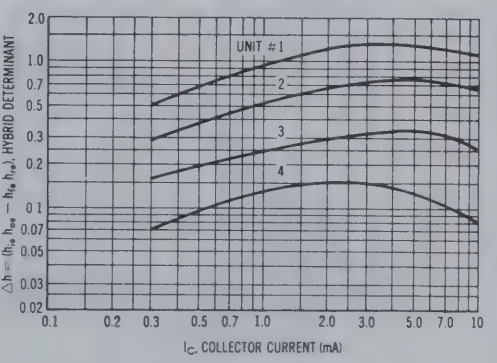


FIGURE 9 — DC CURRENT GAIN

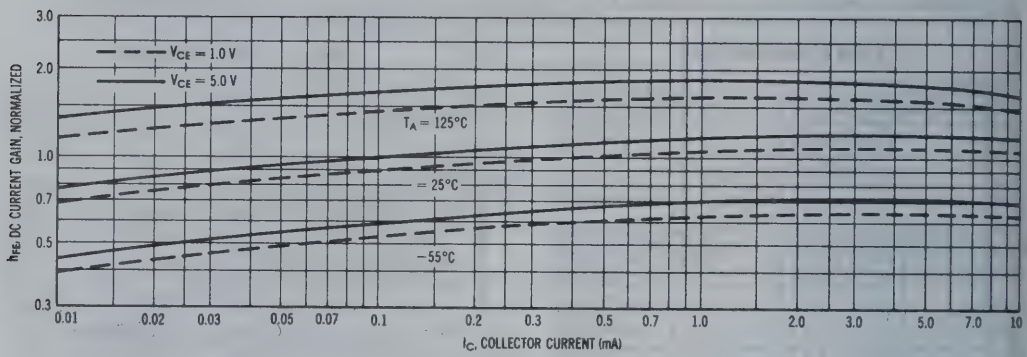


FIGURE 10 — COLLECTOR SATURATION REGION

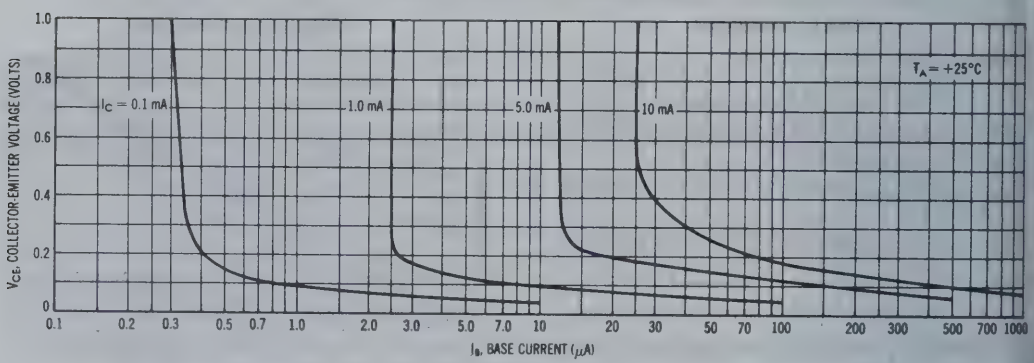


FIGURE 11 — CURRENT GAIN — BANDWIDTH PRODUCT

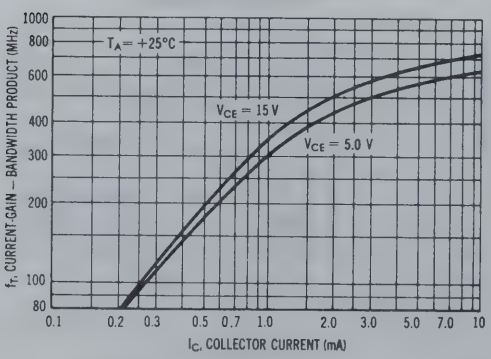
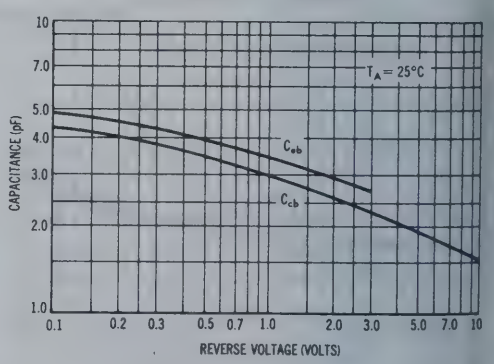


FIGURE 12 — CAPACITANCE



2N5090 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency-multiplier or oscillator circuits in Military or Industrial equipment. Suitable for use as output, driver or pre-driver stages in VHF and UHF equipment.

- 1.2 Watts Output Minimum at 400 MHz (7.8 dB Gain)
- 2.0 Watts Output Typical at 150 MHz (13 dB Gain)
- Multiple-Emitter Overlay Construction for Excellent High-Frequency Performance

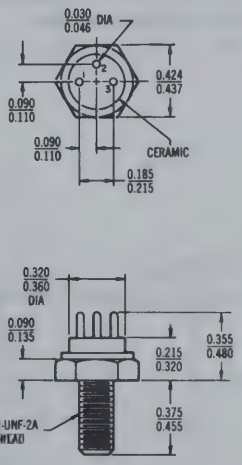
NPN SILICON RF POWER TRANSISTOR



*MAXIMUM RATINGS

Ratings	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current - Continuous	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 75^oC$ Derate above 75^oC	P_D	5.0 0.4	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.



Pin 1. Emitter
2. Base
3. Collector

CASE 36
TO-60

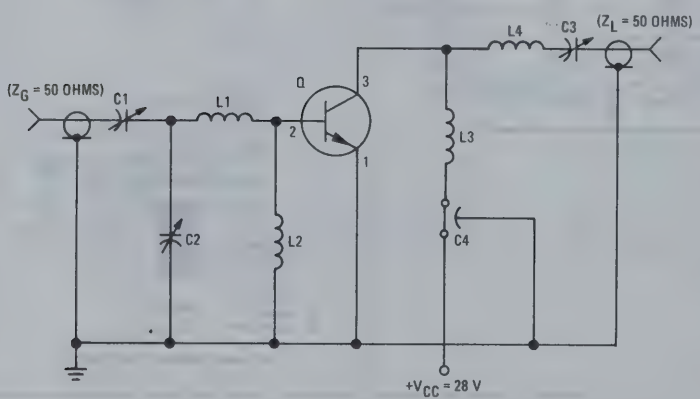
All Leads Isolated from Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	–	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, R_{BE} = 10 Ohms)	$V_{CER(sus)}$	55	–	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	–	20	μAdc
Collector Cutoff Current (V_{CE} = 55 Vdc, V_{BE} = –1.5 Vdc) (V_{CE} = 30 Vdc, V_{BE} = –1.5 Vdc, T_C = 200°C)	I_{CEX}	– –	0.1 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)	I_{EBO}	–	0.1	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc) (I_C = 360 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10 5.0	200 –	–
Collector-Emitter Saturation Voltage (I_C = 0.1 Adc, I_B = 20 mAdc)	$V_{CE(sat)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	3.5	pF
FUNCTIONAL TEST				
Power Input (Figure 1) (P_{out} = 1.2 Watts, R_L = 50 Ohms, f = 400 MHz)	P_{in}	–	0.2	Watt
Collector Efficiency (Figure 1) (P_{out} = 1.2 Watts, R_L = 50 Ohms, f = 400 MHz)	η	45	–	%

*Indicates JEDEC Registered Data.

FIGURE 1 – 400 MHz TEST CIRCUIT



C1 = 0.9–7.0 pF, ARCO 400 or equivalent
C2 = 1.5–20 pF, ARCO 402 or equivalent
C3 = 1.5–20 pF, ARCO 402 or equivalent
C4 = 1000 pF
L1 = 2 turns No. 18 AWG wire, 1/4" ID, 1/8" Long
L2 = RF Choke, 0.1 μH
L3 = 2 turns No. 18 AWG wire, 1/8" ID, 1/8" Long
L4 = 3 turns No. 16 AWG wire, 1/4" ID, 3/8" Long

FIGURE 2 – POWER OUTPUT versus FREQUENCY

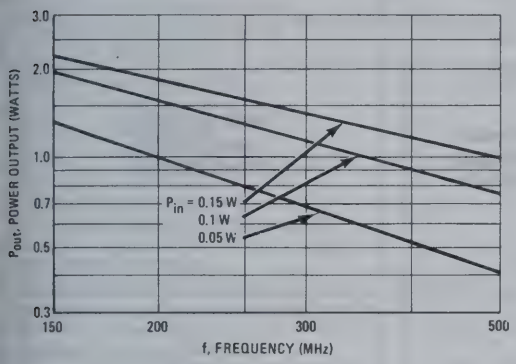


FIGURE 3 – POWER OUTPUT versus POWER INPUT

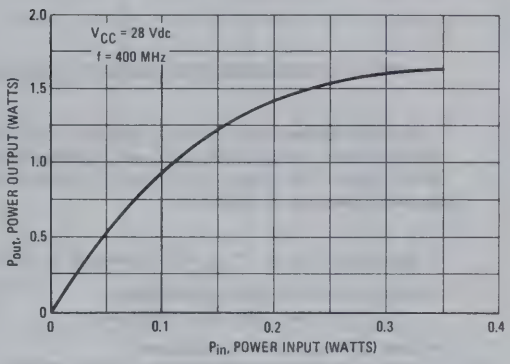


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

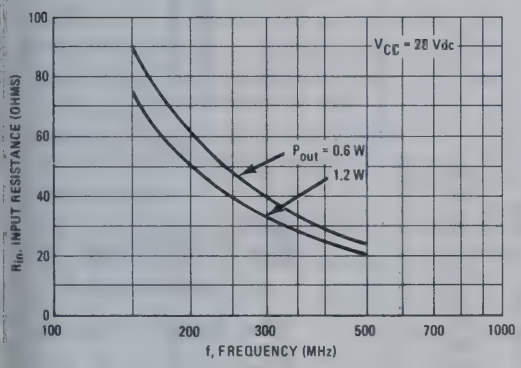


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

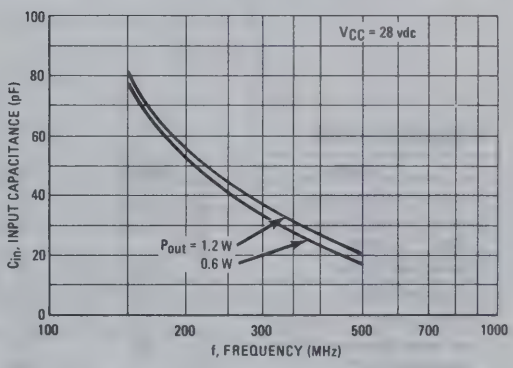
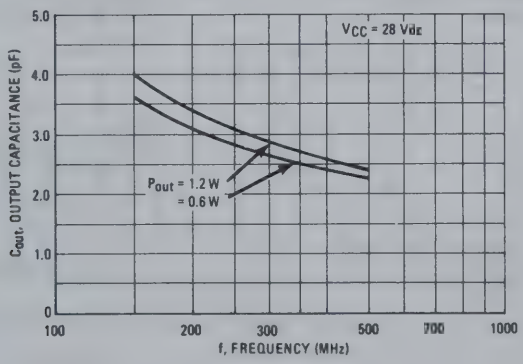


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



2N5108 (SILICON)

NPN SILICON HIGH-FREQUENCY TRANSISTOR

. . . designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output, driver, or pre-driver stages in UHF equipment and as a fundamental frequency oscillator at 1.68 GHz.

- High Power Output – P_{out} = 1.0 W (Min) @ f = 1.0 GHz
- High Current-Gain–Bandwidth Product – f_T = 1200 MHz (Min) @ I_C = 50 mAdc
- Ideal for Radio Sonde Applications – P_{out} (oscillator) = 300 mW (Typ) @ f = 1.68 GHz

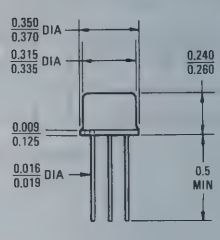
NPN SILICON AMPLIFIER TRANSISTOR

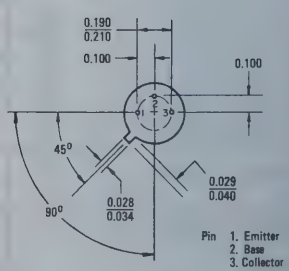


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
*Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CER}	55	Vdc
*Collector-Base Voltage	V_{CB}	55	Vdc
*Emitter-Base Voltage	V_{EB}	3.0	Vdc
*Collector Current – Continuous	I_C	0.4	Adc
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 0.02	Watts W/°C
*Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.





CASE 79(1)
(TO-39)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, R_{BE} = 10 ohms)	$V_{CER(sus)}$	55	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	55	–	–	Vdc
*Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
*Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–	–	20	μAdc
*Collector Cutoff Current (V_{CE} = 50 Vdc, V_{BE} = 0) (V_{CE} = 15 Vdc, V_{BE} = 0, T_C = 150°C)	I_{CES}	– –	– –	1.0 10	μAdc mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS					
*Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	1200	–	–	MHz
*Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	1.3	3.0	pF
FUNCTIONAL TEST					
*Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 1.0 W, V_{CC} = 28 Vdc, I_C = 102 mAdc, f = 1.0 GHz)	G_{PE}	5.0	–	–	dB
Power Output (Figure 1) (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	P_{out}	1.0	–	–	Watt
*Collector Efficiency (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	η	35	–	–	%
Power Output (Oscillator) (Figure 2) (V_{CE} = 20 Vdc, V_{EB} = 1.5 Vdc, f = 1.68 GHz) (Minimum Efficiency = 15%)	P_{out}	–	0.3	–	Watt

*Indicates JEDEC Registered Data.

FIGURE 1 – 1 GHz RF AMPLIFIER POWER OUTPUT TEST CIRCUIT

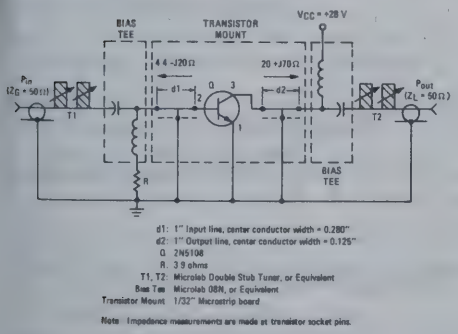


FIGURE 2 – 1.68 GHz RF OSCILLATOR POWER OUTPUT TEST CIRCUIT

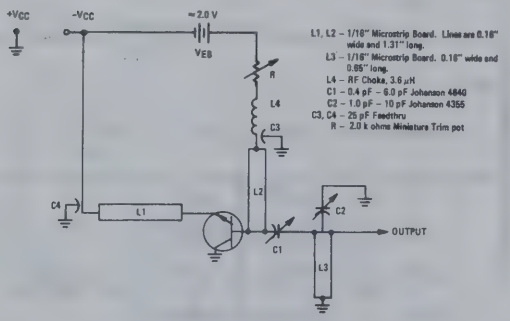


FIGURE 3 – POWER OUTPUT versus POWER INPUT

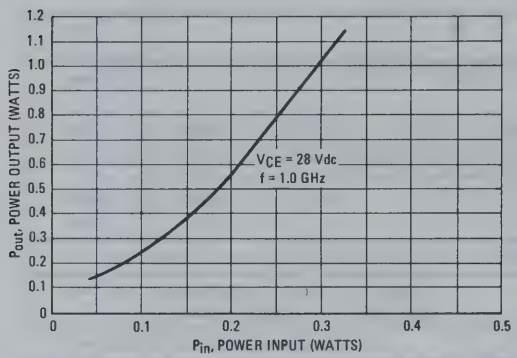


FIGURE 4 – POWER OUTPUT versus FREQUENCY

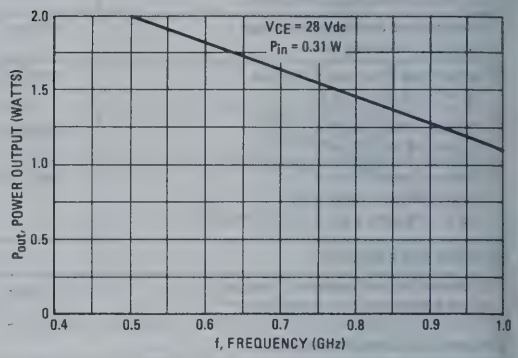


FIGURE 5 – POWER OUTPUT versus COLLECTOR-EMITTER VOLTAGE

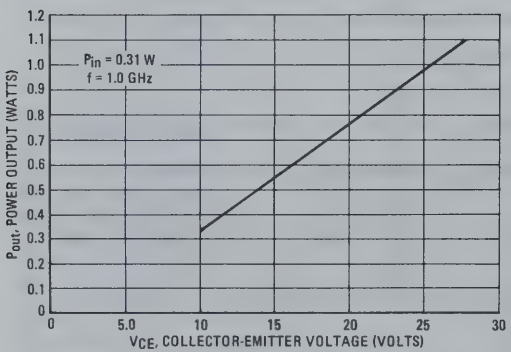


FIGURE 6 – OSCILLATOR POWER OUTPUT versus COLLECTOR CURRENT

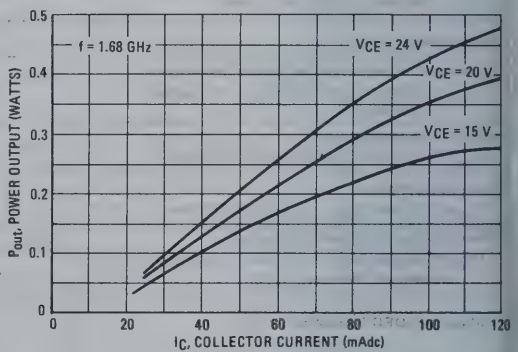


FIGURE 7 CURRENT-GAIN–BANDWIDTH PRODUCT versus CURRENT

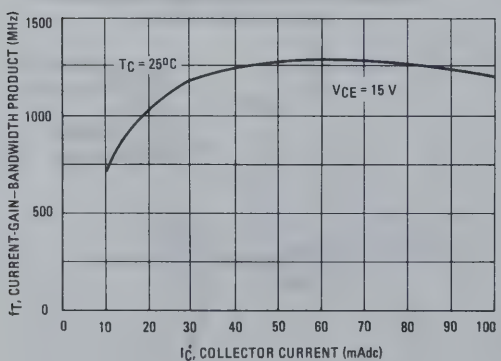
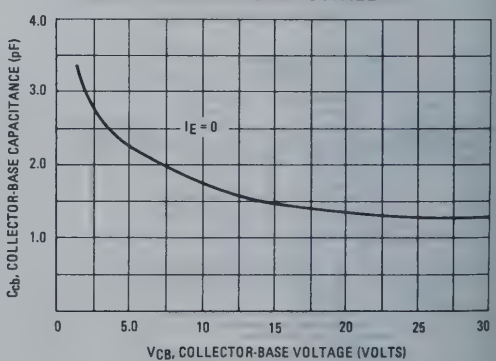
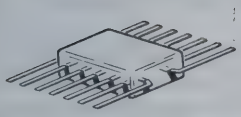


FIGURE 8 COLLECTOR BASE CAPACITANCE versus VOLTAGE

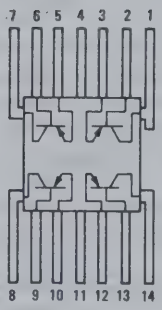


2N5146 (SILICON)

Quad PNP silicon annular transistor designed for medium-current, high-speed switching and driver applications.



CASE 83
(TO-86)



Lead 1 identified by color dot or by elbow on lead. All leads electrically isolated from package.

MAXIMUM RATINGS (each device)

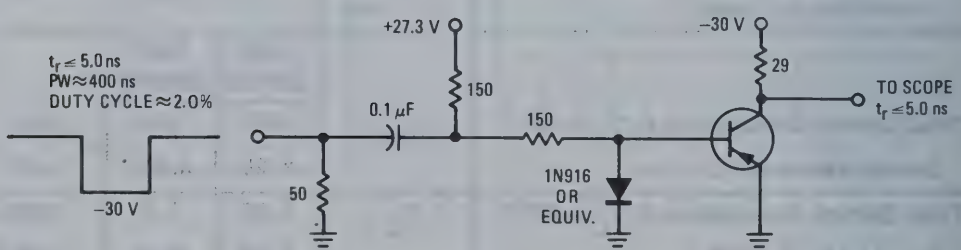
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.5		Adc
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D	400	500	mW
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.25	5.0	Watts
Derate above 25°C		7.15	28.6	mW/°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	40		-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40		-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0		-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	I_{CEX}	-	30	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	30	100	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	I_{BL}	-	-	200	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}*	20	40	-	-
Collector-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$*	-	0.7	1.0	Vdc
Base-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$*	-	1.1	1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	250	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	11	20	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	-	60	80	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = 1.0 Adc, I_{B1} = 0.1 Adc)	t_d	-	7.0	10	ns
Rise Time		t_r	-	15	30	ns
Storage Time	(I_C = 1.0 Adc, I_{B1} = I_{B2} = 0.1 Adc)	t_s	-	30	80	ns
Fall Time		t_f	-	16	30	ns

* Pulse test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



2N5155 (GERMANIUM)

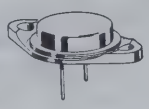
PNP GERMANIUM POWER TRANSISTORS

. . . designed for high-current switching applications requiring low saturation voltages, fast switching times and above average Collector-Emitter Sustaining capability.

- Alloy Diffused Epitaxial Construction
- Low Saturation Voltages —
  $V_{CE(sat)}$ = 0.9 Vdc (Max) @ I_C = 25 Adc
  $V_{BE(sat)}$ = 1.4 Vdc (Max) @ I_C = 25 Adc
- DC Current Gain —
  h_{FE} = 25 (Min) @ I_C = 8.0 Adc

25 AMPERE
PNP ADE GERMANIUM POWER TRANSISTOR

140 VOLTS
106 WATTS



*MAXIMUM RATINGS

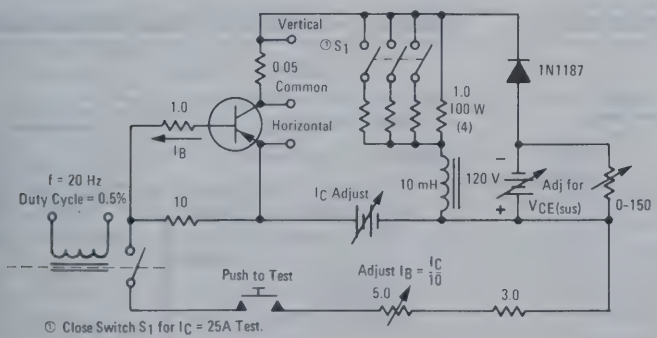
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	120	Vdc
Collector-Base Voltage	V_{CB}	140	Vdc
Emitter-Base Voltage	V_{EB}	1.5	Vdc
Collector Current - Continuous ** - Continuous - Peak	I_C	15 25 25	Adc
Base Current - Continuous	I_B	5.0	Adc
**Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	106 1.25	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

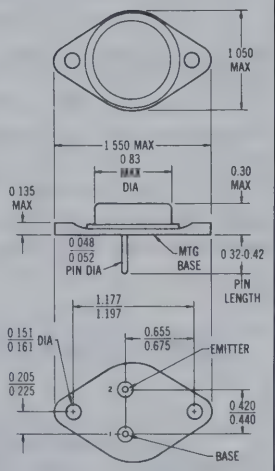
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

*Indicates JEDEC Registered Data.
**Motorola guarantees this data in addition to the JEDEC Registered data shown.

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT



① Close Switch S_1 for I_C = 25A Test.



Collector Connected to Case
CASE 11A
(TO-3)
Except Pin Diameter

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
*Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	120	-	Vdc
*Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 8.0 Adc, R_{EB} = 10 Ohms)	$V_{CE(sus)}$	120	-	Vdc
(I_C = 25 Adc, R_{EB} = 10 Ohms)		80	-	
*Collector Cutoff Current (V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	I_{CEX}	-	10	mAdc
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)		-	25	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	I_{CBO}	-	200	μAdc
*Emitter Cutoff Current (V_{EB} = 1.5 Vdc, I_C = 0)	I_{EBO}	-	500	mAdc
ON CHARACTERISTICS				
*DC Current Gain (I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	-
*Collector-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)	$V_{CE(sat)}$	-	0.9	Vdc
*Base-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)	$V_{BE(sat)}$	-	1.4	Vdc
Pulse Energy Test (Note 1) (See Figure 2) (I_C = 4.2 Adc, V_{CE} = 30 Vdc)	PET	1.26	-	Joule
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc, f = 50 kHz)	f_T	100	-	kHz
SWITCHING CHARACTERISTICS				
Rise Time	t_r	-	18	μs
Storage Time (V_{CC} = -12 Vdc, I_C = 10 Adc, I_{B1} = 1.0 Adc, I_{B2} = 1.0 Adc) (See Figure 3)	t_s	-	12	μs
Fall Time	t_f	-	18	μs

*Indicates JEDEC Registered Data.
Note 1: Pulse Test: Pulse Width = 10 ms, Duty Cycle = 2.5%.

FIGURE 2 – PULSE ENERGY TEST CIRCUIT

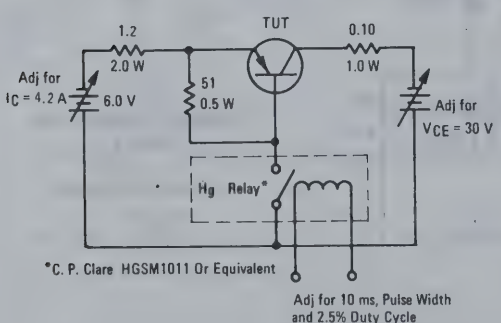
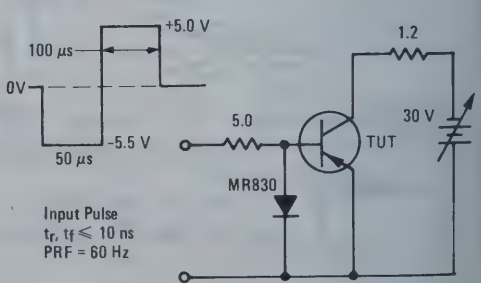


FIGURE 3 – SWITCHING TIME TEST CIRCUIT



2N5160 (SILICON)



CASE 79
(TO-39)

Collector connected to case

PNP silicon RF power transistors designed for amplifier, frequency multiplier or oscillator applications in military and industrial equipment. Suitable for use as Class A, B, or C output driver, or pre-driver stages in VHF and UHF.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$BV_{CEO(sus)}$	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	-	-	20	μAdc
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 0)	I_{CES}	-	-	0.1	mAdc
Collector Cutoff Current (V_{CB} = 28 Vdc, I_E = 0)	I_{CBO}	-	-	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	-	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	900	-	MHz
Collector-Base Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	-	2.5	4.0	pF
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz) (V_{CE} = 28 Vdc, P_{in} = 50 mW, f = 175 MHz)	G_{PE}	8.0 -	8.8 14.5	- -	dB
Power Output (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz) (V_{CE} = 28 Vdc, P_{in} = 50 mW, f = 175 MHz)	P_{out}	1.0 -	1.2 1.4	- -	Watt
Collector Efficiency (V_{CE} = 28 Vdc, P_{in} = 0.16 Watt, f = 400 MHz)	η	45	55	-	%

FIGURE 1 – 400-MHz TEST CIRCUIT

C_1 – 10 pF
C_2, C_3, C_4, C_5 – 1.0 – 10 pF variable
C_6 – 2400 pF feed through
C_7 – 0.004 μF
C_8 – 0.01 μF
L_1 – 30 nH, 1 turn, No. 20 AWG
L_2 – 75 nH, 3 turns, No. 20 AWG
L_3 – 0.33 μH, R.F.C.

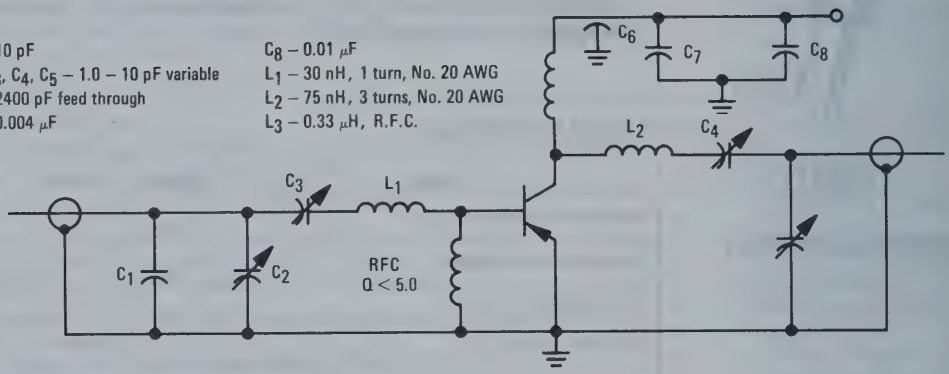


FIGURE 2 – POWER OUTPUT versus FREQUENCY

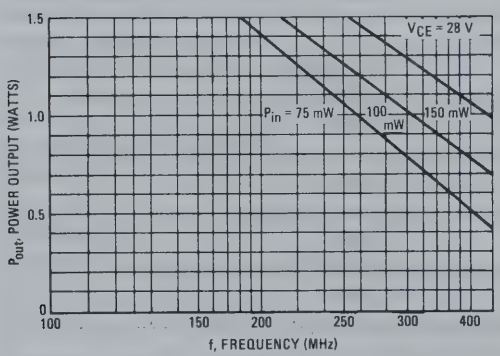


FIGURE 3 – POWER OUTPUT versus POWER INPUT

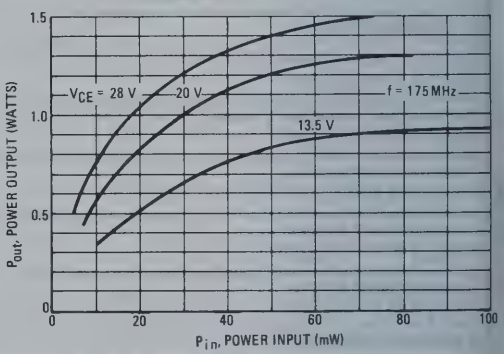


FIGURE 4 – PARALLEL INPUT IMPEDANCE versus FREQUENCY

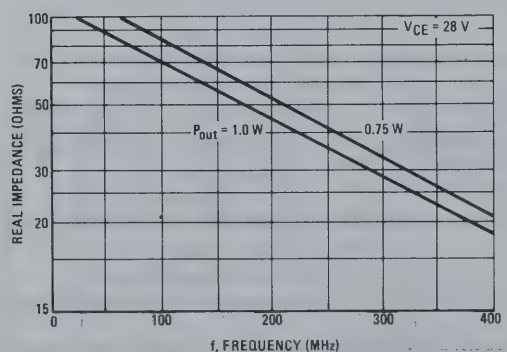


FIGURE 5 – PARALLEL INPUT IMPEDANCE versus FREQUENCY

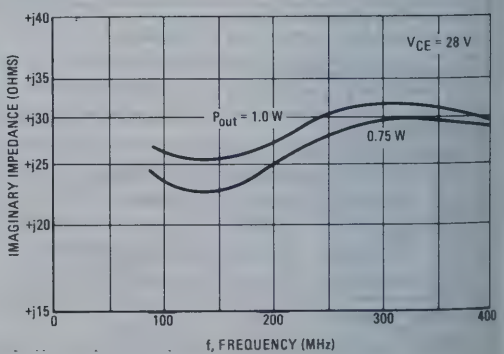


FIGURE 6 – PARALLEL OUTPUT CAPACITANCE versus FREQUENCY

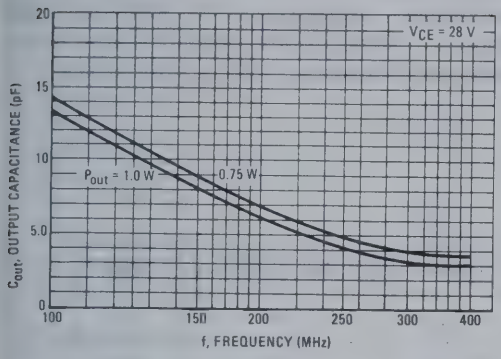


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT versus COLLECTOR CURRENT

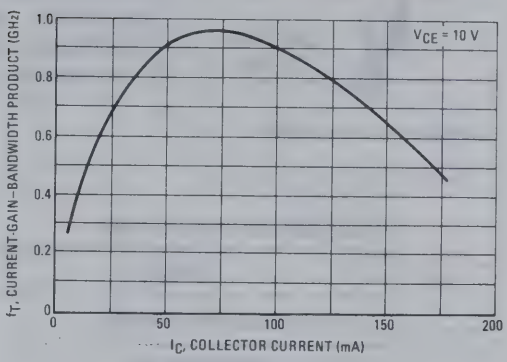


FIGURE 8 – 2N5160 300-MHz COMPLEMENTARY POWER OUTPUT CIRCUIT

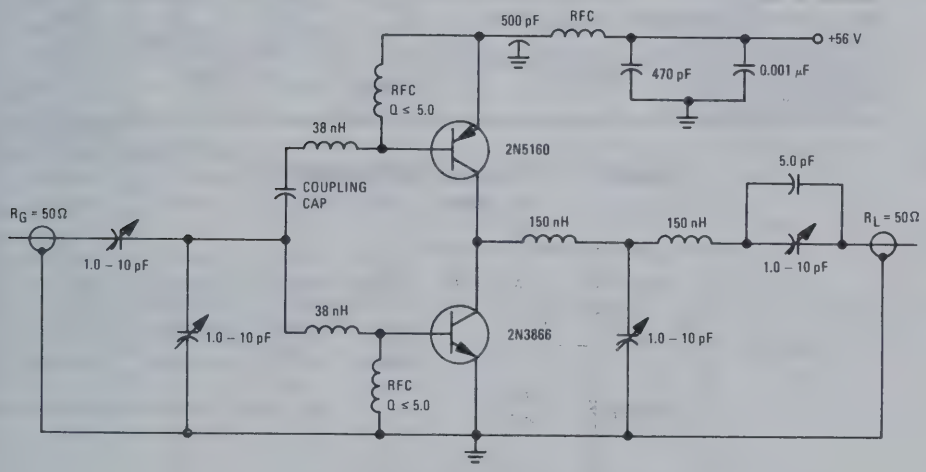
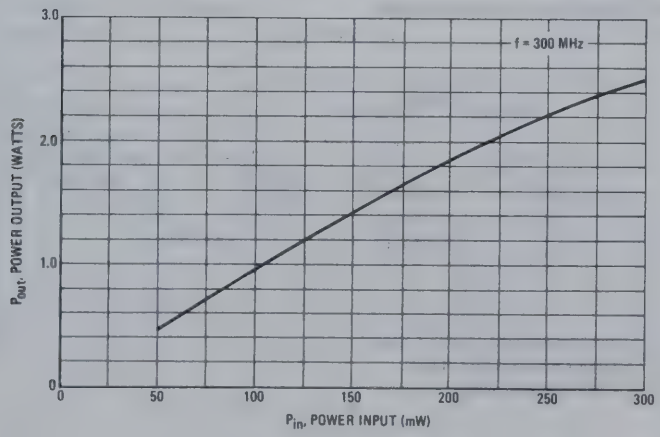


FIGURE 9 – COMPLEMENTARY CIRCUIT – POWER OUTPUT versus POWER INPUT



2N5161 (SILICON)
2N5162



CASE 36
(TO-60)

Case common to emitter

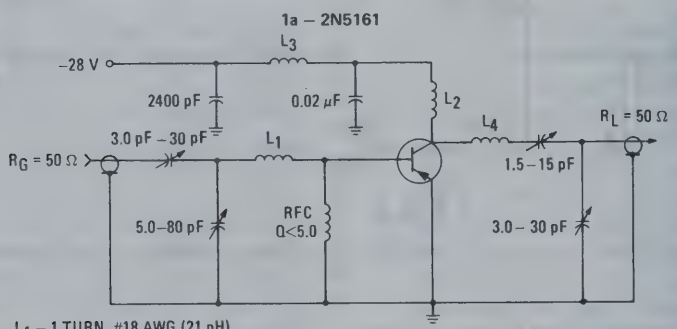
PNP silicon RF power transistors designed for amplifier or oscillator applications in military and industrial equipment. Suitable for use as Class B or C output or power oscillator in VHF applications.

MAXIMUM RATINGS

Rating	Symbol	2N5161	2N5162	Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current	I_C	1.5	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	20 0.114	50 0.286	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

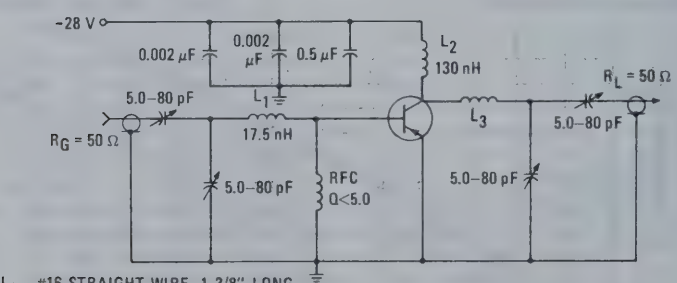
FIGURE 1 – 175 MHz TEST CIRCUITS

1a – 2N5161



L_1 – 1 TURN, #18 AWG (21 nH)
L_2, L_3 – 0.33 μH RFC
L_4 – 4 TURNS, #16 AWG, ½" I.D. (200 nH)

1b – 2N5162



L_1 – #16 STRAIGHT WIRE, 1 3/8" LONG.
L_2 – 5 TURNS #20 AWG, 1/2" LONG.
L_3 – 1 TURN #18 AWG WIRE.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	40	-	-	Vdc
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	2N5161		4.0	-	-	
(I_E = 5.0 mAdc, I_C = 0)	2N5162		4.0	-	-	
Collector Cutoff Current		I_{CES}				mAdc
(V_{CE} = 60 Vdc, V_{BE} = 0)	2N5161		-	-	0.5	
	2N5162		-	-	1.0	
(V_{CE} = 28 Vdc, V_{BE} = 0, T_C = 200°C)	2N5161		-	-	5.0	
	2N5162		-	-	10	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 28 Vdc, I_E = 0)	2N5161		-	-	0.1	
	2N5162		-	-	0.2	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	2N5161		10	-	-	
(I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	2N5162		10	-	-	
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 200 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N5161		-	500	-	
(I_C = 500 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N5162		-	500	-	
Output Capacitance		C_{ob}				pF
(V_{CB} = 28 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	2N5161		-	10	15	
	2N5162		-	45	60	
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain		G_{PE}				dB
(V_{CC} = 28 Vdc, P_{out} = 7.5 Watts, f = 175 MHz)	2N5161		8.75	10.3	-	
(V_{CC} = 28 Vdc, P_{out} = 30 Watts, f = 175 MHz)	2N5162		6.0	7.0	-	
Power Output		P_{out}				Watts
(V_{CC} = 28 Vdc, P_{in} = 1.0 Watt, f = 175 MHz)	2N5161		7.5	8.5	-	
(V_{CC} = 28 Vdc, P_{in} = 7.5 Watts, f = 175 MHz)	2N5162		30	35	-	
Collector Efficiency		η				%
(V_{CC} = 28 Vdc, P_{out} = 7.5 Watts, f = 175 MHz)	2N5161		45	-	-	
(V_{CC} = 28 Vdc, P_{out} = 30 Watts, f = 175 MHz)	2N5162		55	-	-	

* Pulsed through 25 mH inductor

2N5161 DESIGN DATA

FIGURE 2 – POWER OUTPUT versus FREQUENCY

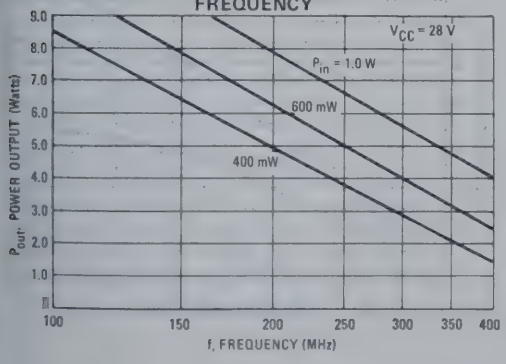
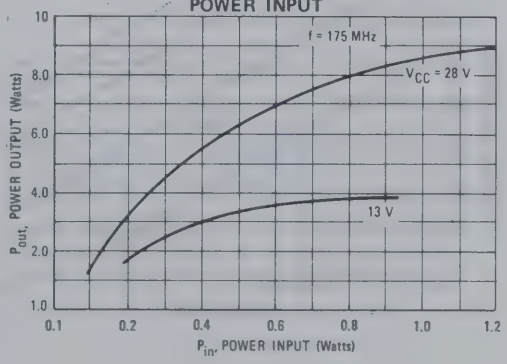


FIGURE 3 – POWER OUTPUT versus POWER INPUT



LARGE SIGNAL IMPEDANCE DATA

FIGURE 4 – REAL SERIES INPUT RESISTANCE versus FREQUENCY

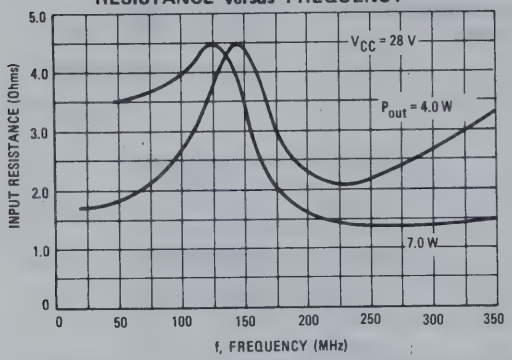


FIGURE 5 – IMAGINARY SERIES INPUT REACTANCE versus FREQUENCY

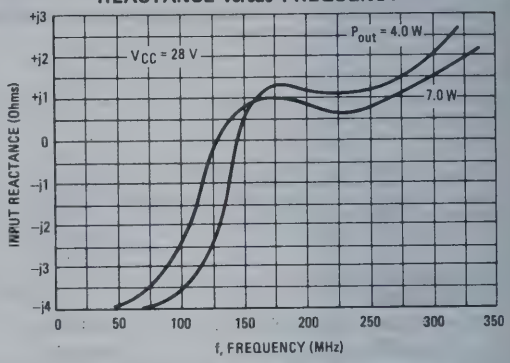
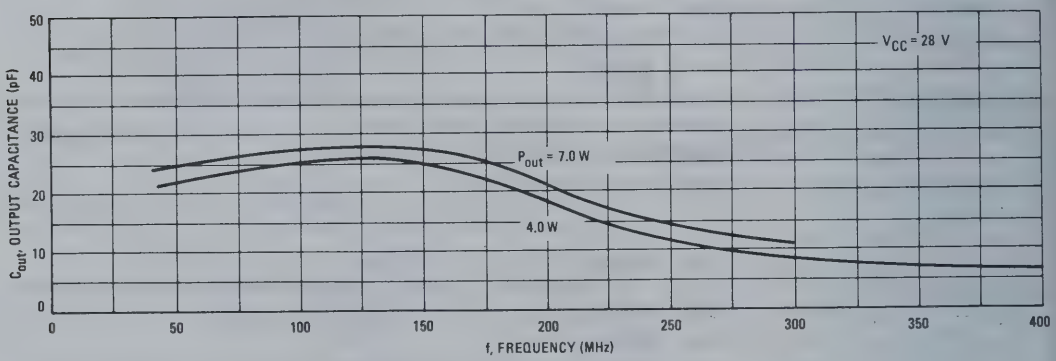


FIGURE 6 – OUTPUT CAPACITANCE versus FREQUENCY



2N5162 DESIGN DATA

FIGURE 7 – POWER OUTPUT versus FREQUENCY

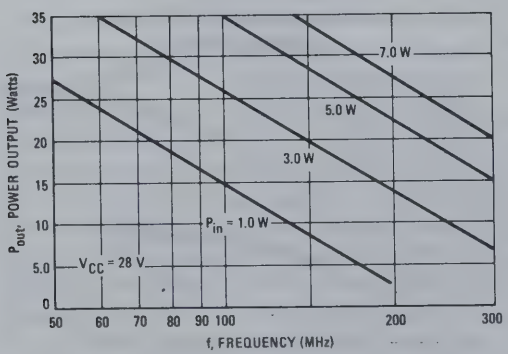
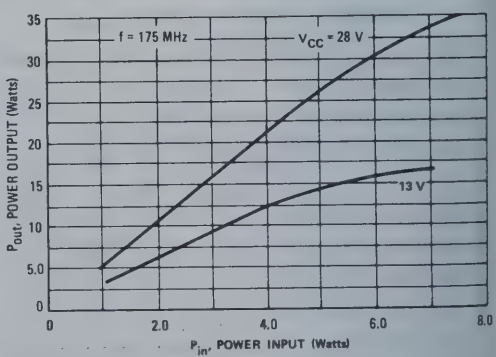


FIGURE 8 – POWER OUTPUT versus POWER INPUT



LARGE SIGNAL IMPEDANCE DATA

FIGURE 9 – REAL SERIES INPUT RESISTANCE versus FREQUENCY

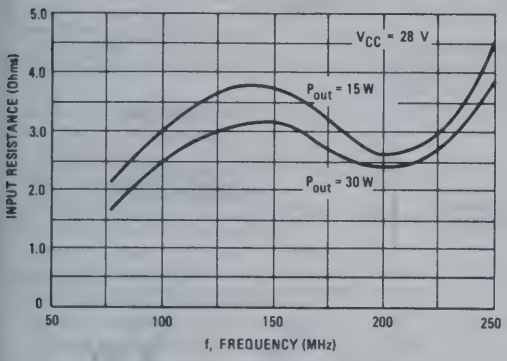


FIGURE 10 – IMAGINARY SERIES INPUT REACTANCE versus FREQUENCY

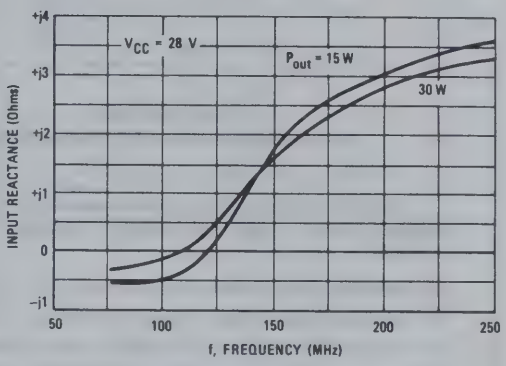
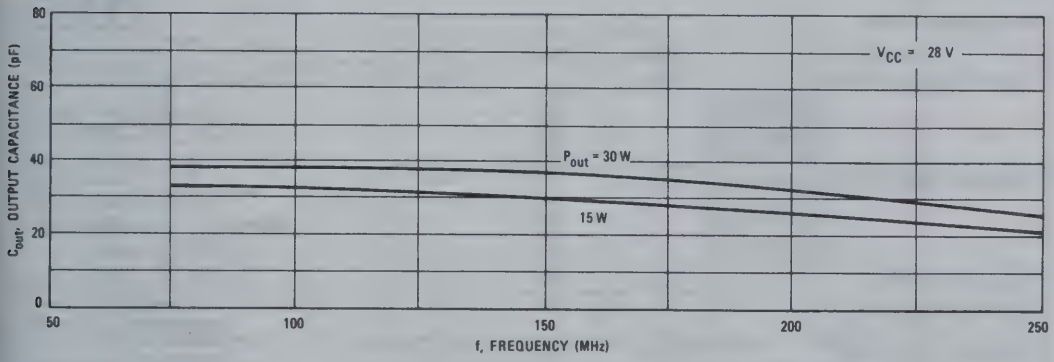


FIGURE 11 – OUTPUT CAPACITANCE versus FREQUENCY



2N5164 thru 2N5171 (SILICON)
2N5164R thru 2N5171R

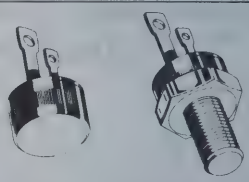
THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies, battery chargers, temperature, motor, light and welder controls.

- Supplied in Either Pressfit or Stud Package
- High Surge Current Rating — I_{TSM} = 240 Amp
- Low On-State Voltage — 1.2 V (Typ) @ I_{TM} = 20 Amp
- Practical Level Triggering and Holding Characteristics — 10 mA (Typ) @ T_C = 25°C

THYRISTORS
PNPN

50–600 VOLTS
20 AMPERES RMS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Peak Reverse Blocking Voltage (1) 2N5164,2N5168 2N5165,2N5169 2N5166,2N5170 2N5167,2N5171	V_{RRM}	 50 200 400 600	Volts
*Non-repetitive Peak Reverse Blocking Voltage 2N5164,2N5168 2N5165,2N5169 2N5166,2N5170 2N5167,2N5171	V_{RSM}	 75 300 500 700	Volts
Forward Current RMS	$I_{T(RMS)}$	20	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t ≤ 8.3 ms)	I^2t	235	A^2s
*Peak Forward Surge Current (One cycle, 60 Hz, T_J = -40 to +100°C)	I_{TSM}	240	Amp
*Peak Forward Gate Power	P_{GFM}	5.0	Watts
*Average Forward Gate Power	$P_{GF(AV)}$	0.5	Watt
*Peak Forward Gate Current	I_{GFM}	2.0	Amp
Peak Gate Voltage — Forward (2) Reverse	V_{GFM} V_{GRM}	10 10	Volts
*Operating Junction Temperature Range	T_J	-40 to +100	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque (3) 2N5168-2N5171		30	in. lb.

THERMAL CHARACTERISTICS

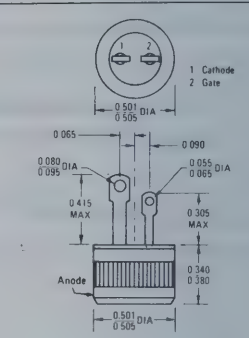
Characteristic	Symbol	Typ	Max	Unit
*Thermal Resistance, Junction to Case 2N5164,65,66,67 2N5168,69,70,71	θ_{JC}	 1.0 1.1	 1.5 1.6	°C/W

*Indicates JEDEC Registered Data.

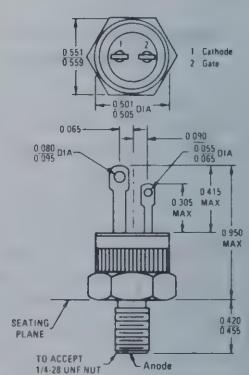
(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage applied exceeds the rated blocking voltage.

(2) Devices should not be operated with a positive bias applied to the gate concurrent with a negative potential applied to the anode.

(3) Reliable operation can be impaired if torque rating is exceeded, terminal tubes bent, or glass seal broken.



CASE 174 (1)



CASE 175 (1)

For "R Suffix devices: e.g., 2N5164R, the cathode and anode terminals are reversed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
*Peak Forward Blocking Voltage (T_J = 100°C) 2N5164, 2N5168	V_{DRM}(1)	50	–	Volts
2N5165, 2N5169		200	–	
2N5166, 2N5170		400	–	
2N5167, 2N5171		600	–	
*Peak Forward Blocking Current (Rated V_{DRM} @ T_J = 100°C, gate open)	I_{DRM}	–	5.0	mA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_J = 100°C, gate open)	I_{RRM}	–	5.0	mA
Gate Trigger Current (Continuous dc)	I_{GT}(2)			mA
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω)		–	40	
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_C = -40°C)		–	75	
Gate Trigger Voltage (Continuous dc)	V_{GT}			Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω)		–	1.5	
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_C = -40°C)		–	2.5	
*(Anode Voltage = Rated V_{DRM}, R_L = 100 Ω, T_J = 100°C)	V_{GD}	0.2	–	
Forward "ON" Voltage (pulsed, 1.0 ms max, duty cycle ≤1%)	V_{TM}			Volts
(I_{TM} = 20 A)		–	1.5	
(I_{TM} = 41 A)		–	1.7	
Holding Current	I_H			mA
(Anode Voltage = 7.0 Vdc, gate open)		–	50	
*(Anode Voltage = 7.0 Vdc, gate open, T_C = -40°C)		–	90	
Turn-On Time (t_d + t_r)		TYPICAL		
(I_{TM} = 20 A, I_{GT} = 40 mAdc)	t_{on}	1.0		μs
Turn-Off Time	t_{off}			μs
(I_{TM} = 10 A, I_R = 10 A)		20		
(I_{TM} = 10 A, I_R = 10 A, T_J = 100°C) (V_{DRM} = rated voltage) (dv/dt = 30 V/μs)		30		
Forward Voltage Application Rate (Gate open, T_J = 100°C)	dv/dt	50		V/μs

*Indicates JEDEC Registered Data.

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. These devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) For optimum operation, i.e. faster turn-on, lower switching losses, best di/dt capability, recommended I_{GT} = 200 mA.

EFFECT OF TEMPERATURE UPON TYPICAL TRIGGER CHARACTERISTICS

FIGURE 1 – GATE TRIGGER CURRENT

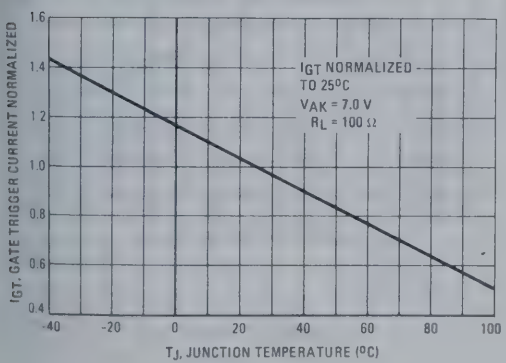
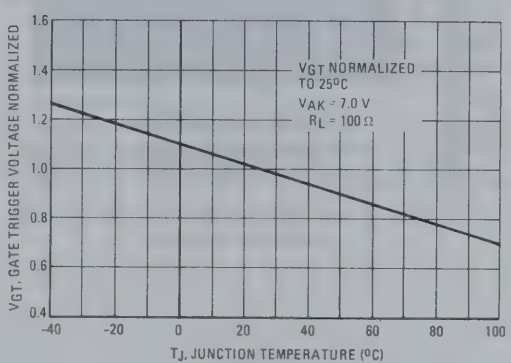


FIGURE 2 – GATE TRIGGER VOLTAGE



MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT

FIGURE 3 – 60 Hz SURGES

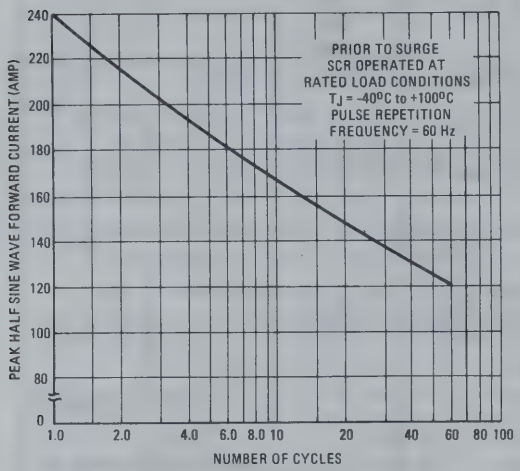


FIGURE 4 – SUB-CYCLE SURGES

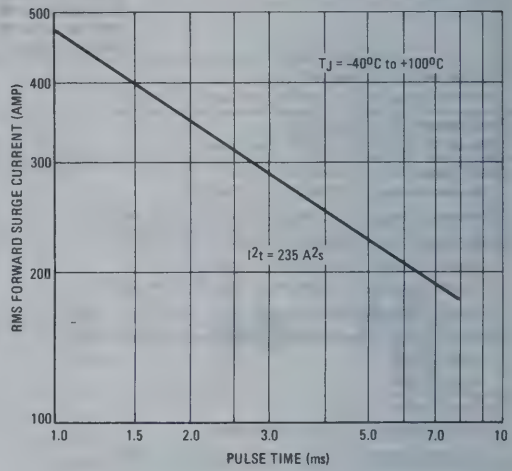


FIGURE 5 – GATE TRIGGER CHARACTERISTICS

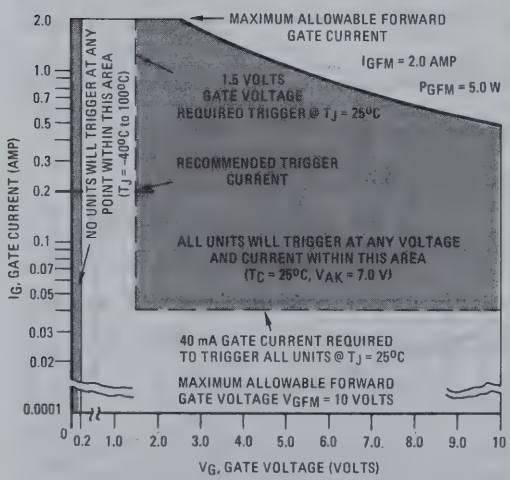
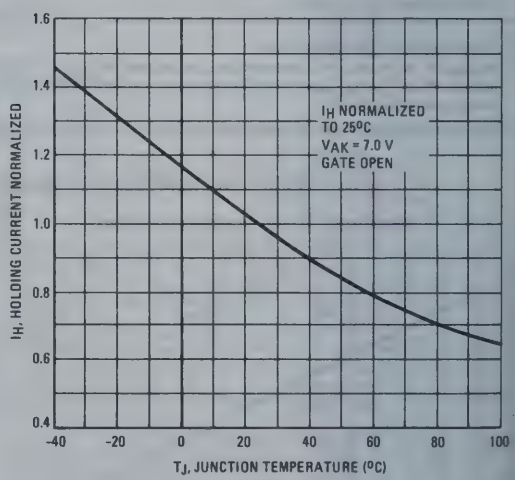


FIGURE 6 – EFFECT OF TEMPERATURE ON TYPICAL HOLDING CURRENT



DERATING AND DISSIPATION FOR RESISTIVE AND INDUCTIVE LOADS (f = 60 to 400 Hz, SINE WAVE)

FIGURE 7 – CURRENT DERATING(1)

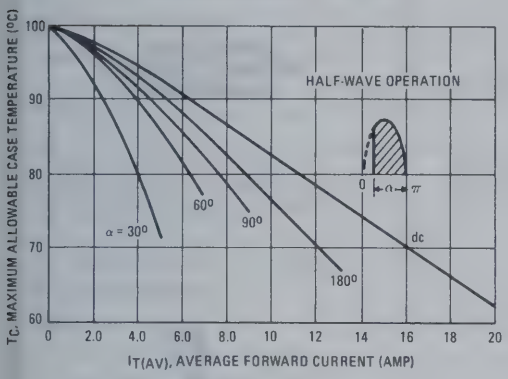


FIGURE 8 – FORWARD POWER DISSIPATION

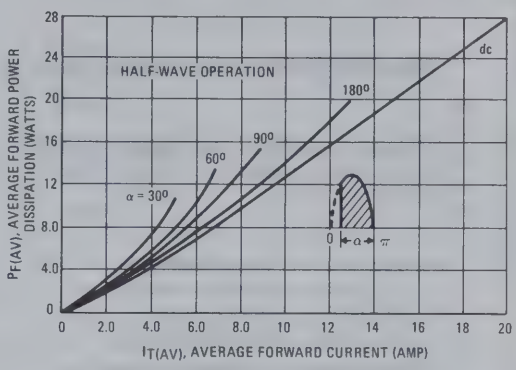


FIGURE 9 – FORWARD CONDUCTION CHARACTERISTICS

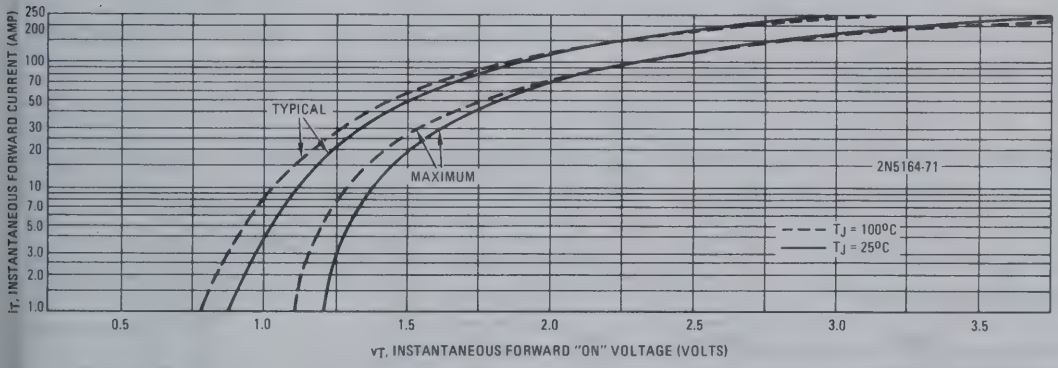
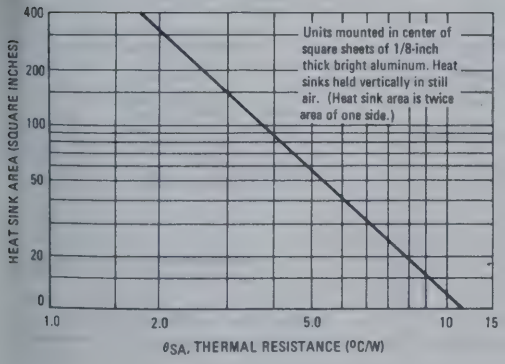


FIGURE 10 – TYPICAL THERMAL RESISTANCE OF PLATES



(1) Reverse polarity units must be derated an additional 10%; i.e., in Figure 7 the maximum allowable case temperature of the 2N5164 at 16 Adc is 70°C, a derating of 30°C below the maximum junction temperature. For the 2N5164R the derating would be an additional 10% or 3.0°C, making the allowable case temperature 67°C.

For additional mounting information, refer to the Motorola brochure "Mounting Techniques for Pressfit Silicon Rectifiers and Silicon Controlled Rectifiers".

2N5179 (SILICON)

NPN SILICON RF SMALL-SIGNAL TRANSISTOR

. . . designed primarily for use in high-gain, low-noise amplifier, oscillator, and mixer applications. Can also be used in UHF converter applications.

- High Current-Gain — Bandwidth Product —
  f_T = 1.4 GHz (Typ) @ I_C = 10 mAdc
- Low Collector-Base Time Constant —
  $r_b'C_c$ = 14 ps (Max) @ I_E = 2.0 mAdc
- Characterized with Scattering Parameters
- Low Noise Figure —
  NF = 4.5 dB (Max) @ f = 200 MHz

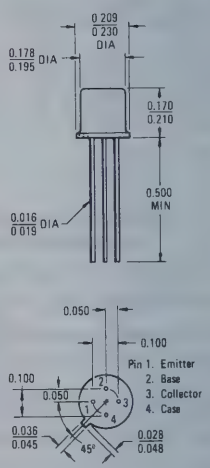
NPN SILICON RF SMALL-SIGNAL TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage Applicable 1.0 to 20 mAdc	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



CASE 20(10)
TO-72 PACKAGE

Active Elements Isolated from Case

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.001 mAdc, I_E = 0)	BV_{CBO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	BV_{EBO}	2.5	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	– –	0.02 1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	250	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product ① (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	900	2000	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	–	1.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	h_{fe}	25	300	–
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.9 MHz)	$r_b' C_c$	3.0	14	ps
Noise Figure (See Figure 1) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	–	4.5	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (See Figure 1) (V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	G_{pe}	15	–	dB
Power Output (See Figure 2) (V_{CB} = 10 Vdc, I_E = 12 mAdc, f≥500 MHz)	P_{out}	20	–	mW

*Indicates JEDEC Registered Values.

① f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – 200 MHz AMPLIFIER POWER GAIN AND NOISE FIGURE CIRCUIT

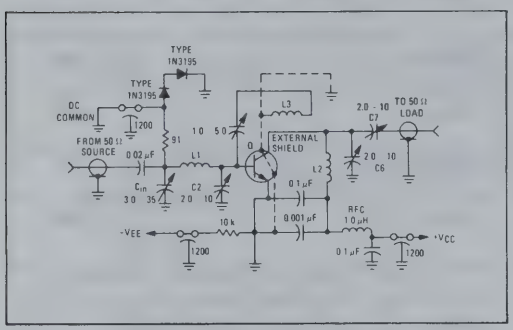


FIGURE 2 – 500 MHz OSCILLATOR CIRCUIT

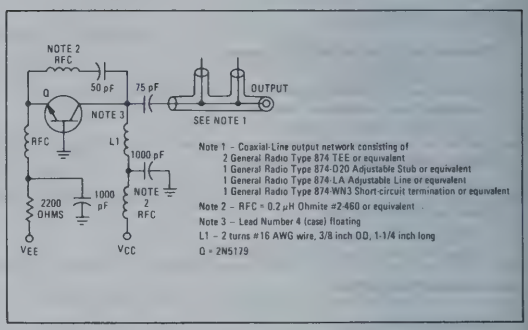


FIGURE 3 – NOISE FIGURE versus FREQUENCY

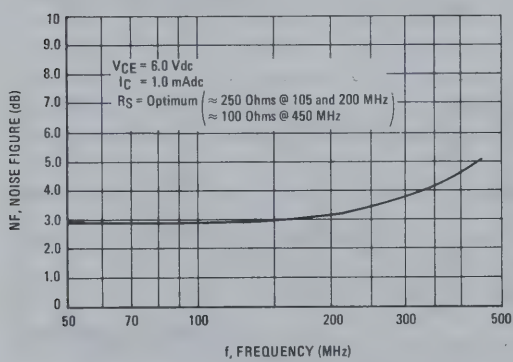


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT

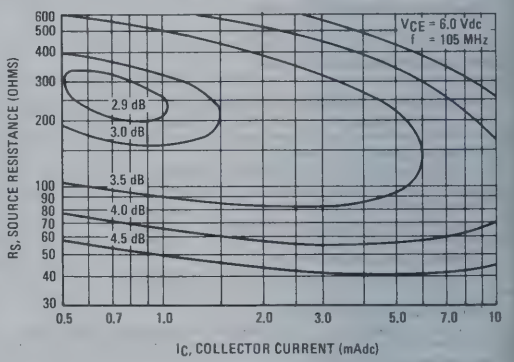


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT

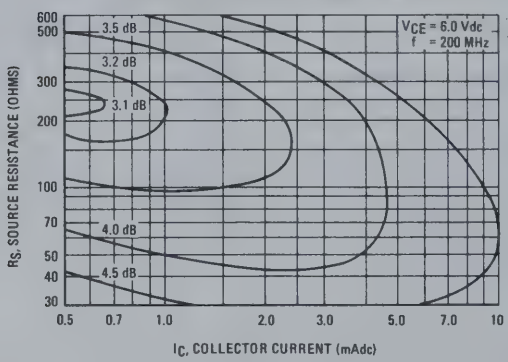


FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT

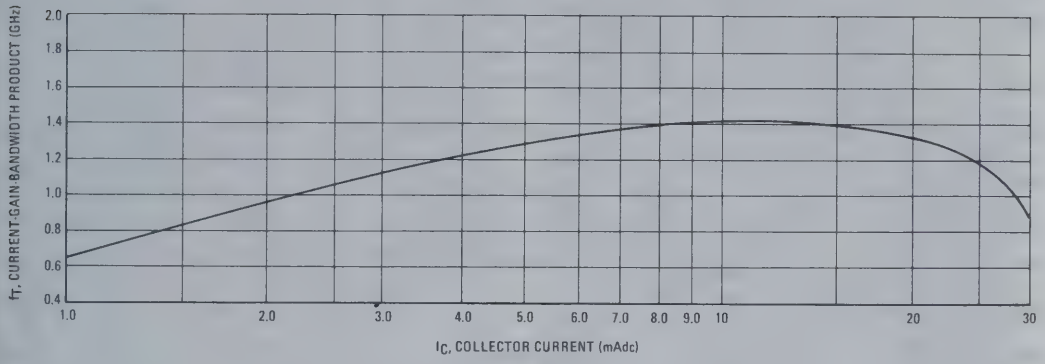


FIGURE 7 – INPUT ADMITTANCE versus FREQUENCY

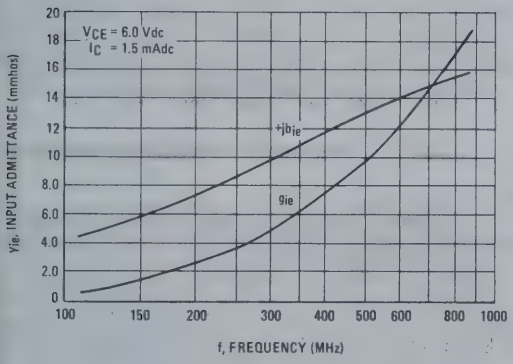


FIGURE 8 – OUTPUT ADMITTANCE versus FREQUENCY

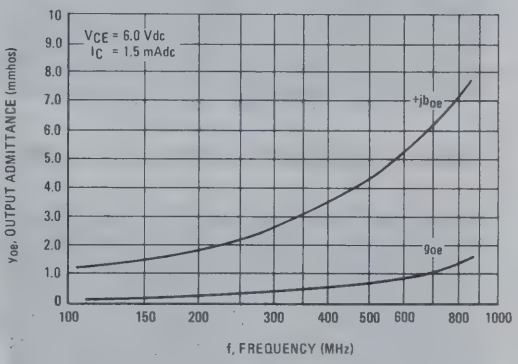


FIGURE 9 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

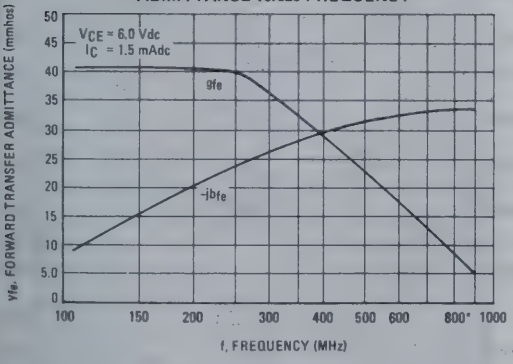


FIGURE 10 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

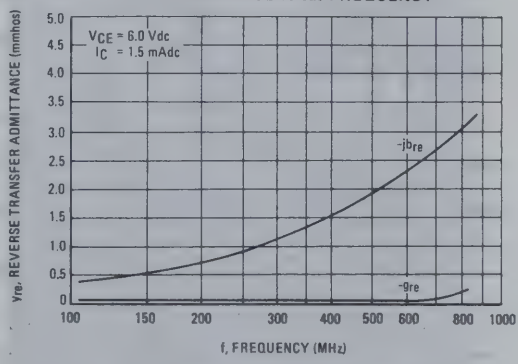


FIGURE 11— S_{11}, INPUT REFLECTION COEFFICIENT

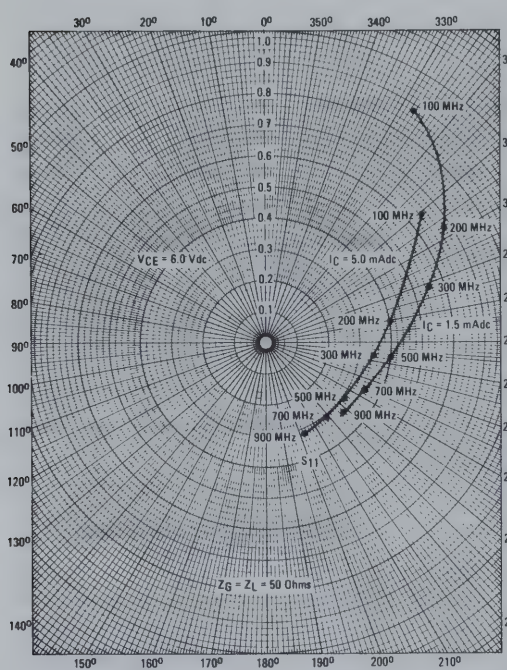


FIGURE 12—S_{22}, OUTPUT REFLECTION COEFFICIENT

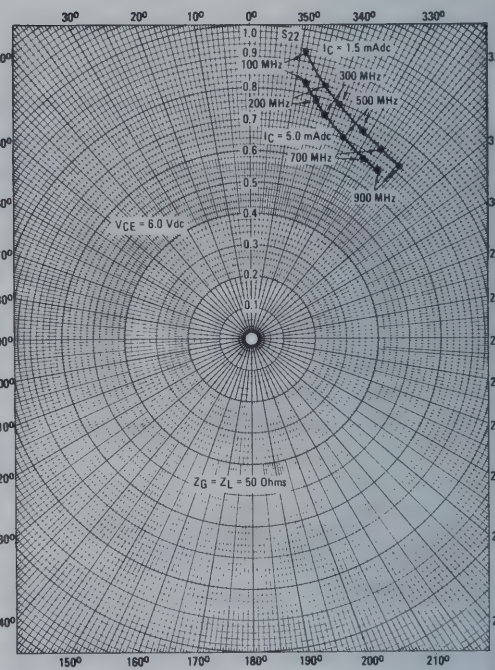


FIGURE 13 — S_{12}, REVERSE TRANSMISSION COEFFICIENT

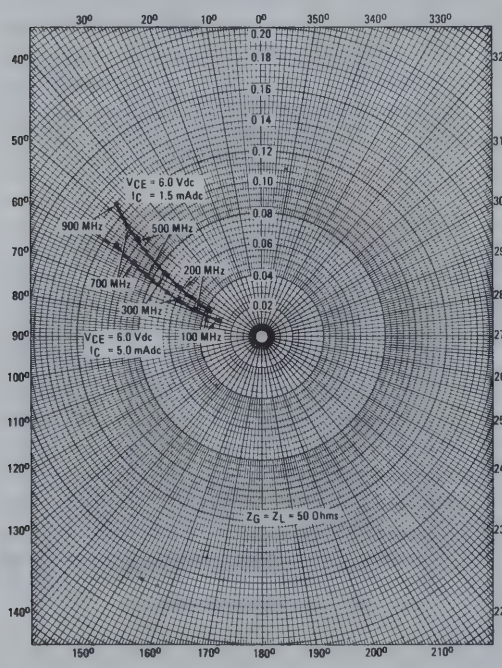


FIGURE 14 — S_{21}, FORWARD TRANSMISSION COEFFICIENT

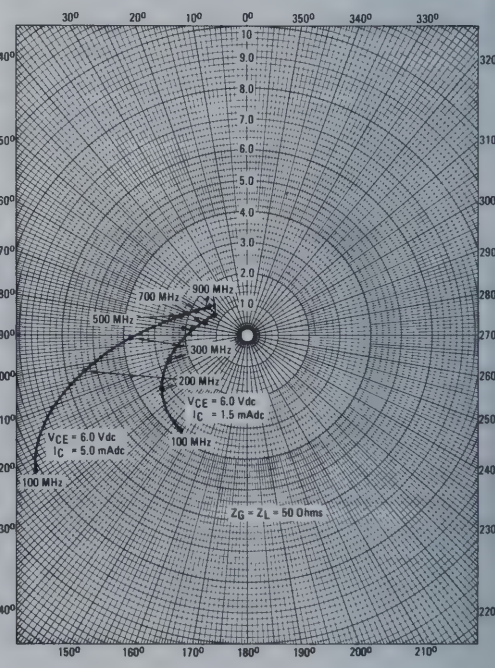
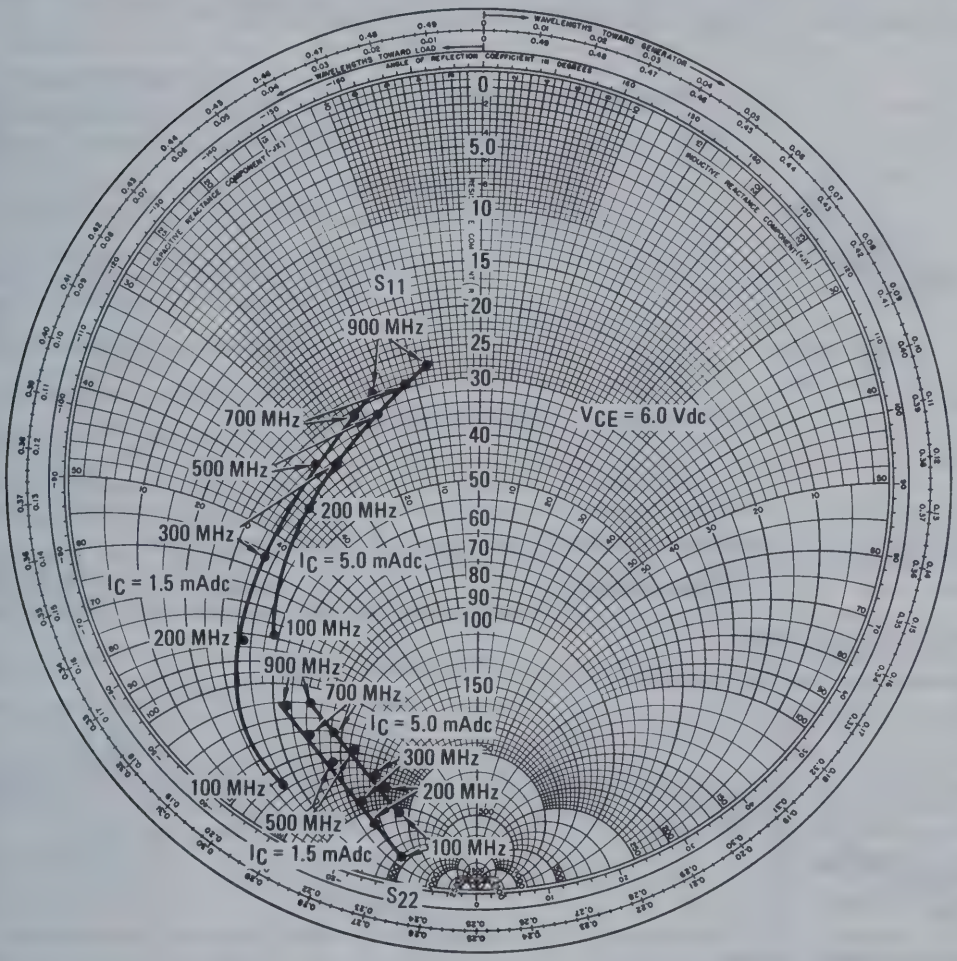
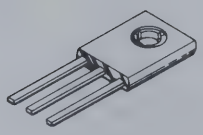


FIGURE 15—S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



2N5190 (SILICON) thru 2N5192

Silicon NPN power transistors for use in power amplifier and switching circuits, – excellent safe area limits. Complement to PNP 2N5193, 2N5194, 2N5195.



CASE 77 (1)

MAXIMUM RATINGS

Rating	Symbol	2N5190	2N5191	2N5192	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Collector Current	I_C	4.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	40 320			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			°C

THERMAL CHARACTERISTICS

	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 0.1 Adc, I_B = 0)	2N5190	$BV_{CEO(sus)}$*	40	-	Vdc
	2N5191		60	-	
	2N5192		80	-	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N5190		-	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N5191		-	1.0	
(V_{CE} = 80 Vdc, I_B = 0)	2N5192		-	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5190		-	0.1	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5191		-	0.1	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5192		-	0.1	
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5190		-	2.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5191		-	2.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5192		-	2.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N5190		-	0.1	
(V_{CB} = 60 Vdc, I_E = 0)	2N5191		-	0.1	
(V_{CB} = 80 Vdc, I_E = 0)	2N5192		-	0.1	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	1.0	mAdc

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			-
(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)	2N5190, 2N5191, 2N5192		25 20	100 80	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	2N5190, 2N5191, 2N5192		10 7.0	- -	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 1.5 Adc, I_B = 0.15 Adc)			-	0.6	
(I_C = 4.0 Adc, I_B = 1.0 Adc)			-	1.4	
Base-Emitter On Voltage*		$V_{BE(on)}$*			Vdc
(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)			-	1.2	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product		f_T			MHz
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)			2.0	-	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

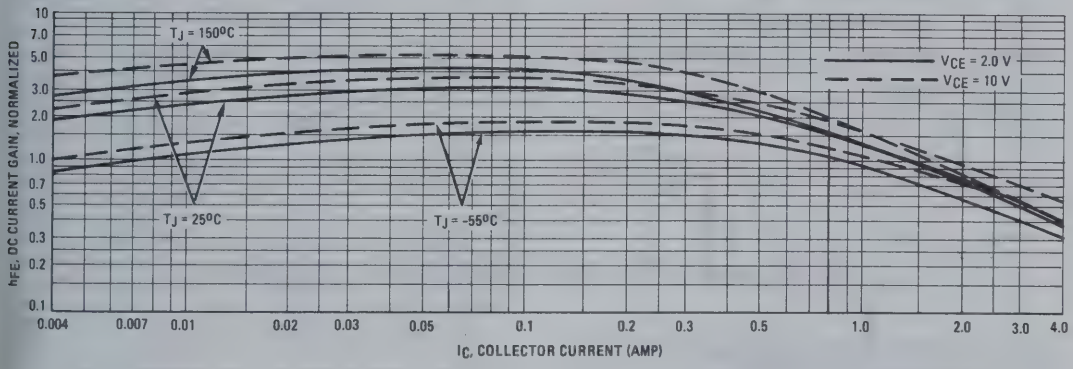


FIGURE 2 – COLLECTOR SATURATION REGION

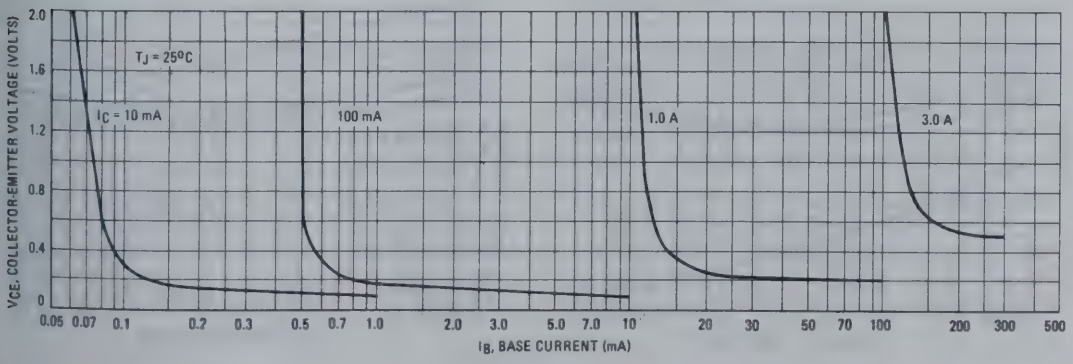


FIGURE 3 – "ON" VOLTAGES

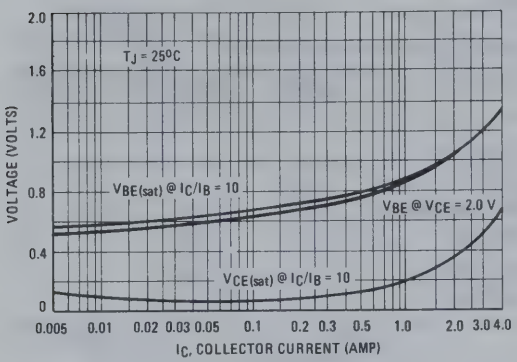
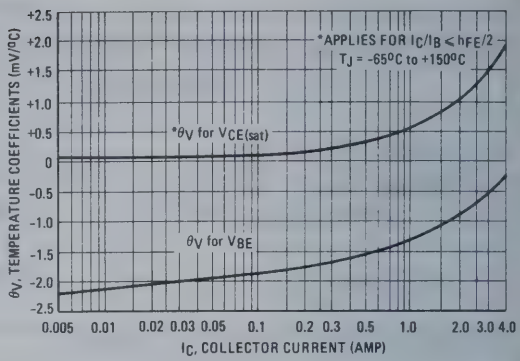


FIGURE 4 – TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 – COLLECTOR CUT-OFF REGION

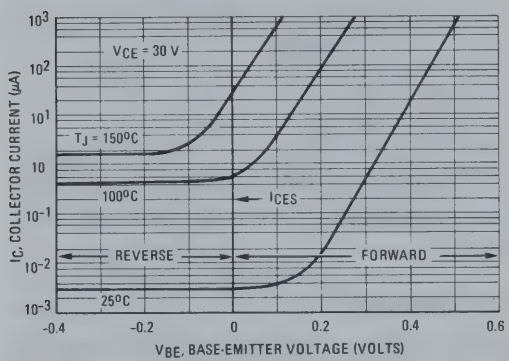


FIGURE 6 – EFFECTS OF BASE-EMITTER RESISTANCE

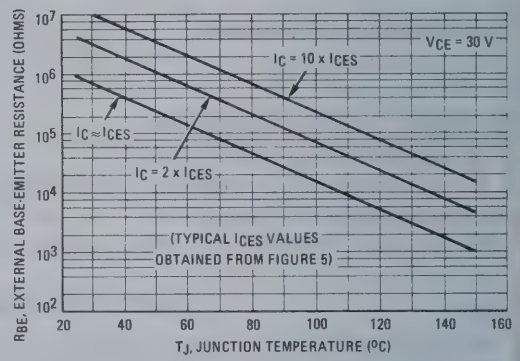


FIGURE 7 – SWITCHING TIME EQUIVALENT CIRCUIT

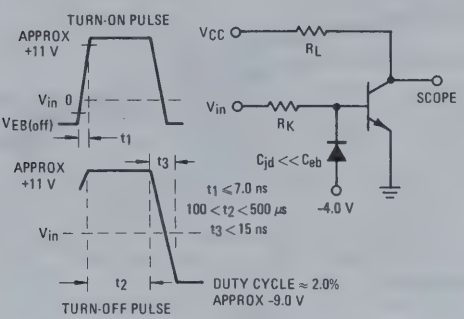


FIGURE 8 – CAPACITANCE

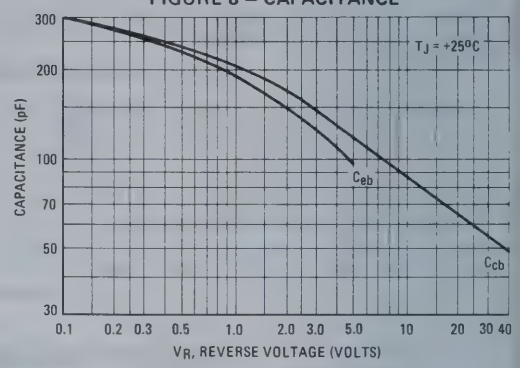


FIGURE 9 – TURN-ON TIME

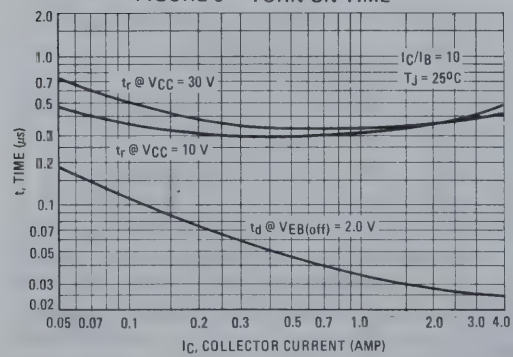
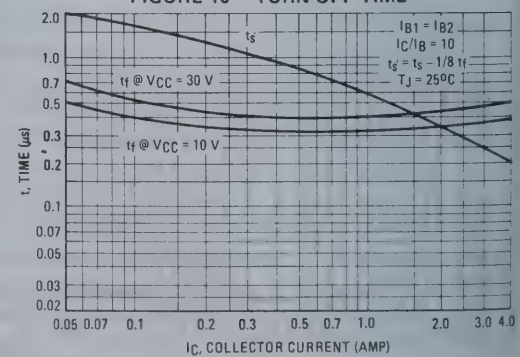
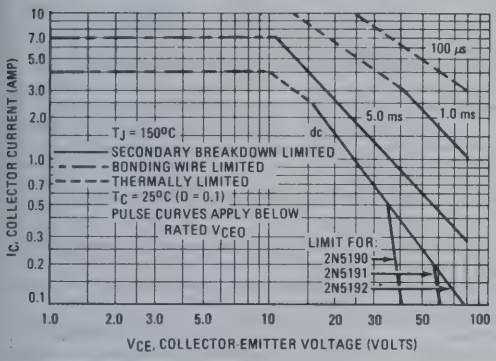


FIGURE 10 – TURN-OFF TIME



RATING AND THERMAL DATA

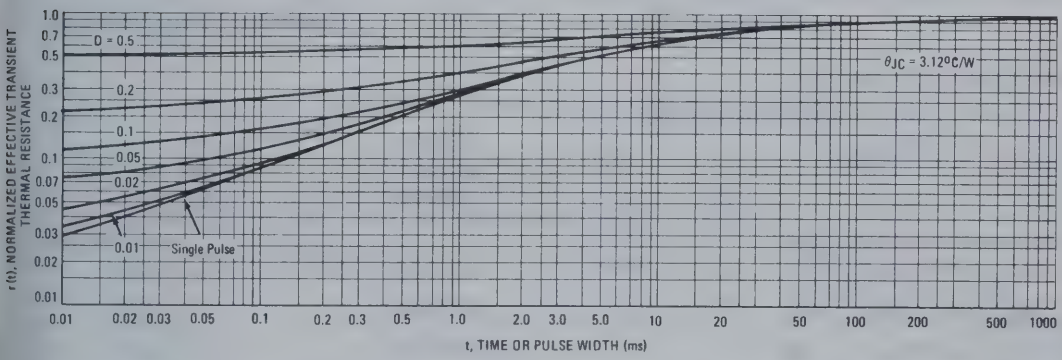
FIGURE 11 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

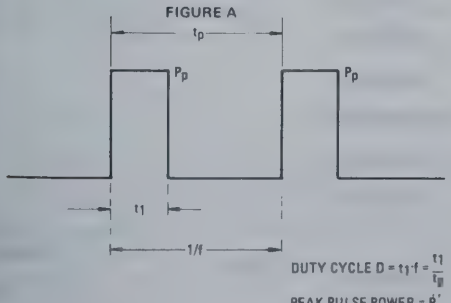
The data of Figure 11 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 150^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 – THERMAL RESPONSE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC}.

Example:

The 2N5190 is dissipating 50 watts under the following conditions: $t_1 = 0.1$ ms, $t_p = 0.5$ ms. (D = 0.2).

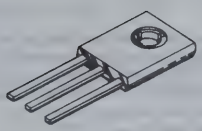
Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of $r(t_1, D)$ is 0.27.

The peak rise in junction temperature is therefore:

$$\Delta T = r(t) \times P_P \times \theta_{JC} = 0.27 \times 50 \times 3.12 = 42.2^oC$$

2N5193 (SILICON) thru 2N5195

Silicon PNP power transistors for use in power amplifier and switching circuits, – excellent safe area limits. Complement to NPN 2N5190, 2N5191, 2N5192.



CASE 77(1)

MAXIMUM RATINGS

Rating	Symbol	2N5193	2N5194	2N5195	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Collector Current	I_C	4.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	40 320			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			°C

THERMAL CHARACTERISTICS

	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 0.1 Adc, I_B = 0)	2N5193	$BV_{CEO(sus)}$*	40	-	Vdc
	2N5194		60	-	
	2N5195		80	-	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N5193		-	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N5194		-	1.0	
(V_{CE} = 80 Vdc, I_B = 0)	2N5195		-	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5193		-	0.1	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5194		-	0.1	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5195		-	0.1	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5193		-	2.0	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5194		-	2.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)	2N5195		-	2.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N5193		-	0.1	
(V_{CB} = 60 Vdc, I_E = 0)	2N5194		-	0.1	
(V_{CB} = 80 Vdc, I_E = 0)	2N5195		-	0.1	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	1.0	mAdc

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain*					-
(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)	2N5193, 2N5194, 2N5195	h_{FE}*	25 20	100 80	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	2N5193, 2N5194, 2N5195		10 7.0	- -	
Collector-Emitter Saturation Voltage*					Vdc
(I_C = 1.5 Adc, I_B = 0.15 Adc)		$V_{CE(sat)}$*	-	0.6	
(I_C = 4.0 Adc, I_B = 1.0 Adc)			-	1.4	
Base-Emitter On Voltage*					Vdc
(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$*	-	1.2	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product					MHz
(I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.0	-	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

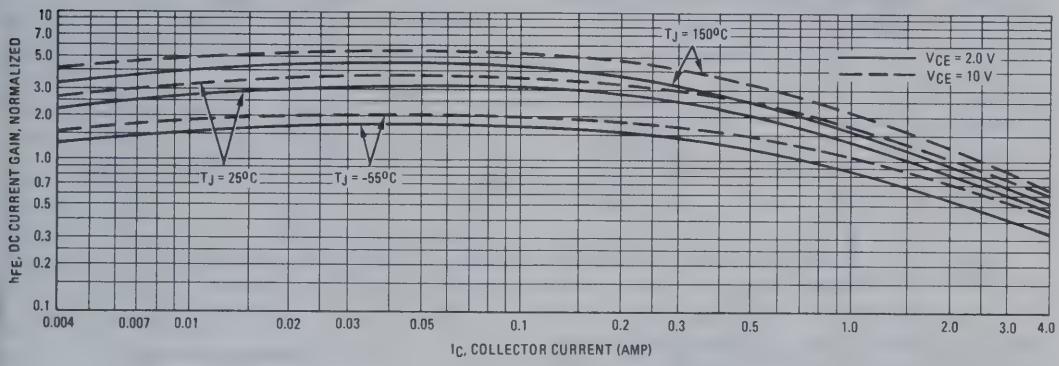


FIGURE 2 – COLLECTOR SATURATION REGION

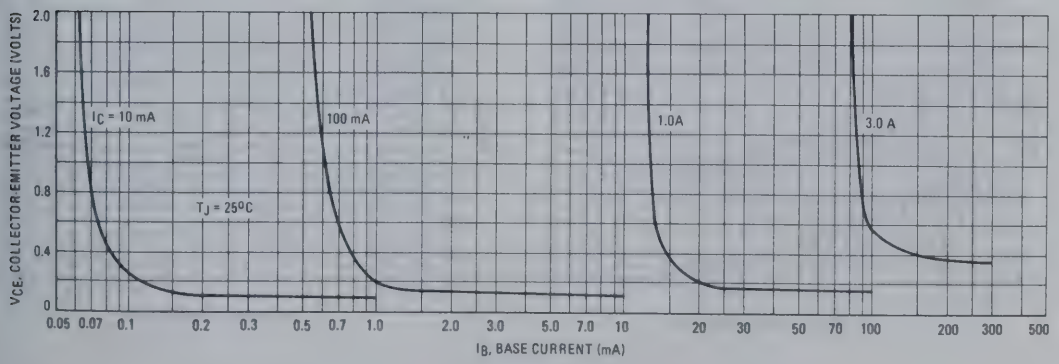


FIGURE 3 – "ON" VOLTAGE

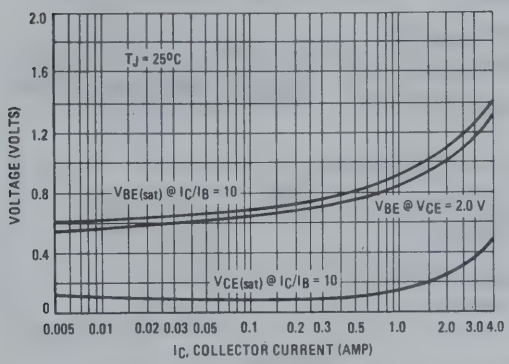
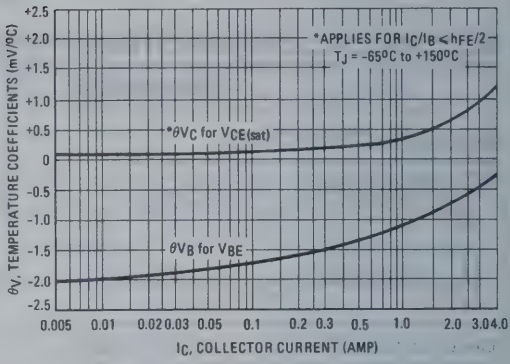


FIGURE 4 – TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 – COLLECTOR CUT-OFF REGION

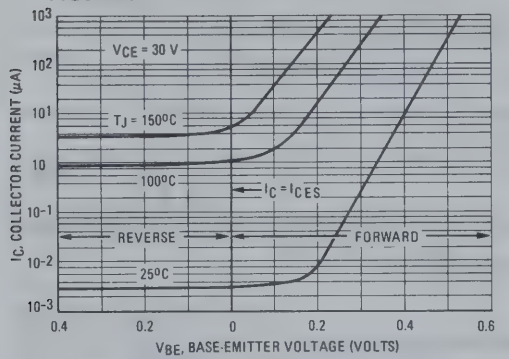


FIGURE 6 – EFFECTS OF BASE-EMITTER RESISTANCE

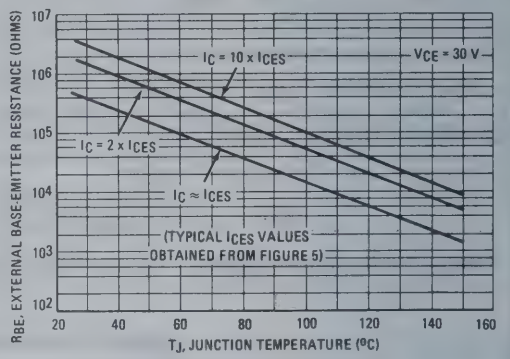


FIGURE 7 – SWITCHING TIME EQUIVALENT CIRCUIT

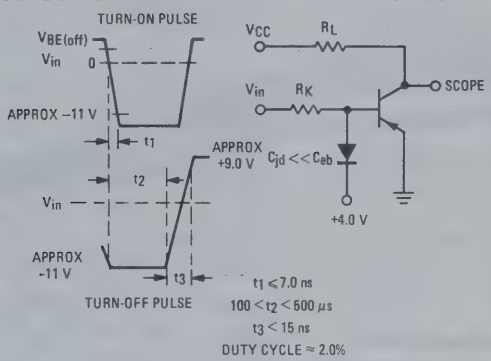


FIGURE 8 – CAPACITANCE

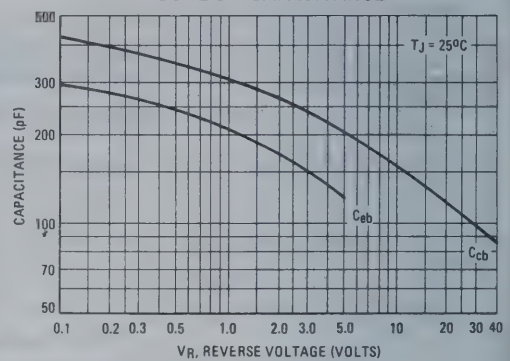


FIGURE 9 – TURN-ON TIME

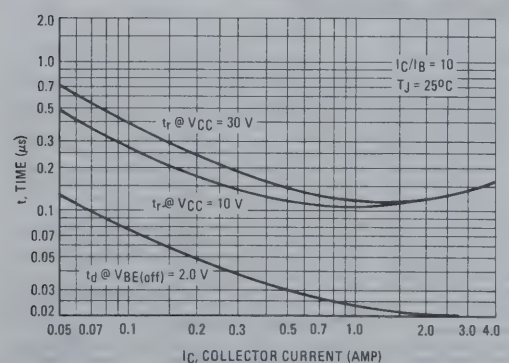
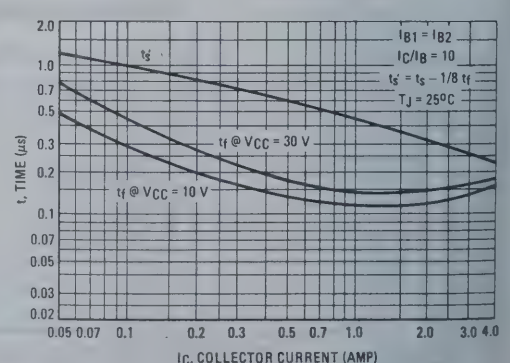
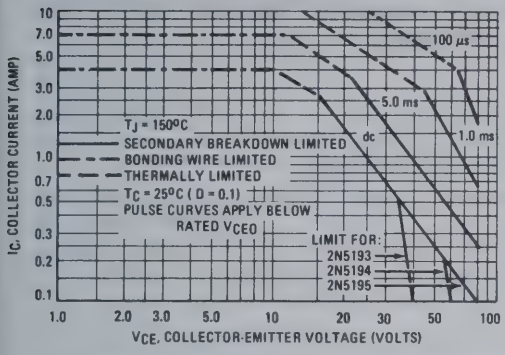


FIGURE 10 – TURN-OFF TIME



RATING AND THERMAL DATA

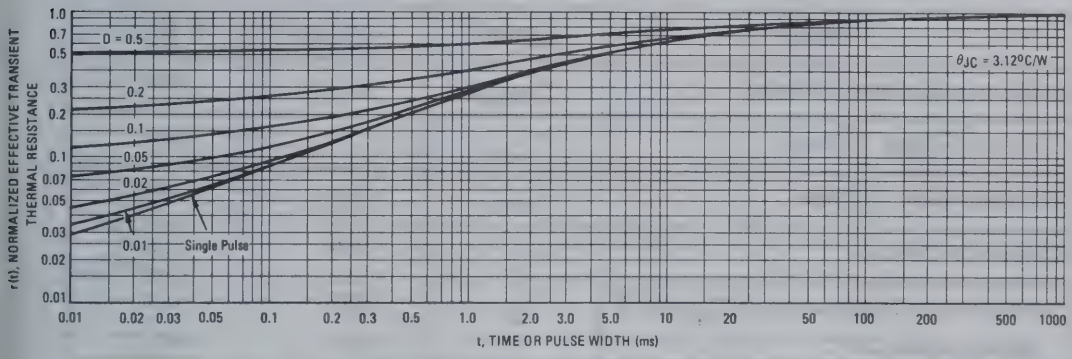
FIGURE 11 – ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

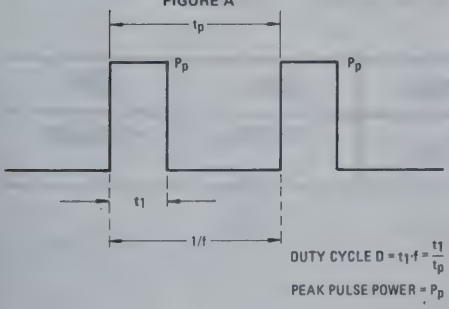
The data of Figure 11 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 – THERMAL RESPONSE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC}.

Example:

The 2N5193 is dissipating 50 watts under the following conditions: t_1 = 0.1 ms, t_p = 0.5 ms. (D = 0.2).

Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of $r(t_1, D)$ is 0.27.

The peak rise in junction temperature is therefore:

$$\Delta T = r(t) \times P_p \times \theta_{JC} = 0.27 \times 50 \times 3.12 = 42.2°C$$

2N5208 (SILICON)



CASE 29(2)
TO-92

PNP silicon annular amplifier transistor designed for general-purpose RF amplifier applications in the frequency range to 300 MHz.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

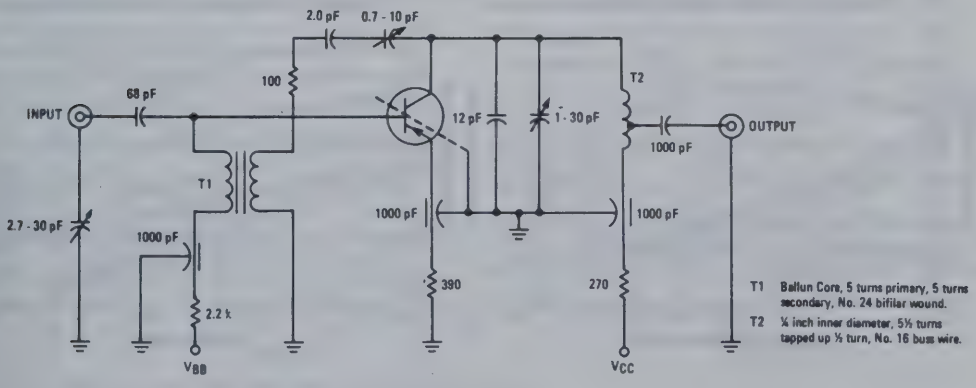
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	10	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	120	-
Base-Emitter On Voltage (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	-	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	1200	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	1.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	-	4.0	pF
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	-	10	ps
Noise Figure (See Figure 1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_S = 75 ohms, f = 100 MHz, BW = 1.0 MHz)	NF	-	3.0	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (See Figure 1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	G_{pe}	22	-	dB

FIGURE 1 - 100 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



COMMON-EMITTER Y PARAMETERS (Polar Plots)

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 2 - INPUT ADMITTANCE

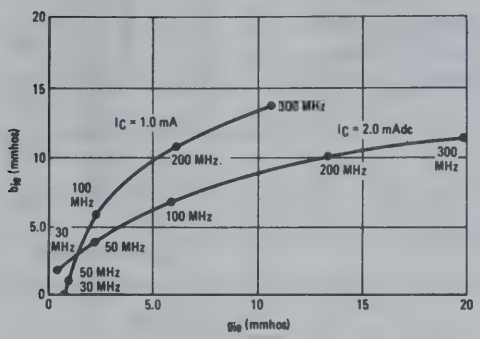


FIGURE 3 - OUTPUT ADMITTANCE

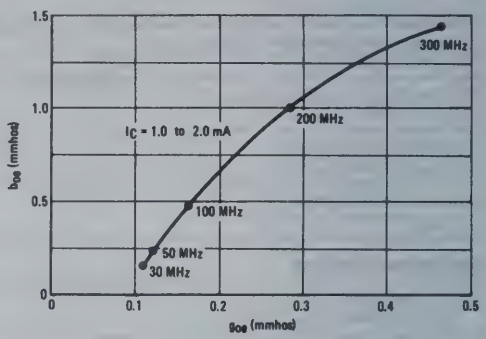


FIGURE 4 - FORWARD TRANSFER ADMITTANCE

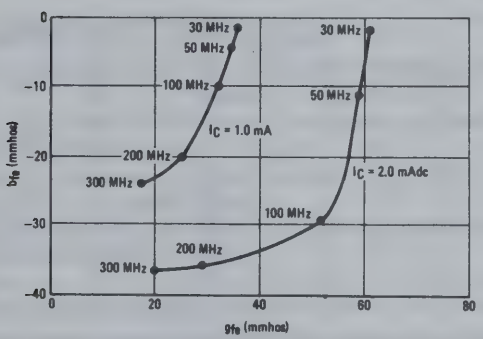
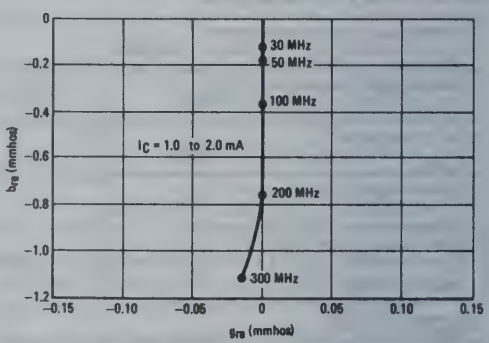


FIGURE 5 - REVERSE TRANSFER ADMITTANCE



STABILITY FACTOR CURVE

FIGURE 6 - POWER GAIN AND NOISE FIGURE

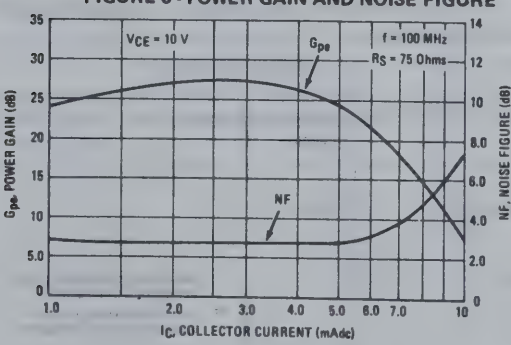
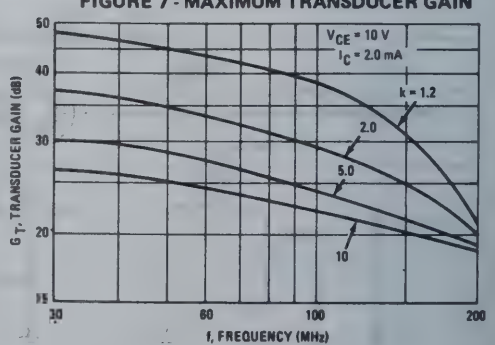


FIGURE 7 - MAXIMUM TRANSDUCER GAIN



COMMON-EMITTER Y PARAMETERS vs FREQUENCY

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 8 - INPUT ADMITTANCE

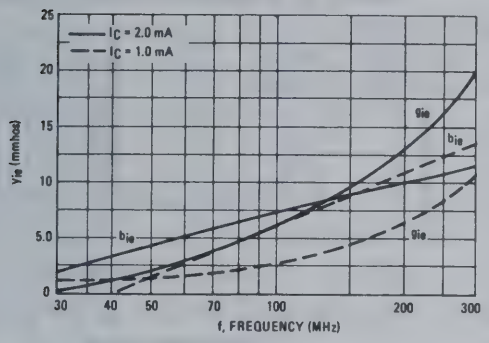


FIGURE 9 - OUTPUT ADMITTANCE

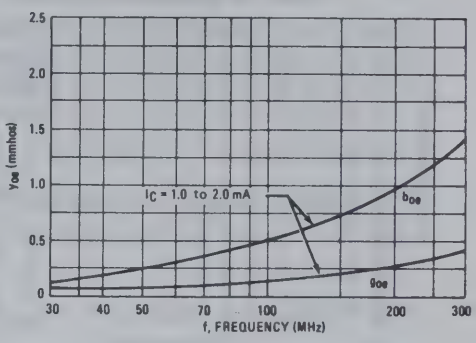


FIGURE 10 - FORWARD TRANSFER ADMITTANCE

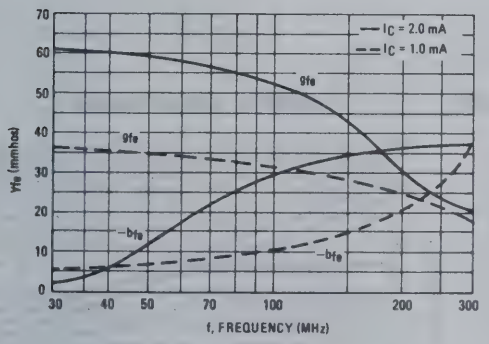
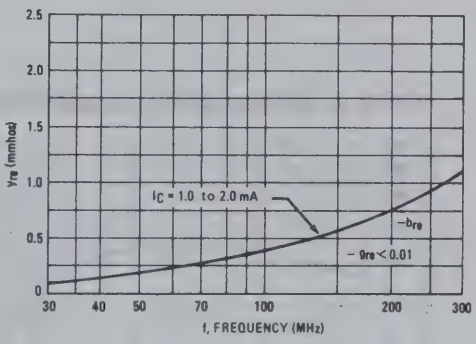


FIGURE 11 - REVERSE TRANSFER ADMITTANCE



STABILITY FACTOR CURVES

FIGURE 12 - OPTIMUM SOURCE ADMITTANCE

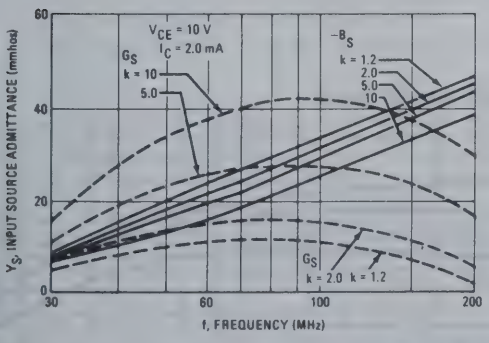
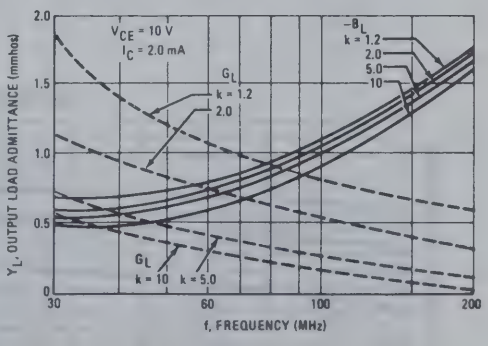


FIGURE 13 - OPTIMUM LOAD ADMITTANCE



When a potentially unstable device is operated without feedback, there is an infinite number of combinations of source and load admittance associated with any given circuit stability factor (k). Equations have been developed for determining the optimum source and load admittance for maximum gain. Figures 7, 12 and 13 provide a solution to the equations for the 2N5208.

NOISE FIGURE

FIGURE 14 - FREQUENCY EFFECTS

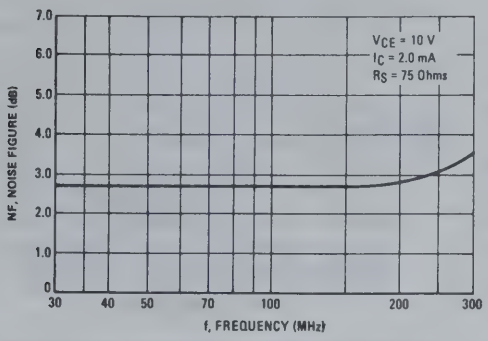


FIGURE 15 - SOURCE RESISTANCE EFFECTS

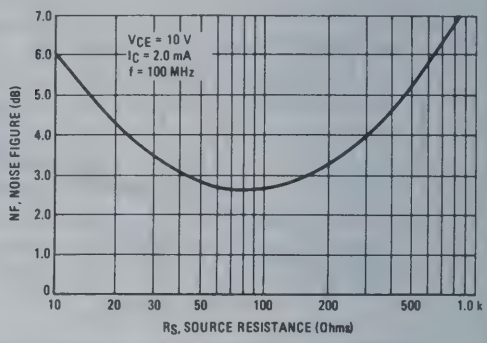


FIGURE 16 - CURRENT-GAIN—BANDWIDTH PRODUCT

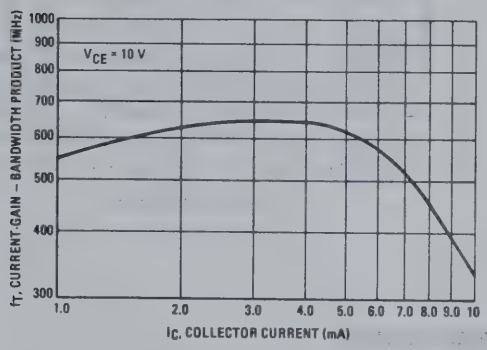


FIGURE 17 - CAPACITANCES

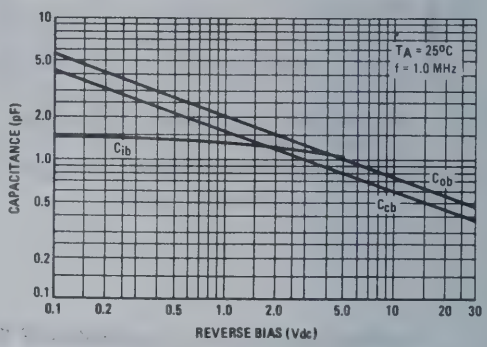
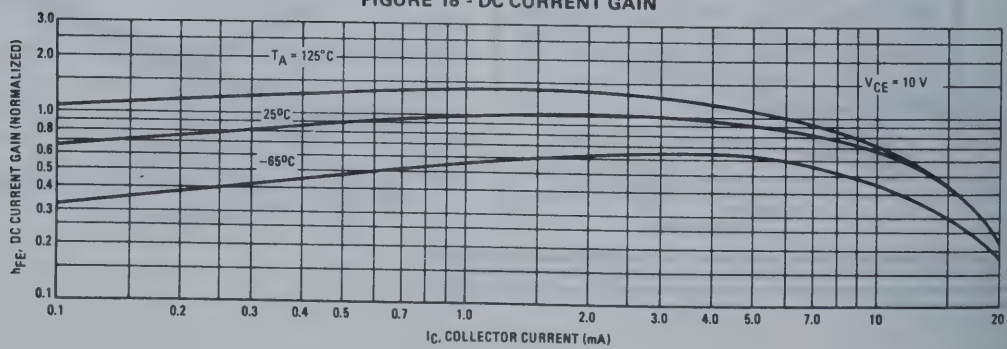


FIGURE 18 - DC CURRENT GAIN



2N5209 (SILICON)
2N5210



CASE 29(1)
(TO-92)

NPN silicon annular transistors designed for low-level, low-noise amplifier applications and for complementary circuitry with PNP types 2N5086 and 2N5087.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current — Continuous Peak	I_C	50 100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	50	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		BV_{CBO}	50	-	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	-	-	10	nAdc
(V_{CB} = 35 Vdc, I_E = 0)			-	-	50	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	-	50	nAdc
(V_{BE} = 4.5 Vdc, I_C = 0)			-	-	100	
ON CHARACTERISTICS						
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N5209	h_{FE}	100	-	300	-
	2N5210		200	-	600	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5209		150	-	-	
	2N5210		250	-	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5209		150	-	-	
	2N5210		250	-	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	-	0.7	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	-	-	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	30	80	-	MHz
Collector Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz) (emitter guarded)		C_{cb}	-	-	4.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N5209	h_{fe}	150	-	600	-
	2N5210		250	-	900	
Noise Figure (I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 22 k ohms, f = 10 Hz to 15.7 kHz)	2N5209	NF	-	-	3.0	dB
	2N5210		-	-	2.0	
(I_C = 20 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)	2N5209		-	1.6	4.0	
	2N5210		-	1.4	3.0	

NOISE FIGURE
(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 1 — NOISE FIGURE versus FREQUENCY

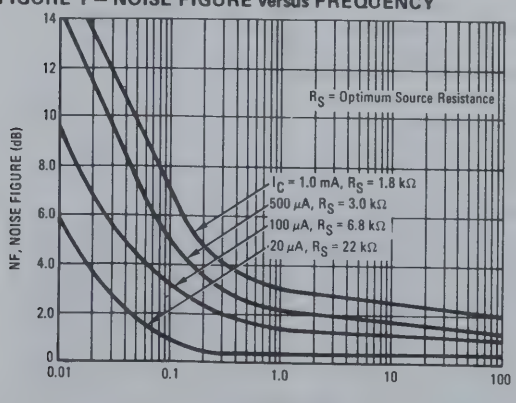
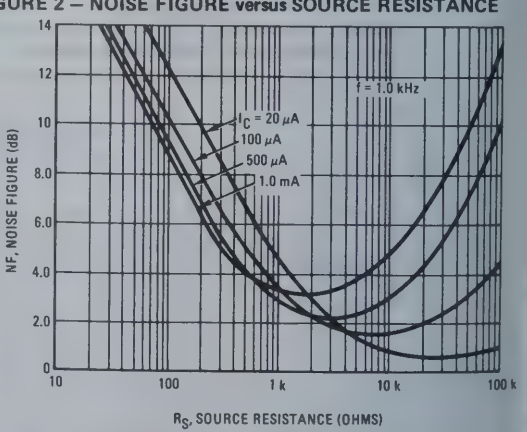


FIGURE 2 — NOISE FIGURE versus SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

(For Figures 3, 4, 5, 6, 8)

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number — the same units were used to develop curves on each graph.

FIGURE 3 — INPUT IMPEDANCE versus COLLECTOR CURRENT

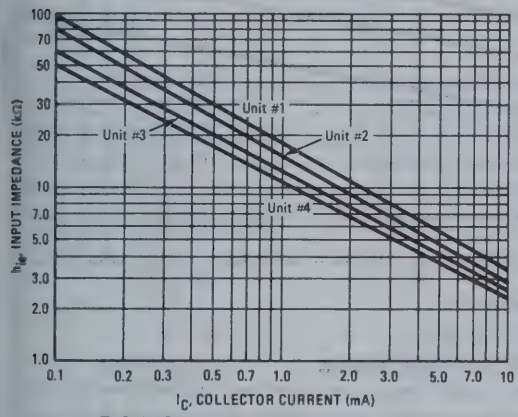


FIGURE 4 — VOLTAGE FEEDBACK RATIO versus COLLECTOR CURRENT

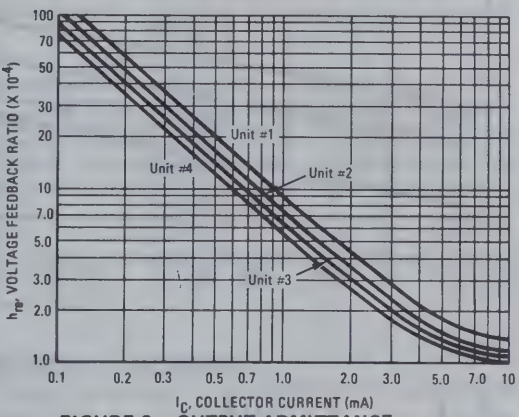


FIGURE 5 — CURRENT GAIN versus COLLECTOR CURRENT

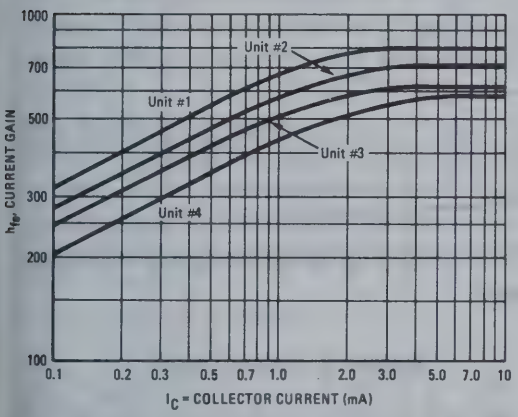


FIGURE 6 — OUTPUT ADMITTANCE versus COLLECTOR CURRENT

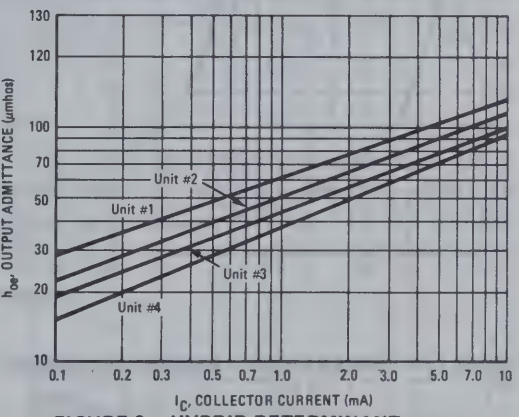


FIGURE 7 — EFFECT OF VOLTAGE

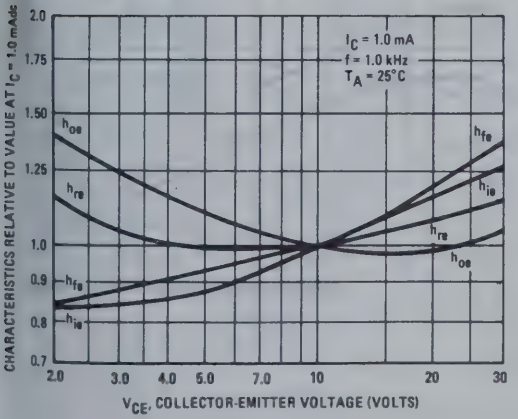


FIGURE 8 — HYBRID DETERMINANT versus COLLECTOR CURRENT

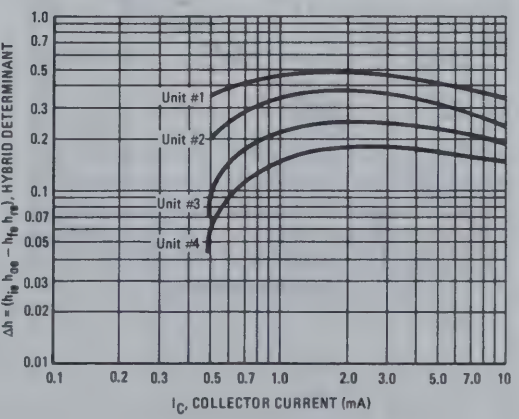


FIGURE 9 – DC CURRENT GAIN

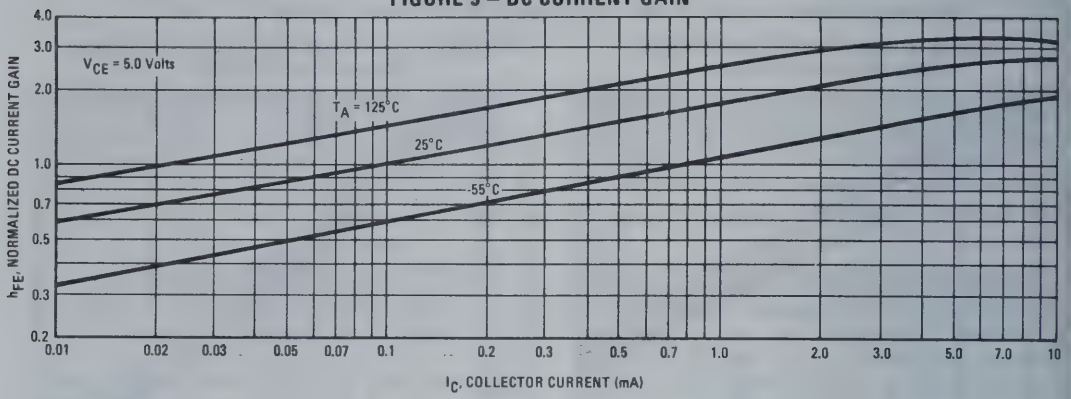


FIGURE 10 – COLLECTOR SATURATION REGION

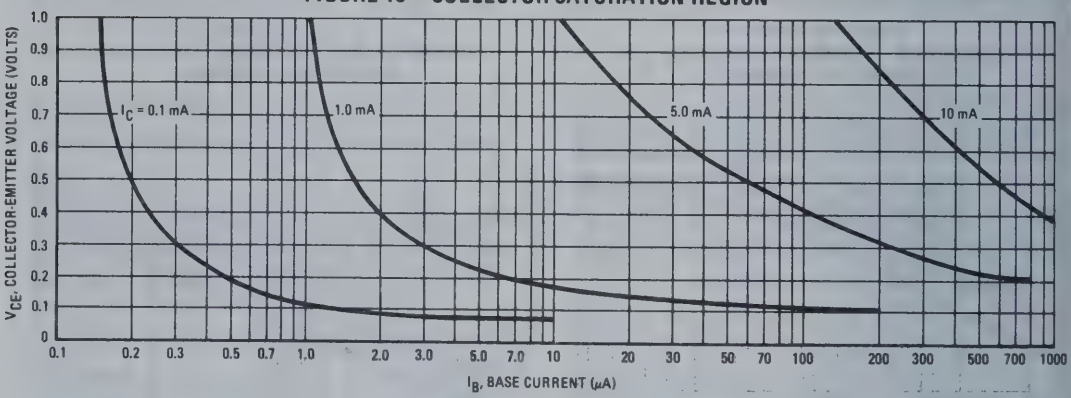


FIGURE 11 – CURRENT-GAIN – BANDWIDTH PRODUCT

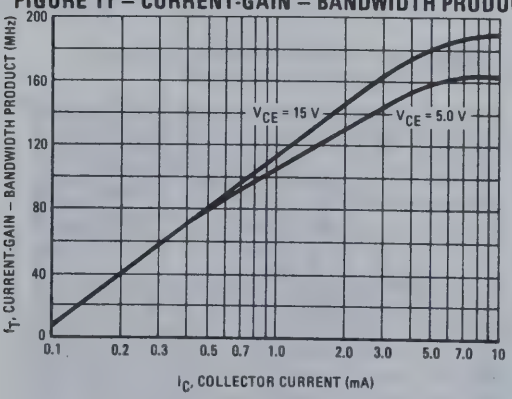
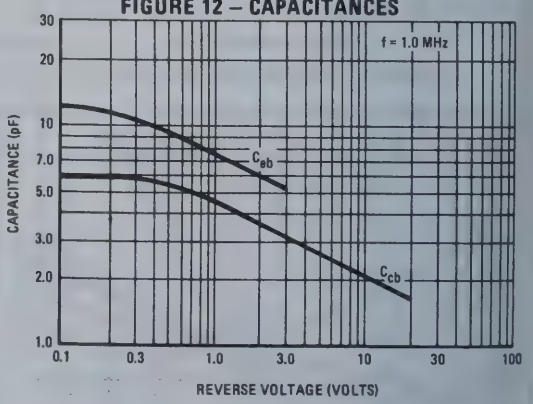


FIGURE 12 – CAPACITANCES



2N5219 (SILICON)

NPN silicon annular transistor. Plastic encapsulated package designed for low-level, small-signal, general-purpose amplifier and oscillator applications.



CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	35	500	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc)	f_T	150	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	4.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	35	1500	-

2N5220 (SILICON)

NPN silicon annular transistor. Plastic encapsulated package designed for low-power, large-signal audio and general-purpose amplifier applications and for complementary circuitry with PNP type 2N5221.



CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 30	 - 600	-
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	-	1.1	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc)	f_T	100	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	10	pF
Small-Signal Current Gain* (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	1800	-

2N5221 (SILICON)

PNP silicon annular transistor. Plastic encapsulated package designed for low-power, large-signal audio and general-purpose amplifier applications, and for complementary circuitry with NPN type 2N5220.



CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 30	 - 600	-
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	-	1.1	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc)	f_T	100	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	15	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	1800	-

2N5222 (SILICON)

NPN silicon annular transistor. Plastic encapsulated package designed for RF amplifier, mixer, and video IF applications in AM/FM radio and television receivers.



CASE 29(2)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	2.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	1500	-
Collector-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 400 μAdc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 400 μAdc)	$V_{BE(sat)}$	-	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc	f_T	450	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	1.3	pF
Small-Signal Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	3000	-

2N5223 (SILICON)

NPN silicon annular transistor. Plastic encapsulated package designed for low-level, small-signal, general-purpose amplifier and oscillator applications.



CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	50	800	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	-	1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc)	f_T	150	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	4.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	1600	-

2N5224 (SILICON)

NPN silicon annular transistor. Plastic encapsulated package designed for general-purpose, low-level switching applications.



CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

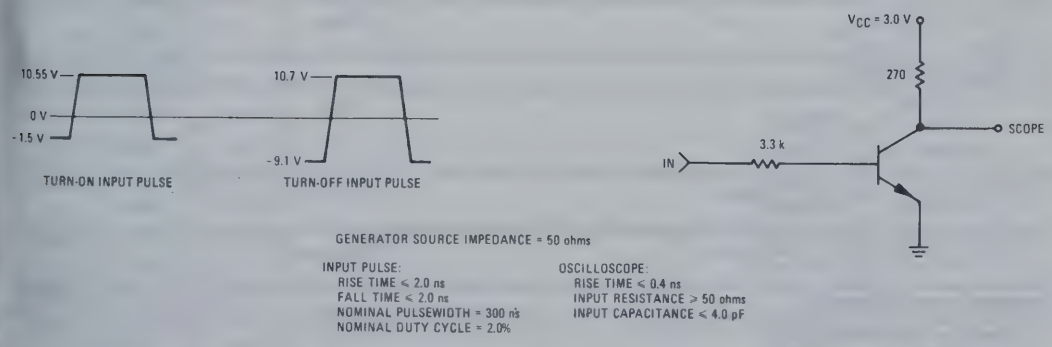
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	12	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	500	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40 15	400 -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	-	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.0 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	4.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (See Figure 1)	t_d	-	25	ns
Rise Time (See Figure 1)	t_r	-	20	ns
Storage Time (See Figure 1)	t_s	-	35	ns
Fall Time (See Figure 1)	t_f	-	25	ns

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



GENERATOR SOURCE IMPEDANCE = 50 ohms

INPUT PULSE:
- RISE TIME ≤ 2.0 ns
- FALL TIME ≤ 2.0 ns
- NOMINAL PULSEWIDTH = 300 ns
- NOMINAL DUTY CYCLE = 2.0%

OSCILLOSCOPE:
- RISE TIME ≤ 0.4 ns
- INPUT RESISTANCE ≥ 50 ohms
- INPUT CAPACITANCE ≤ 4.0 pF

2N5225 (SILICON)

NPN silicon annular transistor. Plastic encapsulated package designed for medium-current amplifier applications and for complementary circuitry with PNP type 2N5226.



CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	300	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 30	 - 600	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	-	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc)	f_T	50	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	20	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	1800	-

2N5226 (SILICON)

PNP silicon annular transistor. Plastic encapsulated package designed for medium-current, amplifier applications and for complementary circuitry with NPN type 2N5225.



CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	300	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 25 30	 - 600	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	-	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc)	f_T	50	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	20	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	1800	-

2N5227 (SILICON)

PNP silicon annular transistor. Plastic encapsulated package designed for low-level, small-signal general-purpose amplifier and oscillator applications.



CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	500	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 30 50	 - 700	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc)	f_T	100	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{cb}	-	5.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	1500	-

2N5228 (SILICON)



CASE 29(1)
(TO-92)

PNP silicon annular transistor. Plastic encapsulated package designed for general-purpose, low level switching applications.

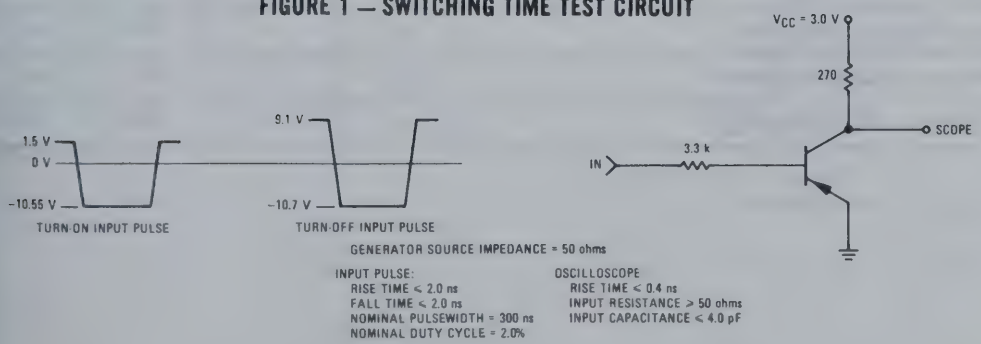
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Emitter Voltage	V_{CES}	6.0	Vdc
Collector-Base Voltage	V_{CB}	5.0	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	5.0	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	6.0	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	5.0	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CE} = 4.0 Vdc, V_{BE} = 0)	I_{CES}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.5 Vdc, I_C = 0)	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30 15	- -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.0 mAdc)	$V_{BE(sat)}$	0.65	1.25	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	300	-	MHz
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	-	5.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (See Figure 1)	t_d	-	25	ns
Rise Time (See Figure 1)	t_r	-	50	ns
Storage Time (See Figure 1)	t_s	-	90	ns
Fall Time (See Figure 1)	t_f	-	50	ns

2N5229 (SILICON)
2N5230
2N5231

PNP SILICON ANNULAR TRANSISTORS

. . . designed for low-level, chopper applications requiring high speed operation. This series of devices offers excellent characteristics for use in servo-loop, sensing instrumentation and control amplifier for motor drive systems. These transistors can also be used as replacement devices for alloy-type transistors where high BV_{EBO} is required.

- Low Offset Voltage – $V_{EC(off)}$ = 0.5 mVdc (Max) @ I_B = 100 μAdc
- Low Dynamic "ON" Series Resistance – $r_{ec(ON)}$ = 6.0 Ohms (Max) @ I_B = 1.0 mAdc
- Space Saving TO-46 Package

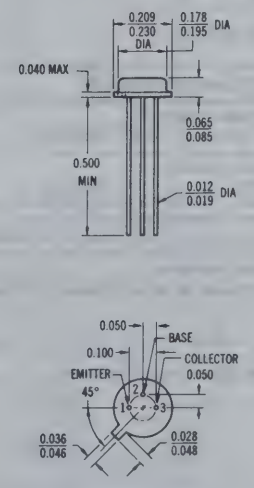
PNP SILICON CHOPPER TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	2N5229	2N5230	2N5231	Unit
*Collector-Emitter Voltage	V_{CEO}	10	20	30	Vdc
*Collector-Base Voltage	V_{CB}	15	30	50	Vdc
*Emitter-Base Voltage	V_{EB}	15	30	50	Vdc
*Collector Current	I_C	← 50 →			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 0.5 → ← 2.86 →			Watt mW/°C
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 2.0 → ← 12 →			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +200 →			°C

*Indicates JEDEC Registered Data.



CASE 26
TO–46 PACKAGE

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Emitter-Collector Breakdown Voltage		BV_{ECO}			Vdc
(I_E = 10 μAdc, I_B = 0)	2N5229		10	–	
	2N5230		20	–	
	2N5231		30	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 10 μAdc, I_E = 0)	2N5229		15	–	
	2N5230		30	–	
	2N5231		50	–	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0)	2N5229		15	–	
	2N5230		30	–	
	2N5231		50	–	
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 12 Vdc, I_E = 0)	2N5229		–	1.0	
(V_{CB} = 25 Vdc, I_E = 0)	2N5230		–	1.0	
(V_{CB} = 40 Vdc, I_E = 0)	2N5231		–	1.0	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{EB} = 12 Vdc, I_C = 0)	2N5229		–	1.0	
(V_{EB} = 25 Vdc, I_C = 0)	2N5230		–	1.0	
(V_{EB} = 40 Vdc, I_C = 0)	2N5231		–	1.0	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 100 μAdc, V_{CE} = 1.0 Vdc)			50	–	
(I_C = 200 μAdc, V_{CE} = 0.5 Vdc) (Inverted Connection)			15	–	
Offset Voltage		$V_{EC(off)}$			mVdc
(I_B = 100 μAdc, I_E = 0)	2N5229,2N5230		–	0.5	
	2N5231		–	0.8	
(I_B = 1.0 mAdc, I_E = 0)	2N5229		–	0.8	
	2N5230,2N5231		–	1.0	
DYNAMIC CHARACTERISTICS					
Collector-Base Capacitance		C_{cb}	–	5.0	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)					
Emitter-Base Capacitance		C_{eb}	–	4.0	pF
(V_{EB} = 10 Vdc, I_C = 0, f = 140 kHz)					
Small-Signal Current Gain		h_{fe}	2.0	–	–
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 4.0 MHz)					
"ON" Series Resistance		$r_{ec\ (ON)}$			Ohms
(I_B = 1.0 mAdc, I_E = 0, I_e = 100 μAdc, f = 1.0 kHz)	2N5229		1.0	6.0	
	2N5230		2.0	8.0	
	2N5231		2.0	10	

*Indicates JEDEC Registered Data.

TYPICAL CHARACTERISTICS

FIGURE 1 – EMITTER-COLLECTOR VOLTAGE versus BASE CURRENT

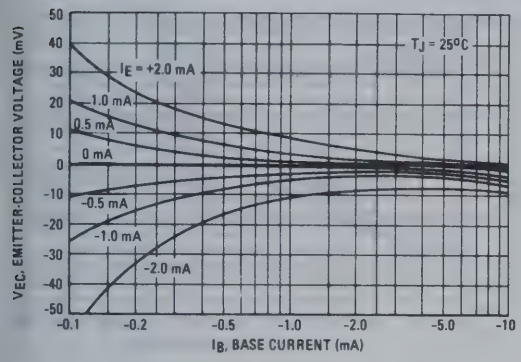


FIGURE 2 – EMITTER-COLLECTOR VOLTAGE versus JUNCTION TEMPERATURE

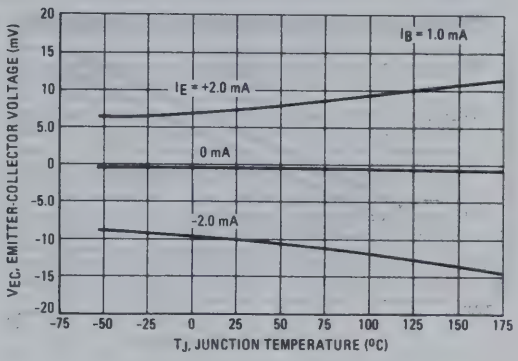


FIGURE 3 – EMITTER-COLLECTOR "ON" RESISTANCE versus BASE CURRENT

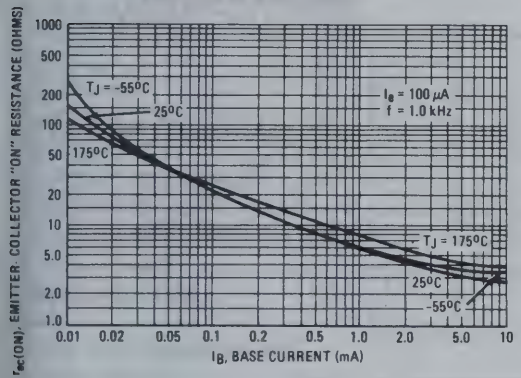


FIGURE 4 – EMITTER-COLLECTOR "ON" RESISTANCE TEMPERATURE COEFFICIENT versus BASE CURRENT

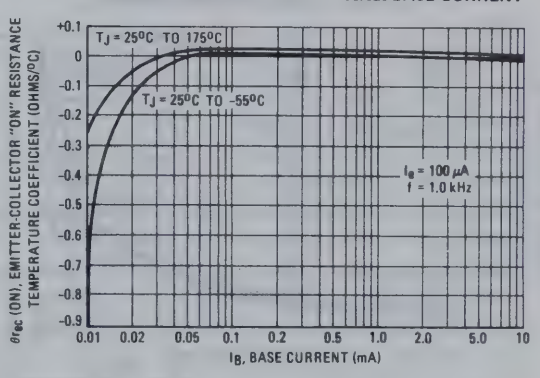


FIGURE 5 – CURRENT GAIN versus COLLECTOR CURRENT

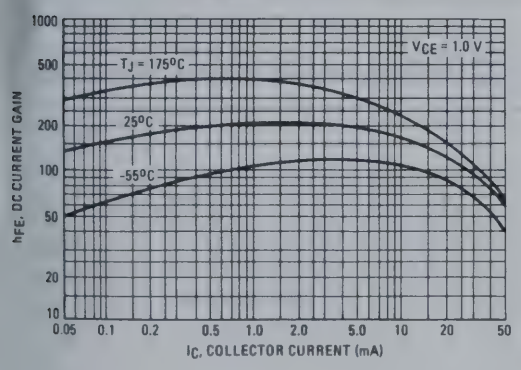


FIGURE 6 – CURRENT GAIN (Inverted Connection) versus EMITTER CURRENT

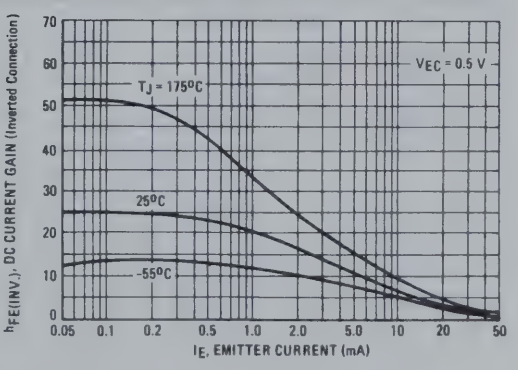


FIGURE 7 – COLLECTOR CUTOFF CURRENT versus JUNCTION TEMPERATURE

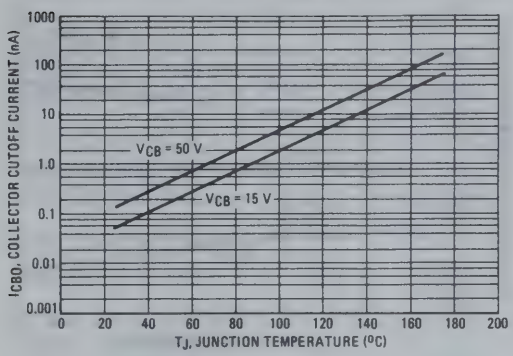


FIGURE 8 – EMITTER CUTOFF CURRENT versus JUNCTION TEMPERATURE

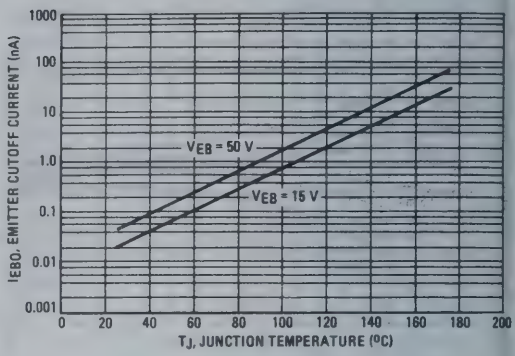


FIGURE 9 – COLLECTOR-EMITTER SATURATION VOLTAGE versus COLLECTOR CURRENT

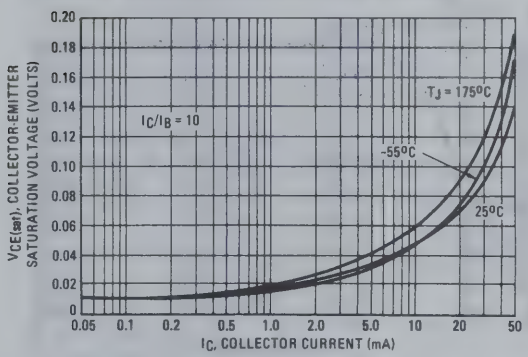
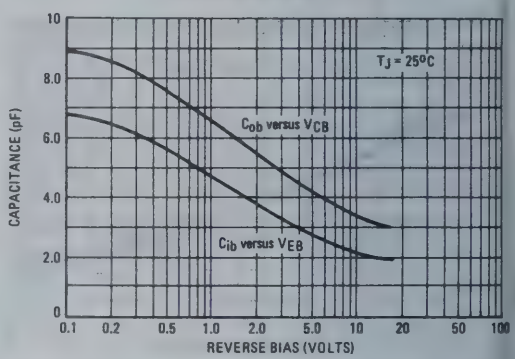


FIGURE 10 – JUNCTION CAPACITANCE versus REVERSE BIAS VOLTAGE



2N5265 thru 2N5270



P-Channel junction depletion mode (Type A) field-effect transistors designed for general-purpose amplifier applications.

CASE 20(5)
(TO-72)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Drain-Gate Voltage	V_{DG}	60	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	60	Vdc
Drain Current	I_D	20	mAdc
Gate Current-forward	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	60	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	2N5265, 2N5266	$V_{GS(off)}$	-	3.0	Vdc
	2N5267, 2N5268		-	6.0	
	2N5269, 2N5270		-	8.0	
Gate Reverse Current (V_{GS} = 30 Vdc, V_{DS} = 0)		I_{GSS}	-	2.0	nAdc
(V_{GS} = 30 Vdc, V_{DS} = 0, T_A = 150°C)			-	2.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5265	I_{DSS}	0.5	1.0	mAdc
	2N5266		0.8	1.6	
	2N5267		1.5	3.0	
	2N5268		2.5	5.0	
	2N5269		4.0	8.0	
	2N5270		7.0	14	
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 0.05 mAdc)	2N5265	V_{GS}	0.3	1.5	Vdc
(V_{DS} = 15 Vdc, I_D = 0.08 mAdc)	2N5266		0.4	2.0	
(V_{DS} = 15 Vdc, I_D = 0.15 mAdc)	2N5267		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 0.25 mAdc)	2N5268		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 0.4 mAdc)	2N5269		2.0	6.0	
(V_{DS} = 15 Vdc, I_D = 0.7 mAdc)	2N5270		2.0	6.0	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5265	$\|y_{fs}\|$	900	2700	μmhos
	2N5266		1000	3000	
	2N5267		1500	3500	
	2N5268		2000	4000	
	2N5269		2200	4500	
	2N5270		2500	5000	
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5265	$Re(y_{fs})$	800	-	μmhos
	2N5266		900	-	
	2N5267		1400	-	
	2N5268		1700	-	
	2N5269		1900	-	
	2N5270		2100	-	
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	2.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 M ohm, f = 100 Hz, BW = 1.0 Hz)		NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	-	115	$nV/\sqrt{Hz}$

FIGURE 1–6 TRANSFER CHARACTERISTIC CURVES
FOR MIN/MAX I_{DSS} LIMITS

FIGURE 1

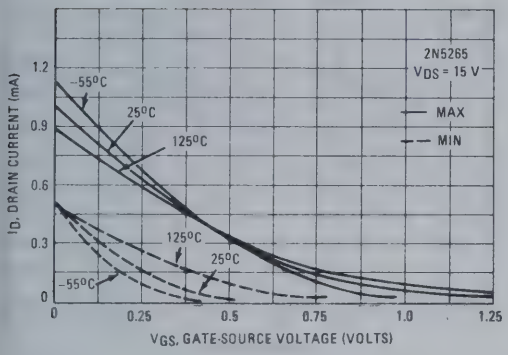


FIGURE 2

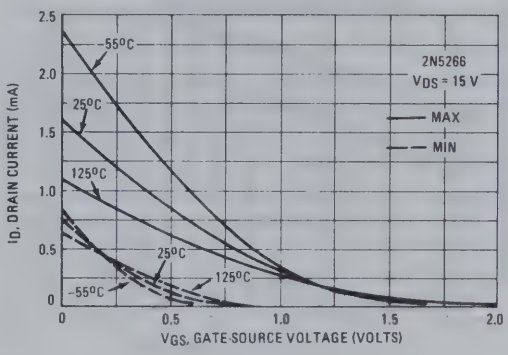


FIGURE 3

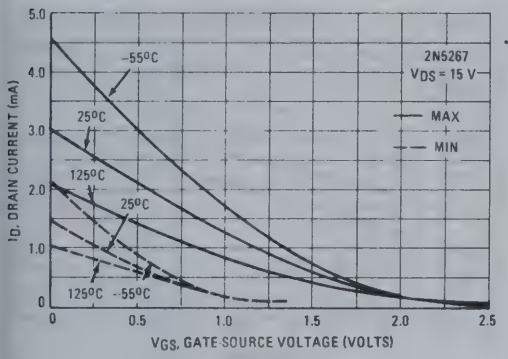


FIGURE 4

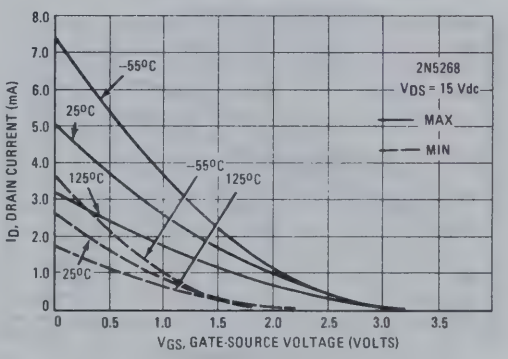


FIGURE 5

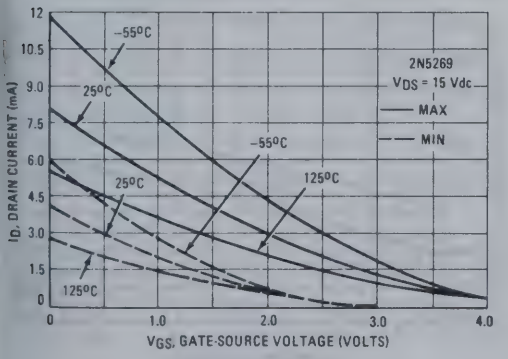
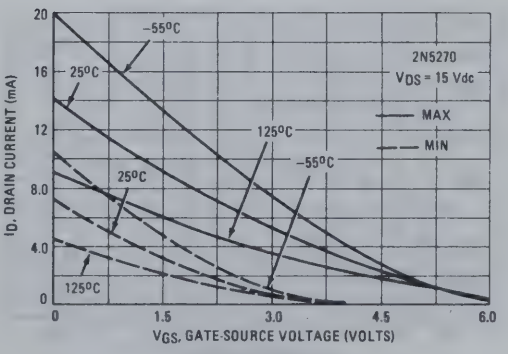


FIGURE 6



FIGURES 7-12 – TYPICAL AND MINIMUM FORWARD TRANSFER ADMITTANCE

FIGURE 7

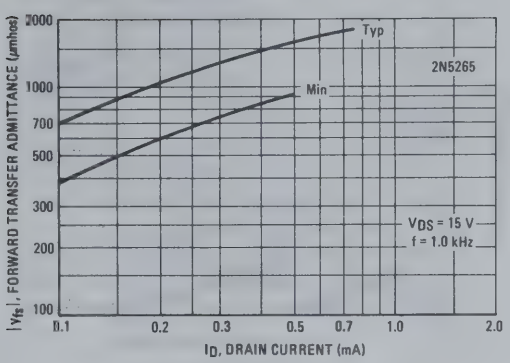


FIGURE 8

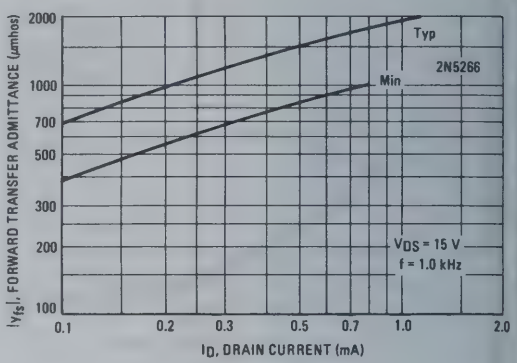


FIGURE 9

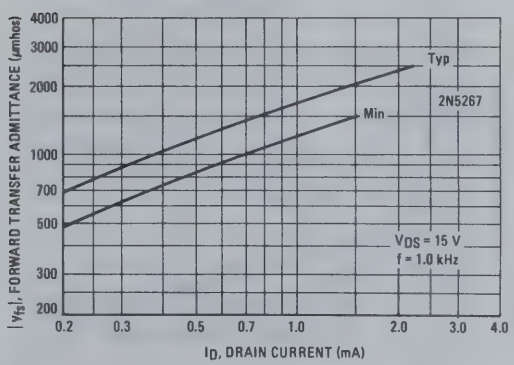


FIGURE 10

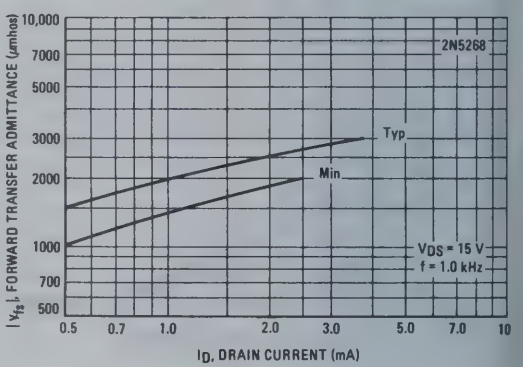


FIGURE 11

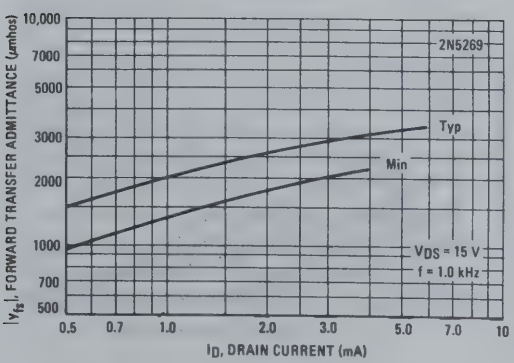
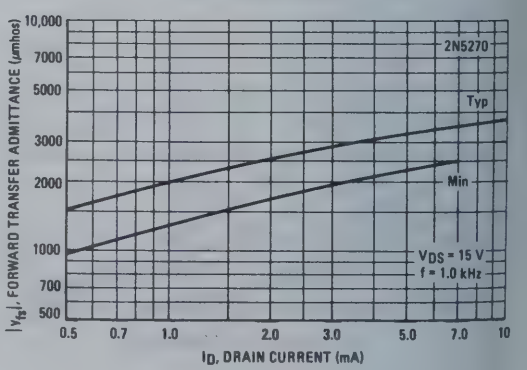


FIGURE 12



TYPICAL CURVES

FIGURE 13 – OUTPUT RESISTANCE versus DRAIN CURRENT

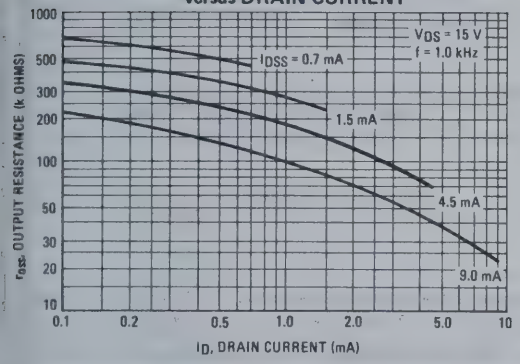


FIGURE 14 – CAPACITANCE versus DRAIN-SOURCE VOLTAGE

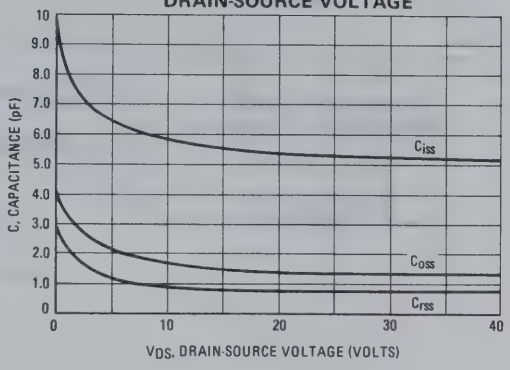


FIGURE 15 – NOISE FIGURE versus FREQUENCY

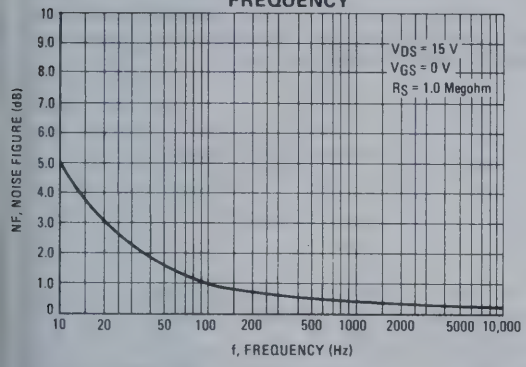


FIGURE 16 – NOISE FIGURE versus SOURCE RESISTANCE

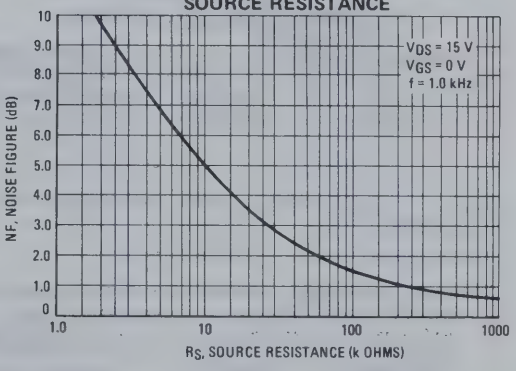


FIGURE 17 – DRAIN CURRENT TEMPERATURE COEFFICIENT versus DRAIN CURRENT

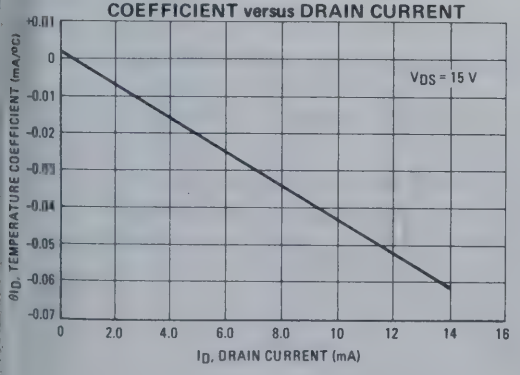


FIGURE 18 – FORWARD TRANSADMITTANCE COEFFICIENT versus DRAIN CURRENT

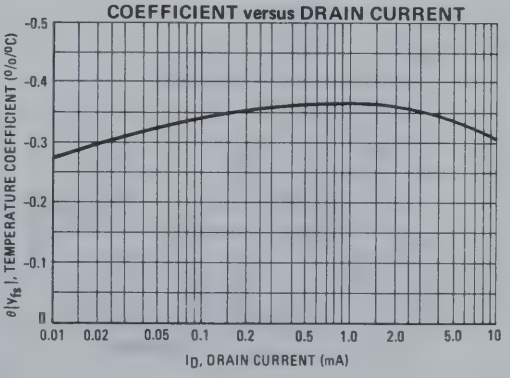
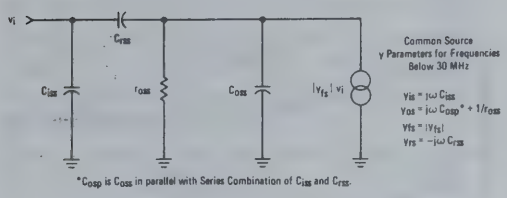


FIGURE 19 – EQUIVALENT LOW FREQUENCY CIRCUIT



BIAS NETWORK DESIGN FOR WORST CASE I_{DSS} VARIANCE

This Designers Data Sheet has been published to assist the circuit designer in optimizing his "worst case" design. The following example illustrates the use of the forward transfer characteristics curves (Figures 1 thru 6) in the design of a typical bias network.

Given: V_{DD} = -30 Vdc, I_D = 1.0 ± 0.25 mAdc from -55°C to +125°C

Procedure: The 2N5268 "worst case" bias conditions across the temperature range (from Figure 4) are reproduced in Figure A. The first step in the bias network design is to determine the value of the source resistance (R_S) necessary to hold the ± 0.25 mAdc I_D bias tolerance. To solve R_S, plot $I_{D(max)}$ and $I_{D(min)}$ on Figure A and calculate R_S, and V_G.

$$R_S = \frac{V_{GS(max)} - V_{GS(min)}}{I_{D(max)} - I_{D(min)}} = \frac{1.9\ \text{Vdc} - 0.8\ \text{Vdc}}{(1.25\ \text{mA} - 0.75\ \text{mA})} = 2.2\ \text{k Ohms}$$

$$V_G = \frac{I_{D(max)}\, V_{GS(min)} - I_{D(min)}\, V_{GS(max)}}{I_{D(max)} - I_{D(min)}}$$

$$= \frac{1.25 \times 0.80 - 0.75 \times 1.9}{0.5} = -0.9\ \text{Vdc}$$

In Figure B the maximum allowable value for R_1 will be determined by loading due to gate reverse current. Gate reverse current variations with temperature follow the pattern of all silicon devices, and, as a rule, we can assume that it will double with each 15°C temperature rise. Therefore, we can assume a maximum reverse current of approximately 0.5 μAdc at 125°C, based on the specified maximum 2.0 μAdc reverse at 150°C. The variation in V_G bias versus temperature will not be too great if we chose a value for R_1 which results in a bias network current (I_1 in Figure B) greater than 5 times the maximum reverse current. Assuming a value for R_1 of 9.1 Megohms, R_2 can be solved from the equation:

$$V_G = -0.9\ \text{Vdc} \approx \frac{-30\ R_2}{9.1 + R_2}\ \text{(Ignoring } I_G\text{)}$$

$$R_2 \approx 300\ \text{k Ohms}$$

Using the above values of R_1 and R_2, the variation in V_G can be computed for I_G = 0 to I_G = 0.5 μAdc. V_G will vary from 0.81 Vdc at I_G = 0.5 μAdc to 0.96 Vdc @ I_G = 0. This variation will have a minimal effect on I_D, as can be seen from Figure A by plotting load lines with a slope equal to $1/R_S$ from V_G = 0.81 Vdc and 0.96 Vdc respectively.

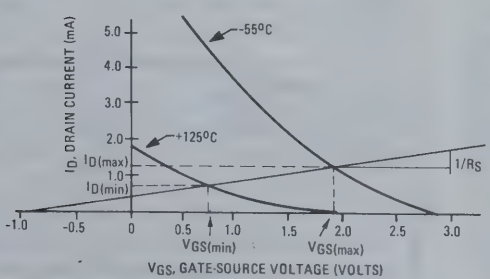


FIGURE A

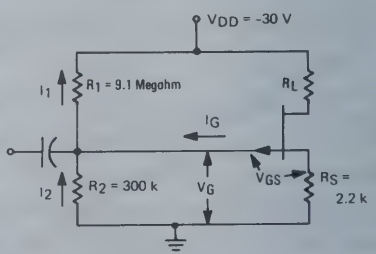


FIGURE B

2N5301 (SILICON)
2N5302
2N5303

HIGH-POWER NPN SILICON TRANSISTORS

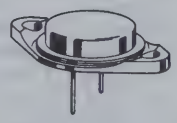
. . . for use in power amplifier and switching circuits applications.

- High Collector-Emitter Sustaining Voltage –
  $BV_{CEO(sus)}$ = 80 Vdc (Min) @ I_C = 200 mAdc (2N5303)
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.75 Vdc (Max) @ I_C = 10 Adc (2N5301, 2N5302)
  1.0 Vdc (Max) @ I_C = 10 Adc (2N5303)
- Excellent Safe Operating Area –
  200 Watts dc Power Rating to 30 Vdc (2N5303)
- Complements to PNP 2N4398, 2N4399 and 2N5745

20 AND 30 AMPERE POWER TRANSISTORS

NPN SILICON

40–60–80 VOLTS
200 WATTS



*MAXIMUM RATINGS

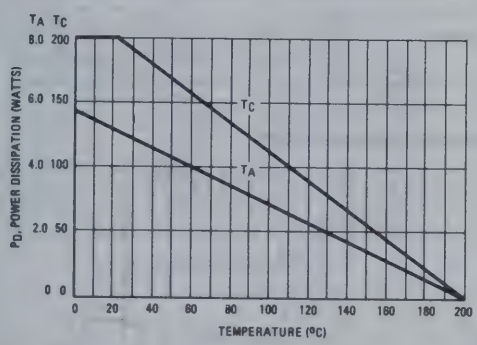
Rating	Symbol	2N5301	2N5302	2N5303	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Collector Current – Continuous	I_C	30	30	20	Adc
Base Current	I_B	← 7.5 →			Adc
Total Device Dissipation @ T_C=25°C Derate above 25°C	P_D	← 200 → ← 1.14 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	← -65 to +200 →			°C

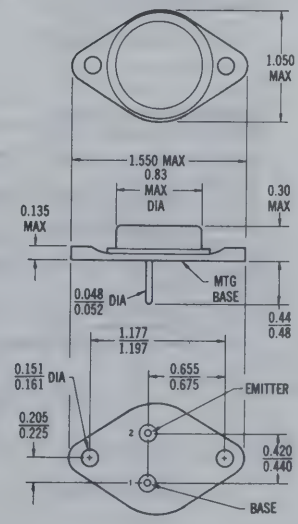
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	34	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER TEMPERATURE DERATING CURVE





CASE 12
(TO-3 Except Pin Diameter)
Collector Connected to Case

2N5301, 2N5302, 2N5303 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25° unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N5301		40	–	
	2N5302		60	–	
	2N5303		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N5301		–	5.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N5302		–	5.0	
(V_{CE} = 80 Vdc, I_B = 0)	2N5303		–	5.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5301		–	1.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5302		–	1.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5303		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5301		–	10	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5302		–	10	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5303		–	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N5301		–	1.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N5302		–	1.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N5303		–	1.0	
Emitter Cutoff Current		I_{EBO}	–	5.0	mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
*(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	ALL TYPES		40	–	
*(I_C = 10 Adc, V_{CE} = 2.0 Vdc)	2N5303		15	60	
*(I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N5301,2N5302		15	60	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)	2N5303		5.0	–	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)	2N5301,2N5302		5.0	–	
*Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)	2N5301,2N5302		–	0.75	
(I_C = 10 Adc, I_B = 1.0 Adc)	2N5303		–	1.0	
(I_C = 15 Adc, I_B = 1.5 Adc)	2N5303		–	1.5	
(I_C = 20 Adc, I_B = 2.0 Adc)	2N5301,2N5302		–	2.0	
(I_C = 20 Adc, I_B = 4.0 Adc)	2N5303		–	2.0	
(I_C = 30 Adc, I_B = 6.0 Adc)	2N5301,2N5302		–	3.0	
*Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)	ALL TYPES		–	1.7	
(I_C = 15 Adc, I_B = 1.5 Adc)	2N5301,2N5302		–	1.8	
(I_C = 15 Adc, I_B = 1.5 Adc)	2N5303		–	2.0	
(I_C = 20 Adc, I_B = 2.0 Adc)	2N5301,2N5302		–	2.5	
(I_C = 20 Adc, I_B = 4.0 Adc)	2N5303		–	2.5	
*Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$			Vdc
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)	2N5303		–	1.5	
(I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N5301,2N5302		–	1.7	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)	2N5303		–	2.5	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)	2N5301,2N5302		–	3.0	
***DYNAMIC CHARACTERISTICS**					
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.0	–	MHz
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	40	–	–
***SWITCHING CHARACTERISTICS**					
Rise Time	(V_{CC} = 30 Vdc, I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)	t_r	–	1.0	μs
Storage Time		t_s	–	2.0	μs
Fall Time		t_f	–	1.0	μs

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 2 – TURN-ON TIME

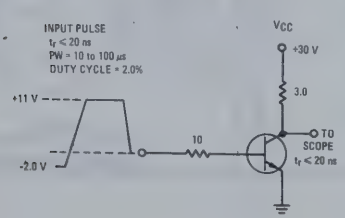


FIGURE 3 – TURN-OFF TIME

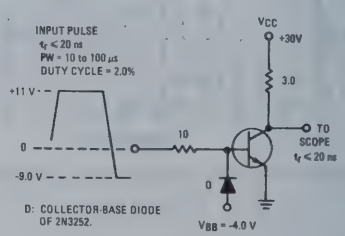


FIGURE 4 – THERMAL RESPONSE

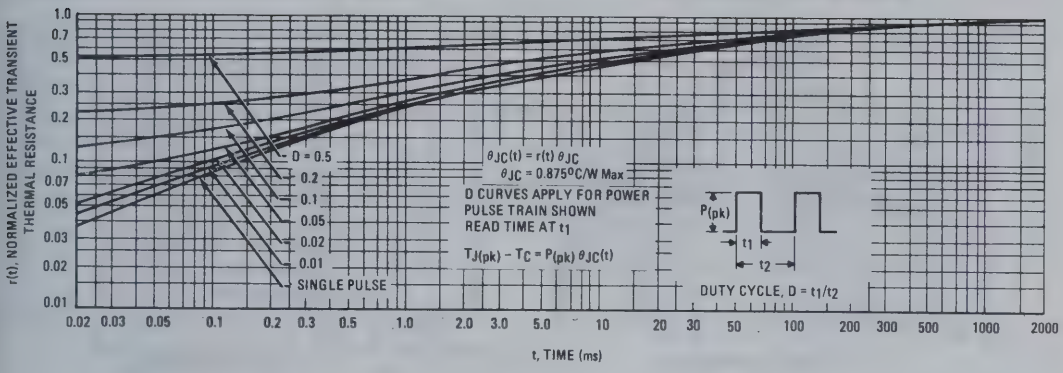


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA

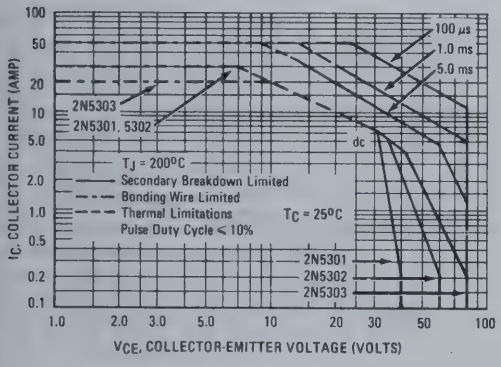


FIGURE 6 – CAPACITANCE versus VOLTAGE

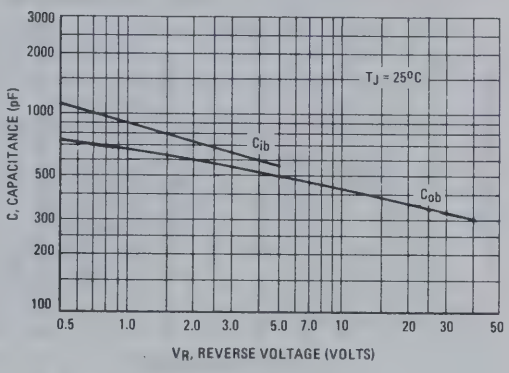


FIGURE 7 – TURN-ON TIME

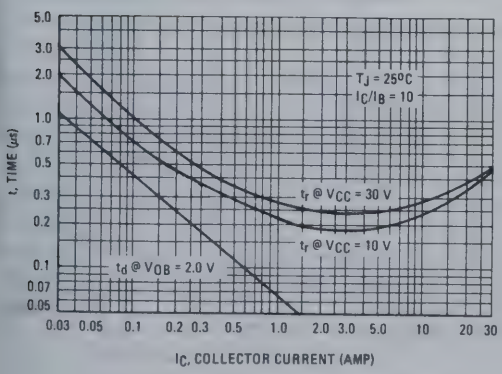


FIGURE 8 – TURN-OFF TIME

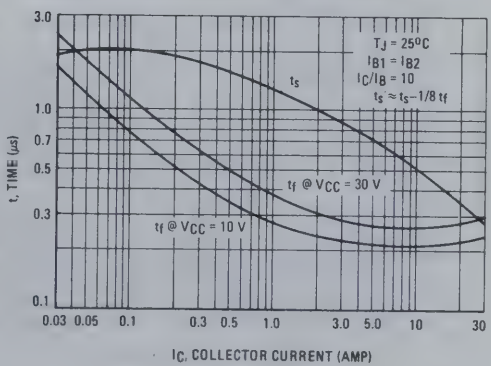


FIGURE 9 – DC CURRENT GAIN

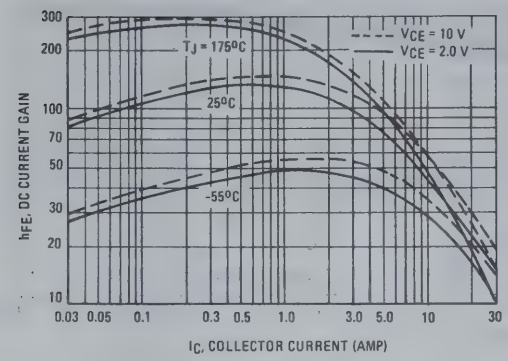


FIGURE 10 – COLLECTOR SATURATION REGION

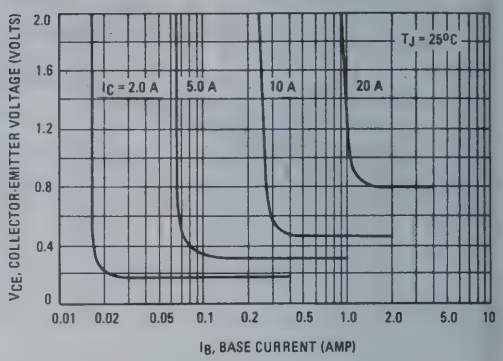


FIGURE 11 – EFFECTS OF BASE-EMITTER RESISTANCE

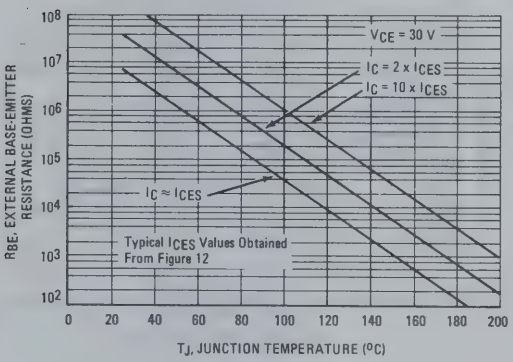


FIGURE 12 – "ON" VOLTAGES

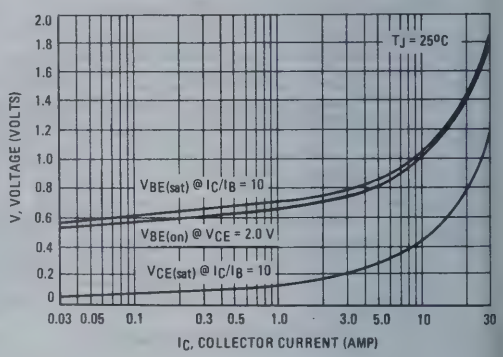


FIGURE 13 – COLLECTOR CUT-OFF REGION

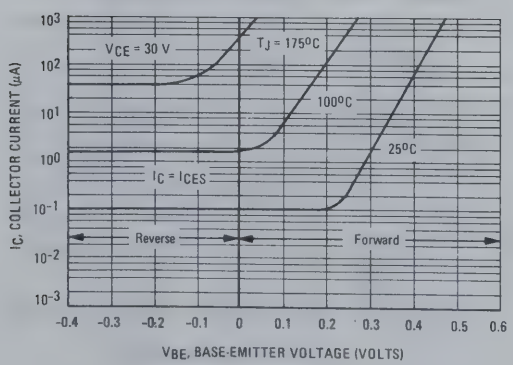
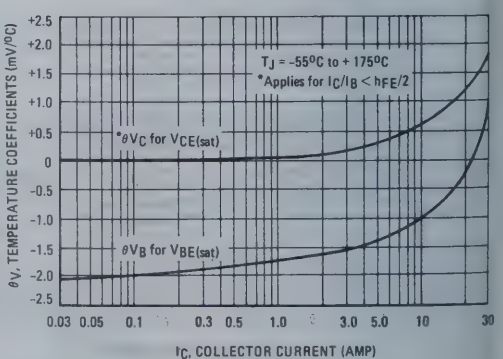


FIGURE 14 – TEMPERATURE COEFFICIENTS



2N5324 (GERMANIUM)
2N5325

PNP GERMANIUM POWER TRANSISTORS

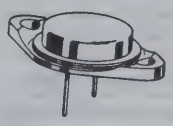
. . . designed primarily for switching, inverter, and industrial power supply applications.

- Low Collector Cutoff Current –
  I_{CEX} = 7.0 mAdc (Max) @ V_{CEX} = 250 Vdc (2N5324)
  7.0 mAdc (Max) @ V_{CEX} = 325 Vdc (2N5325)
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 10 Adc
- Low Base-Emitter Saturation Voltage –
  $V_{BE(sat)}$ = 0.75 Vdc (Max) @ I_C = 10 Adc
- Guaranteed Excellent Safe Operating Area ($V_{CER(sus)}$)
  Specified at 3.0 Amps and 10 Amps
- 100% Stabilization Bake at 125°C for 100 Hours

10 AMPERE
POWER TRANSISTORS
PNP GERMANIUM
EPITAXIAL BASE
250-325 VOLTS
56 WATTS

*MAXIMUM RATINGS

Rating	Symbol	2N5324	2N5325	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	Vdc
Collector-Base Voltage	V_{CB}	250	325	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	10		Adc
Base Current – Continuous	I_B	3.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	56 0.67		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110		°C

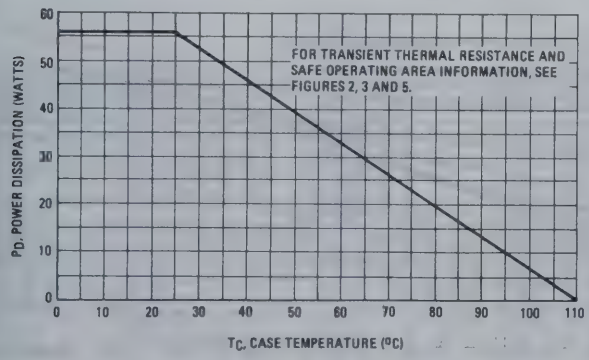


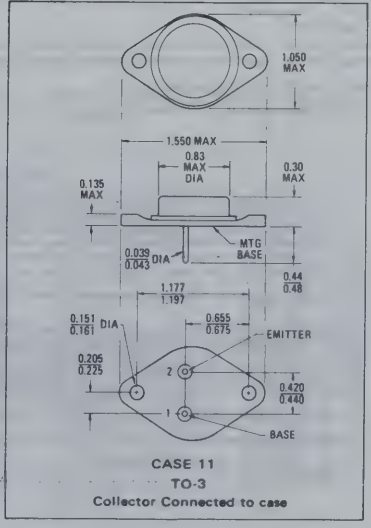
*Indicates JEDEC Registered Data.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.5	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





CASE 11
TO-3
Collector Connected to case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
†Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0)	2N5324	BV_{CEO}	150	–	Vdc
	2N5325		200	–	
Collector-Emitter Sustaining Voltage (I_C = 3.0 Adc, R_{BE} = 10 Ohms) (Figure 4, Test Condition 1)	2N5324	$V_{CER(sus)}$	165	–	Vdc
	2N5325		200	–	
(I_C = 10 Adc, R_{BE} = 10 Ohms) (Figure 4, Test Condition 2)	2N5324		100	–	
	2N5325		115	–	
*Collector Cutoff Current (See Note 1) (V_{CE} = 250 Vdc, V_{BE} (off) = 0.2 Vdc)	2N5324	I_{CEV}	–	7.0	mAdc
(V_{CE} = 250 Vdc, V_{BE} (off) = 0.2 Vdc, T_C = 85°C)			–	35	
(V_{CE} = 325 Vdc, V_{BE} (off) = 0.2 Vdc)	2N5325		–	7.0	
(V_{CE} = 325 Vdc, V_{BE} (off) = 0.2 Vdc, T_C = 85°C)			–	35	
*Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	100	mAdc
ON CHARACTERISTICS					
*DC Current Gain (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20	60	–
*Collector-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)		$V_{CE(sat)}$	–	0.5	Vdc
*Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)		$V_{BE(sat)}$	–	0.75	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc, f = 0.5 MHz)		f_T	2.0	–	MHz
SWITCHING CHARACTERISTICS					
*Rise Time	(I_C = 5.0 Adc, I_{B1} = I_{B2} = 0.5 Adc) (See Figure 6)	t_r	–	15	μs
*Storage Time		t_s	–	10	μs
*Fall Time		t_f	–	7.0	μs

Note 1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

*Indicates JEDEC Registered Data.

†JEDEC Registration Defined as $V_{(BR)CEO}$

FIGURE 2 – TRANSIENT THERMAL RESPONSE

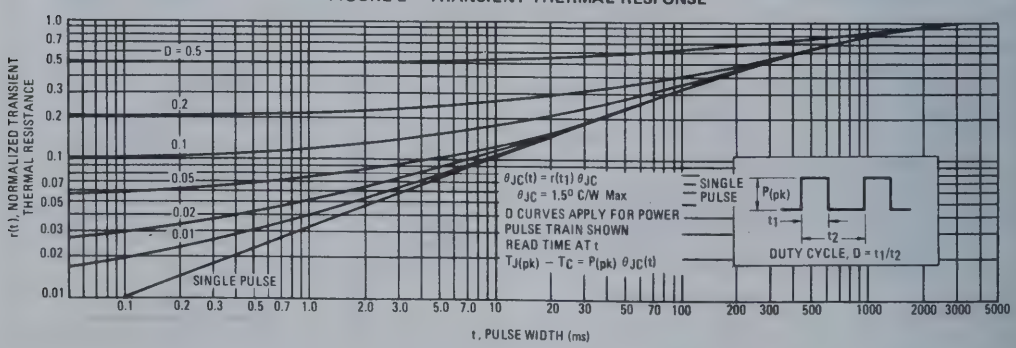


FIGURE 3 – COLLECTOR-EMITTER SUSTAINING VOLTAGE

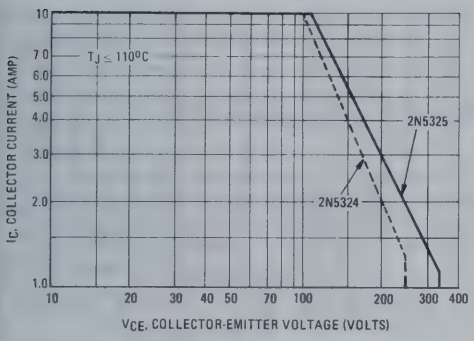


FIGURE 4 – COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST CIRCUIT

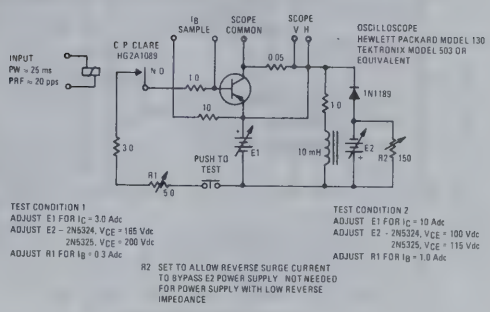


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA

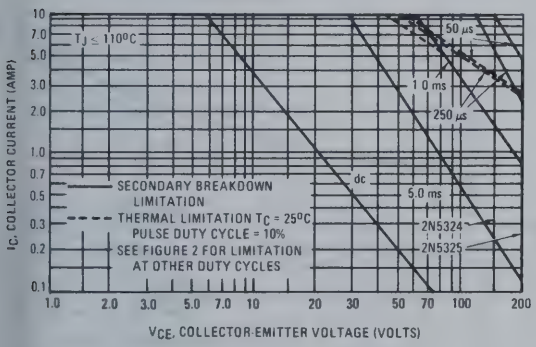


FIGURE 6 – SWITCHING TIME TEST CIRCUIT

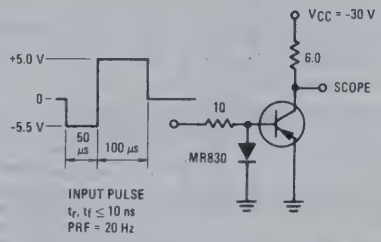


FIGURE 7 – SWITCHING TIMES

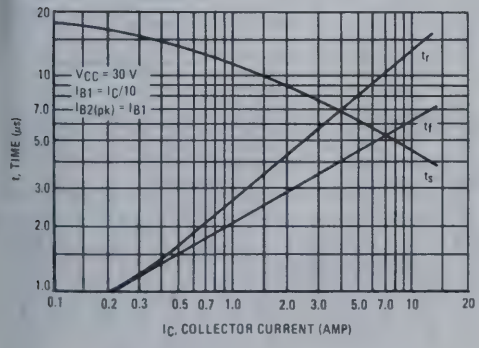


FIGURE 8 - CURRENT GAIN BANDWITH PRODUCT

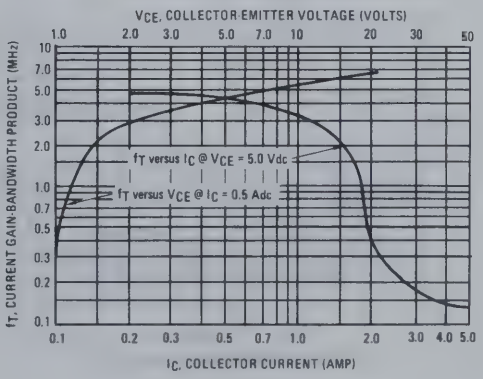


FIGURE 9 – DC CURRENT GAIN

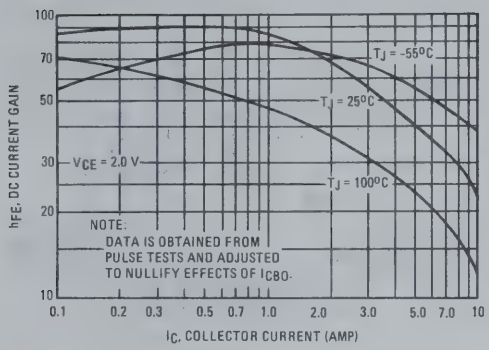


FIGURE 10 – COLLECTOR SATURATION REGION

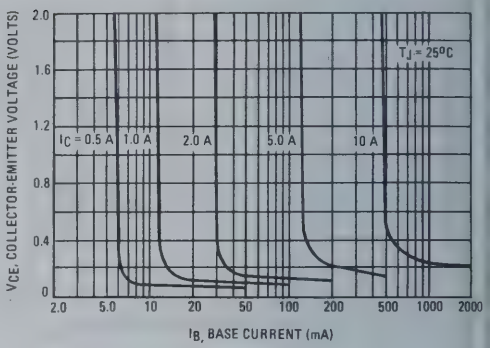


FIGURE 11 – EFFECTS OF EMITTER-BASE RESISTANCE

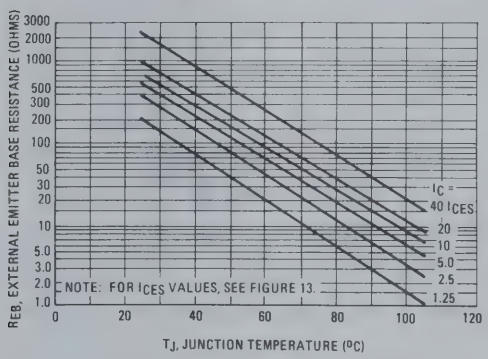


FIGURE 12 – "ON" VOLTAGES

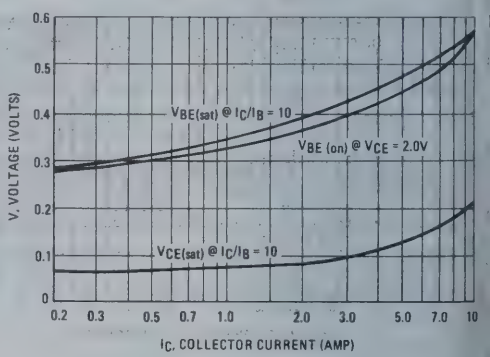


FIGURE 13 – COLLECTOR CUTOFF REGION

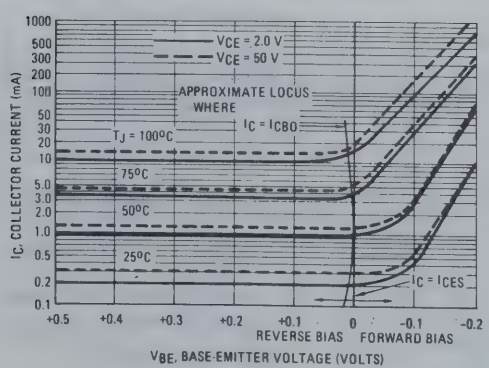
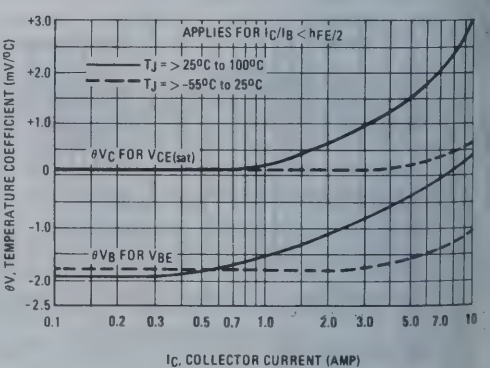


FIGURE 14 – TEMPERATURE COEFFICIENTS



2N5332 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for use in general-purpose, high-frequency amplifier and saturated and non-saturated switching circuit applications. Unique fabrication techniques are employed to maintain useful characteristics after fast-neutron radiation fluences to 10^{15} n/cm^2.

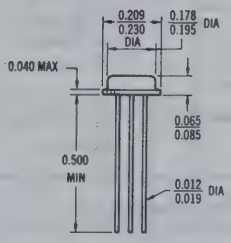
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.2 Vdc (Max) @ I_C = 20 mAdc
- High Current-Gain—Bandwidth Product — f_T = 2300 MHz (Typ) @ I_C = 50 mAdc
- High Tolerance to Neutron Radiation @ I_C = 100 mAdc, h_{FE} Degradation Typically Less Than 40% after 3 x 10^{15} Neutrons/cm^2

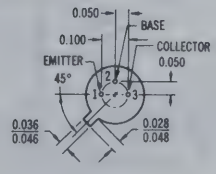
PNP SILICON GENERAL-PURPOSE TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	12	Vdc
*Collector-Base Voltage	V_{CB}	20	Vdc
*Emitter-Base Voltage	V_{EB}	2.0	Vdc
*Collector Current — Continuous	I_C	100	mAdc
*Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4	mW mW/°C
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 8.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C





CASE 26
TO-46 PACKAGE

*POST-IRRADIATION ELECTRICAL CHARACTERISTICS

(T_A = 25°C unless otherwise noted)

	Characteristic	Symbol	Min	Max	Unit
Φ_n	Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	10	μAdc
@ 10^{15}n/cm^2	DC Current Gain (I_C = 20 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	10	–	–
	Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 4.0 mAdc)	$V_{CE(sat)}$	–	0.6	Vdc

*Indicates JEDEC Registered Data.

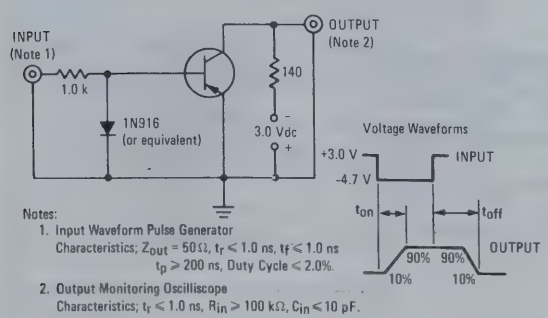
2N5332 (continued)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	2.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	10	nAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 125°C)		–	10	μAdc
Emitter Cutoff Current (V_{BE} = 1.5 Vdc, I_C = 0)	I_{EBO}	–	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	80	–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (Note 1)		20	80	
(I_C = 20 mAdc, V_{CE} = 1.0 Vdc) (Note 1)		20	80	
(I_C = 20 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (Note 1)		10	–	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc) (Note 1)		20	80	
Collector-Emitter Saturation Voltage (Note 1) (I_C = 20 mAdc, I_B = 4.0 mAdc)	$V_{CE(sat)}$	–	0.2	Vdc
Base-Emitter Saturation Voltage (Note 1) (I_C = 20 mAdc, I_B = 4.0 mAdc)	$V_{BE(sat)}$	0.7	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	600	–	MHz
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		800	–	
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	3.5	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	–	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.7 Vdc, I_C = 20 mAdc, I_{B1} = 4.0 mAdc) (See Figure 1)	t_d	–	12	ns
Rise Time		t_r	–	8.0	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 20 mAdc, I_{B1} = I_{B2} = 4.0 mAdc) (See Figure 1)	t_s	–	70	ns
Fall Time		t_f	–	16	ns

*Indicates JEDEC Registered Data.
Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



Notes:
1. Input Waveform Pulse Generator Characteristics; Z_{out} = 50Ω, t_r ≤ 1.0 ns, t_f ≤ 1.0 ns, t_p ≥ 200 ns, Duty Cycle ≤ 2.0%.
2. Output Monitoring Oscilliscope Characteristics; t_r ≤ 1.0 ns, R_{in} ≥ 100 kΩ, C_{in} ≤ 10 pF.

FIGURE 2 – DC CURRENT GAIN

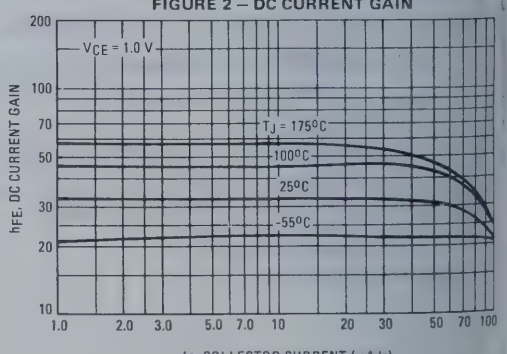


FIGURE 3 – "ON" VOLTAGES

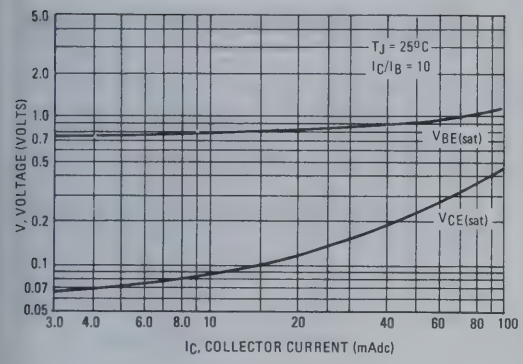


FIGURE 4 – COLLECTOR SATURATION REGION

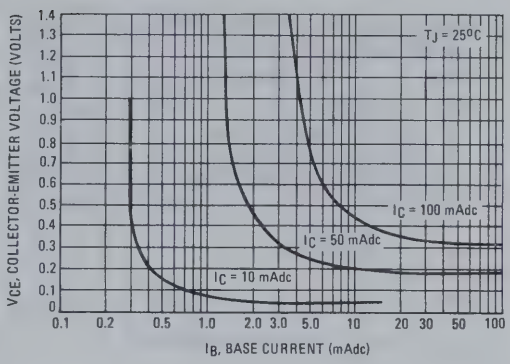


FIGURE 5 – TEMPERATURE COEFFICIENTS

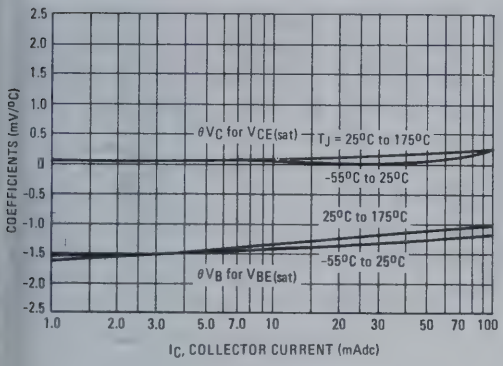


FIGURE 6 – CAPACITANCES

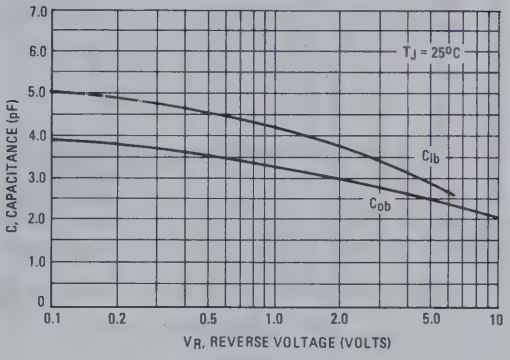


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

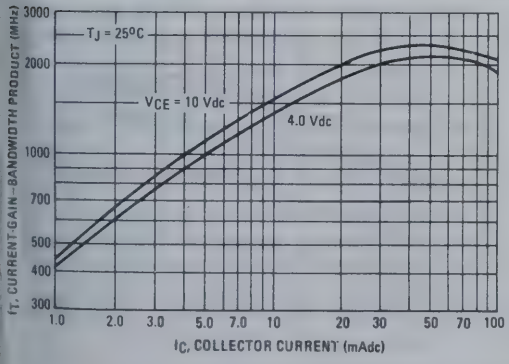


FIGURE 8 – COLLECTOR-BASE TIME CONSTANT

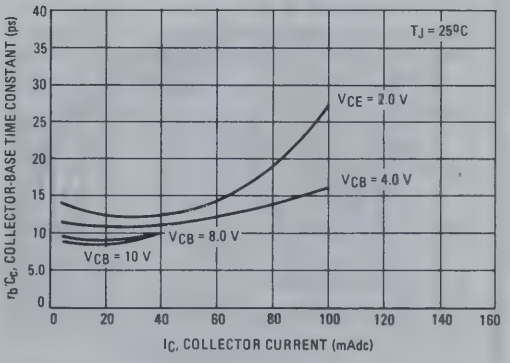


FIGURE 9 – SWITCHING TIMES

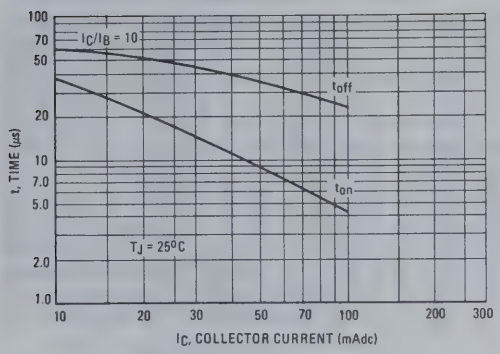


FIGURE 10 – COLLECTOR-CUTOFF CURRENT versus FAST NEUTRON DOSAGE

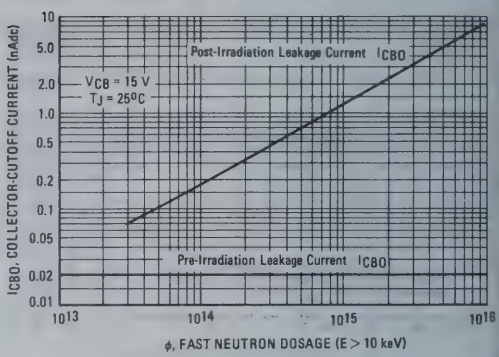


FIGURE 11 – NORMALIZED DC CURRENT GAIN versus FAST NEUTRON DOSAGE

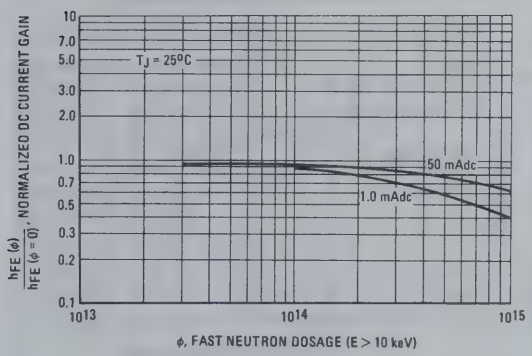


FIGURE 12 – NORMALIZED DC CURRENT GAIN versus FAST NEUTRON DOSAGE

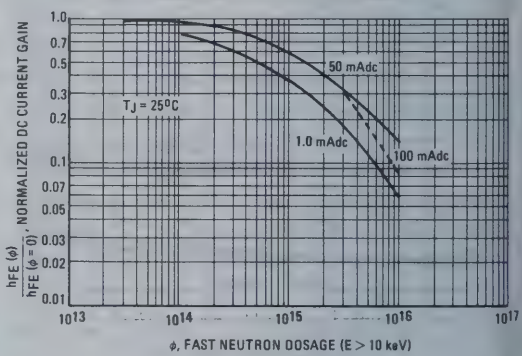


FIGURE 13 – TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGE versus FAST NEUTRON DOSAGE

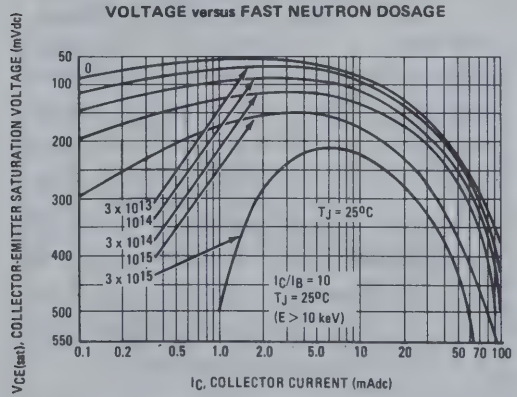
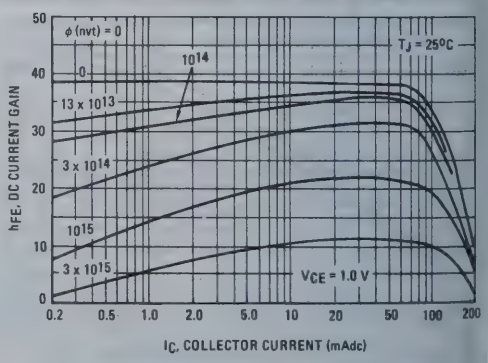


FIGURE 14 – DC CURRENT GAIN versus FAST NEUTRON DOSAGE



2N5334 (SILICON)
2N5335

HIGH-SPEED NPN SILICON POWER TRANSISTORS

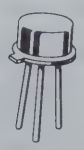
. . . designed for fast switching and amplifier applications.

- Total Switching Time – 1.15 μs Max
- High Current Switching Specified at 1.0 Adc –
  t_{on} = 100 ns Max
  t_{off} = 1.05 μs Max
- Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 2.0 Adc

3 AMPERE POWER TRANSISTORS

NPN SILICON

60-80 VOLTS
6 WATTS



*MAXIMUM RATINGS

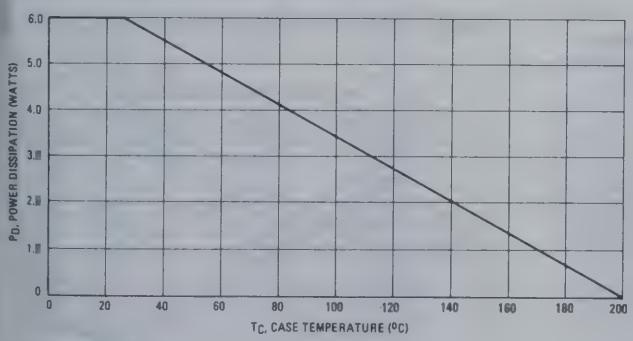
Rating	Symbol	2N5334	2N5335	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	8.0		Vdc
Collector Current - Continuous	I_C	3.0		Adc
Base Current - Continuous	I_B	0.5		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	6.0 34		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS**

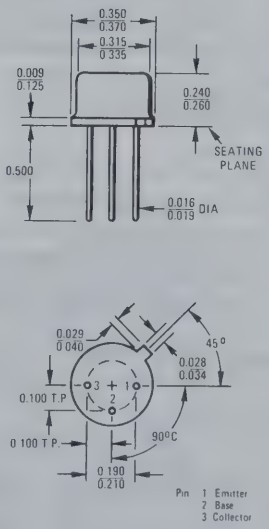
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	29.1	°C/W

*Indicates JEDEC Registered Data.
**Motorola Guarantees this data in addition to JEDEC Registered Data.

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.



CASE 79 (1)
TO-39

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$			Vdc
(I_C = 50 mAdc, I_B = 0)	2N5334		60	–	
	2N5335		80	–	
**Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5334		–	1.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5335		–	1.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5334		–	500	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5335		–	500	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N5334		–	5.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N5335		–	5.0	
Emitter Cutoff Current		I_{EBO}	–	100	μAdc
(V_{EB} = 8.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)			30	150	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)			15	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)			–	0.7	
**(I_C = 3.0 Adc, I_B = 0.6 Adc)			–	1.8	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$	–	1.5	Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)					
**Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$			Vdc
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)			–	1.5	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)			–	1.8	
***DYNAMIC CHARACTERISTICS**					
Current-Gain–Bandwidth Product (Note 2)		f_T	40	–	MHz
(I_C = 0.1 Adc, V_{CE} = 10 Vdc, f = 10 MHz)					
Output Capacitance		C_{ob}	–	75	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)					
Input Capacitance		C_{ib}	–	250	pF
(V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)					
SWITCHING CHARACTERISTICS					
**Delay Time	(V_{CC} = 20 Vdc, $V_{EB(off)}$ = 3.7 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_d	–	50	ns
Rise Time		t_r	–	50	ns
Storage Time		t_s	–	950	ns
Fall Time		t_f	–	100	ns

*Indicates JEDEC Registered Data. **Motorola Guarantees this data in addition to JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

Note 2: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

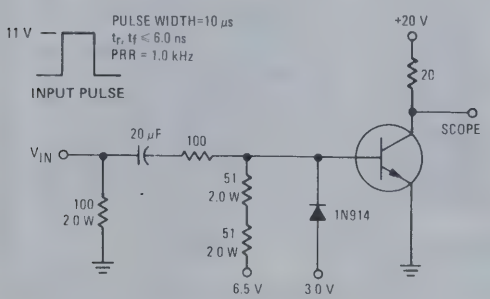


FIGURE 3 – TURN ON TIME

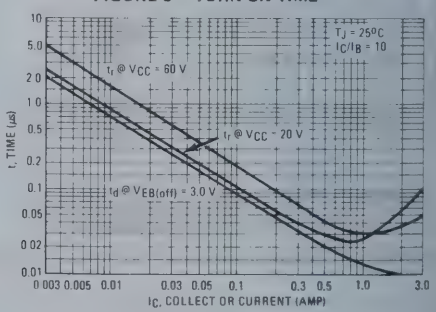


FIGURE 4 – THERMAL RESPONSE

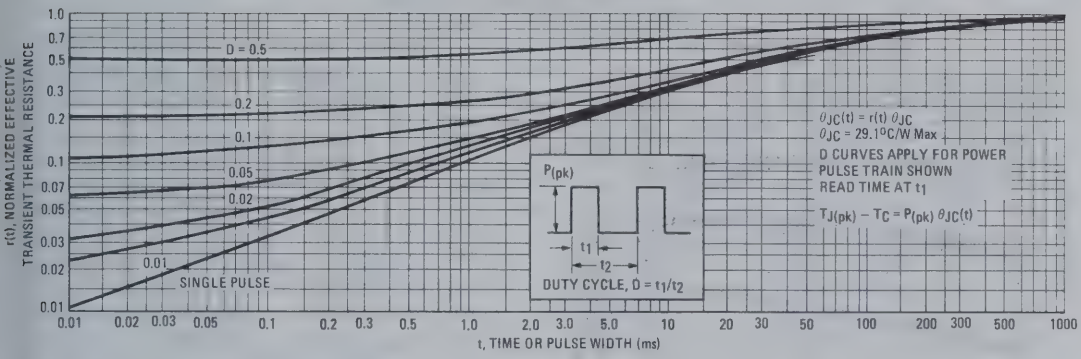
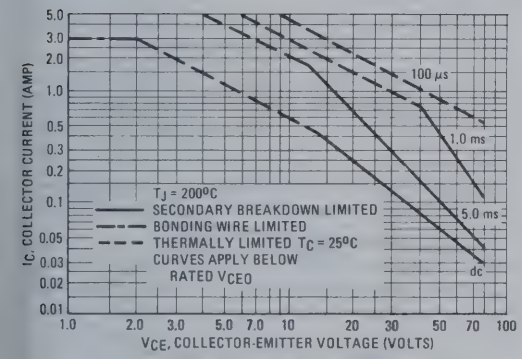


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C @ V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

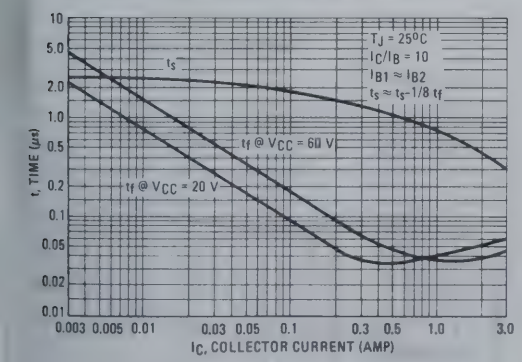
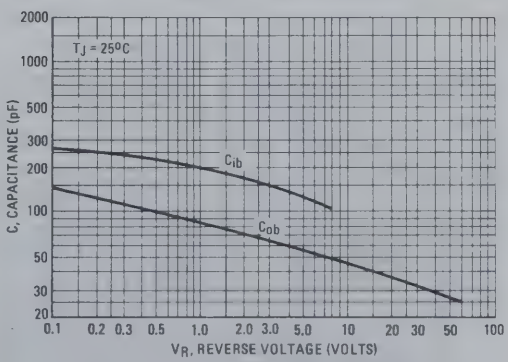


FIGURE 7 – CAPACITANCES



ELECTRICAL CHARACTERISTICS
(T_J = 25°C unless otherwise noted)

FIGURE 8 – CURRENT GAIN

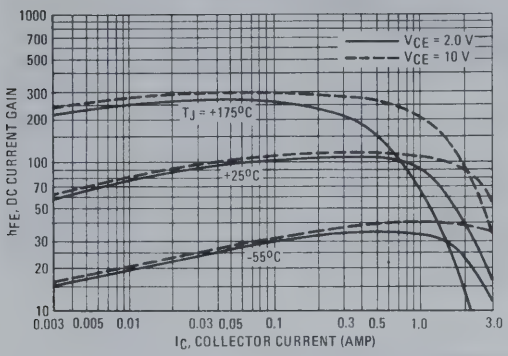


FIGURE 9 – COLLECTOR SATURATION REGION

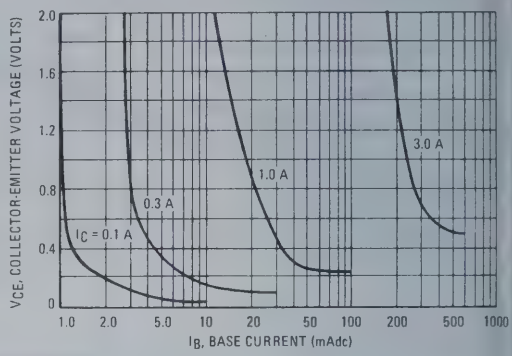


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

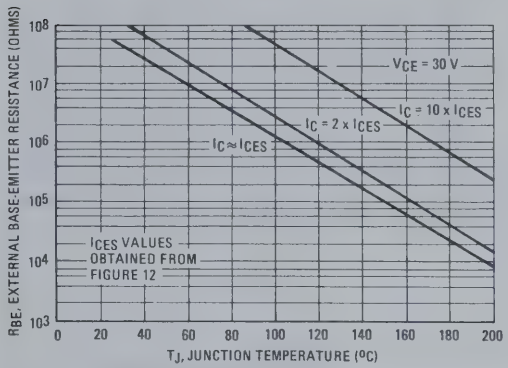


FIGURE 11 – "ON" VOLTAGES

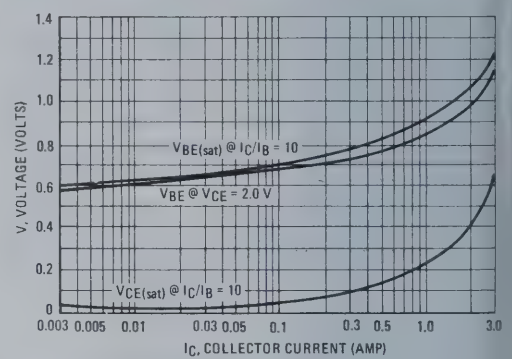


FIGURE 12 – COLLECTOR CUTOFF REGION

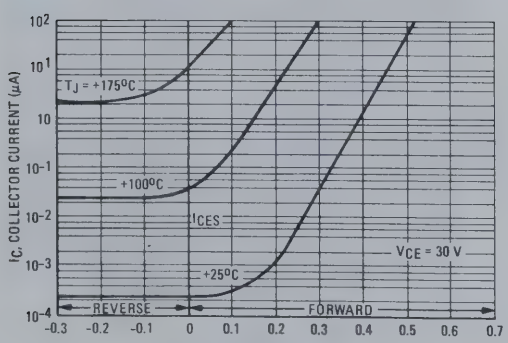
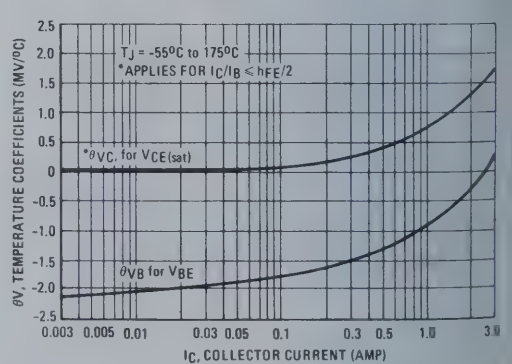


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5336 (SILICON) thru 2N5339



Medium-power NPN silicon transistors designed for switching and wide band amplifier applications.

CASE 79
(TO-39)

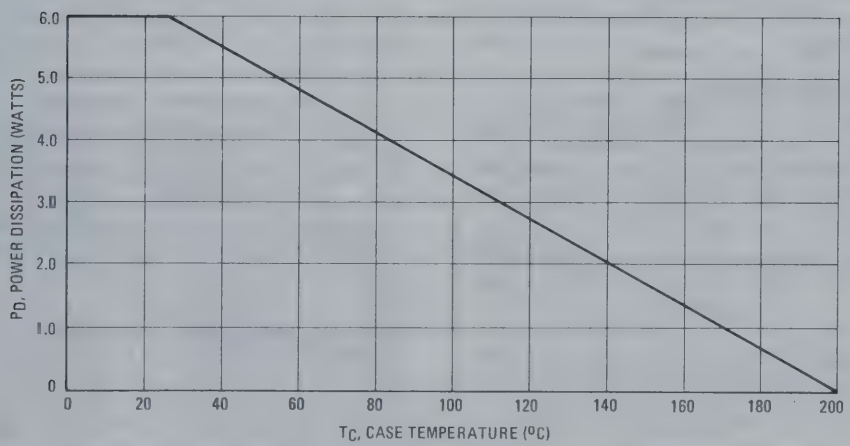
MAXIMUM RATINGS

Rating	Symbol	2N5336 2N5337	2N5338 2N5339	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	5.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	6.0 34.3		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	29.2	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 50 mAdc, I_B = 0)	2N5336, 2N5337	-	$BV_{CEO(sus)}$*	80	-	Vdc
	2N5338, 2N5339			100	-	
Collector Cutoff Current (V_{CE} = 75 Vdc, I_B = 0)	2N5336, 2N5337	-	I_{CEO}	-	100	μAdc
(V_{CE} = 90 Vdc, I_B = 0)	2N5338, 2N5339			-	100	
Collector Cutoff Current (V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5336, 2N5337	12	I_{CEX}	-	10	μAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5338, 2N5339			-	10	
(V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5336, 2N5337			-	1.0	mAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5338, 2N5339			-	1.0	
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	2N5336, 2N5337	-	I_{CBO}	-	10	μAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N5338, 2N5339			-	10	
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		-	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N5336, 2N5338	8	h_{FE}*	30	-	-
	2N5337, 2N5339			60	-	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N5336, 2N5338			30	120	
	2N5337, 2N5339			60	240	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N5336, 2N5338			20	-	
	2N5337, 2N5339			40	-	
Collector-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		9, 11, 13	$V_{CE(sat)}$*	-	0.7	Vdc
(I_C = 5.0 Adc, I_B = 0.5 Adc)				-	1.2	
Base-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		11, 13	$V_{BE(sat)}$*	-	1.2	Vdc
(I_C = 5.0 Adc, I_B = 0.5 Adc)				-	1.8	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 10 MHz)		-	f_T	30	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		7	C_{ob}	-	250	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		7	C_{ib}	-	1,000	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 40 Vdc, $V_{EB(off)}$ = 3.0 Vdc,	2,3	t_d	-	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 0.2 Adc)		t_r	-	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	2,6	t_s	-	2.0	μs
Fall Time	I_{B1} = I_{B2} = 0.2 Adc)		t_f	-	200	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

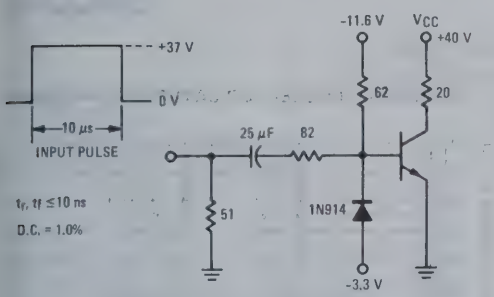


FIGURE 3 – TURN ON TIME

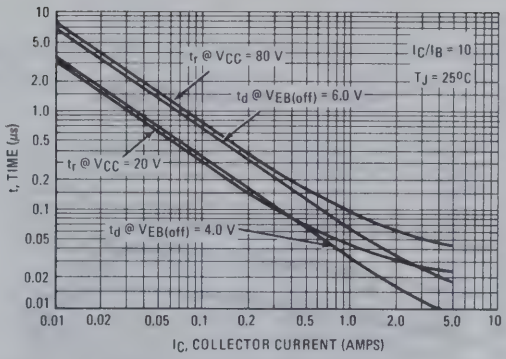


FIGURE 4 – THERMAL RESPONSE

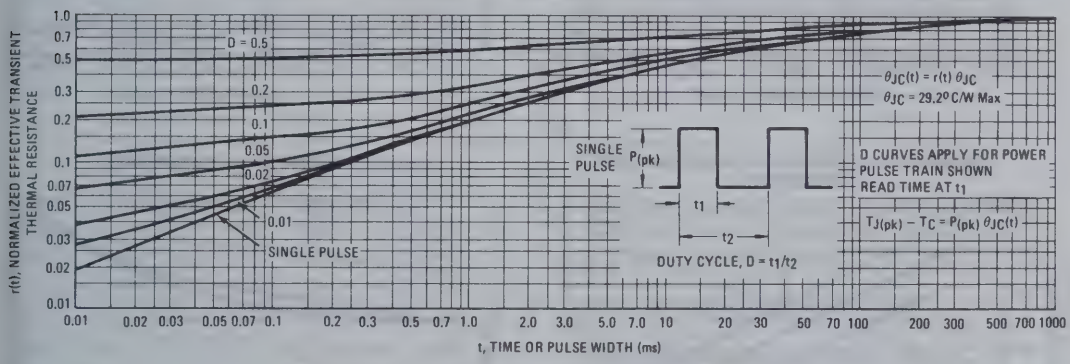
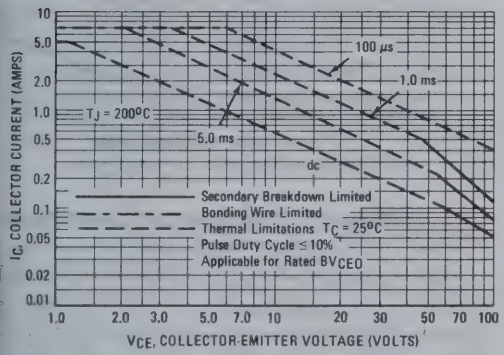


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

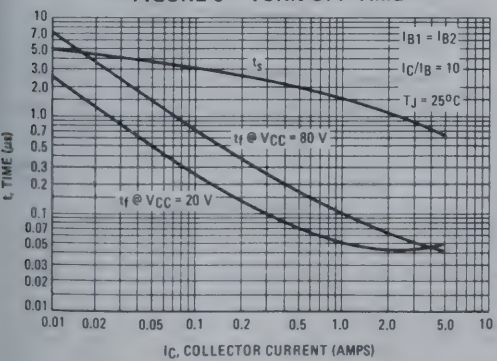


FIGURE 7 – CAPACITANCE versus VOLTAGE

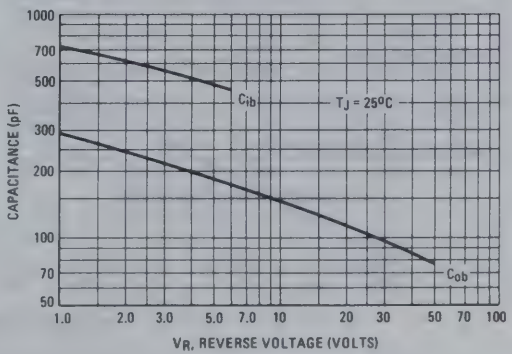


FIGURE 8 – DC CURRENT GAIN

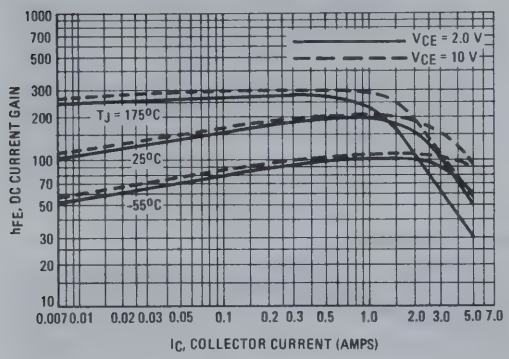


FIGURE 9 – COLLECTOR SATURATION REGION

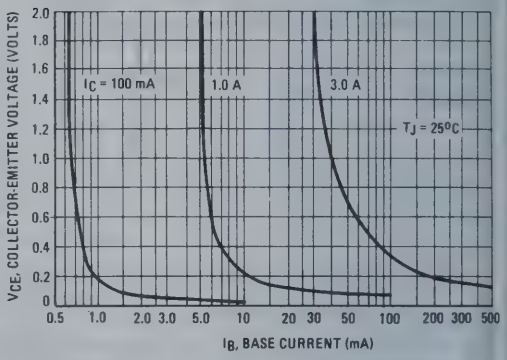


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

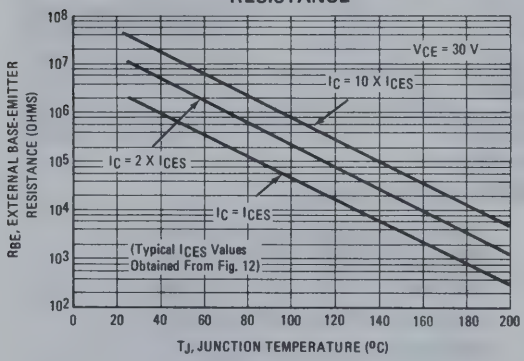


FIGURE 11 – ON VOLTAGES

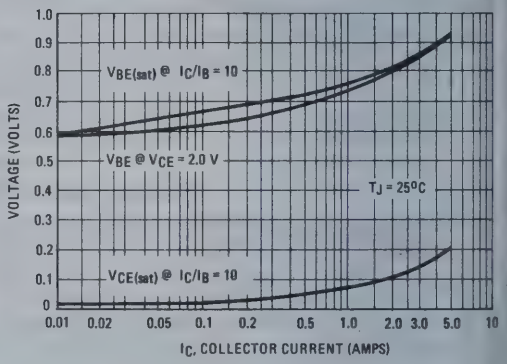


FIGURE 12 – COLLECTOR CUT-OFF REGION

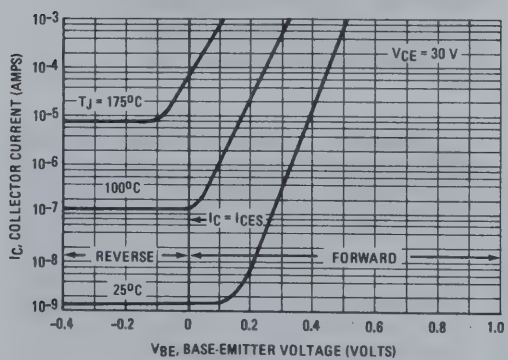
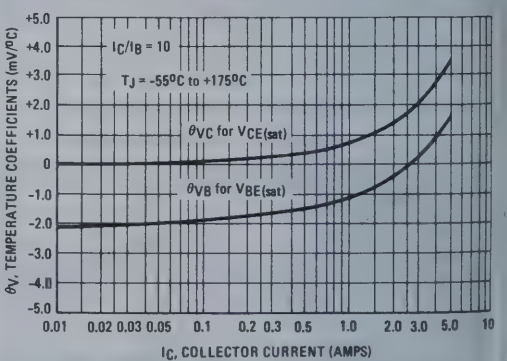
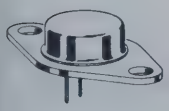


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5344 (SILICON)
2N5345

High voltage power PNP silicon transistors designed for high-voltage switching and amplifier applications.



CASE 80
(TO-66)

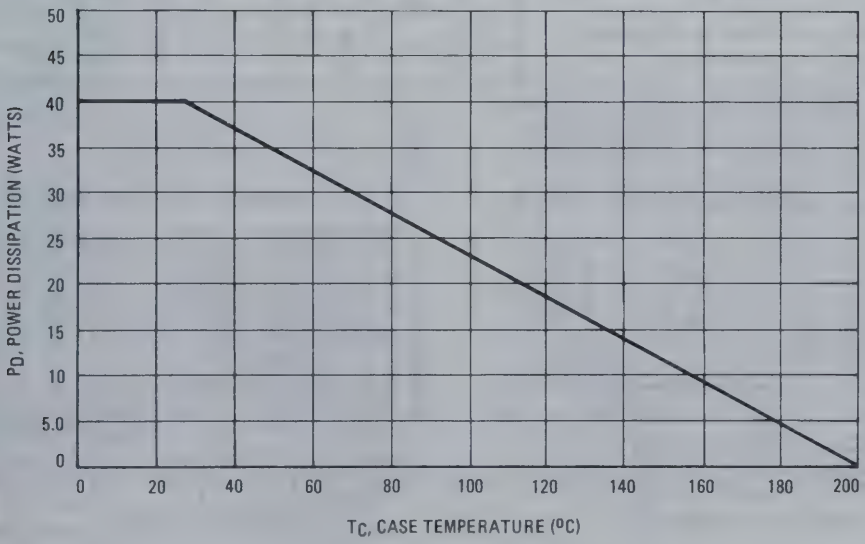
MAXIMUM RATINGS

Rating	Symbol	2N5344	2N5345	Unit
Collector-Emitter Voltage	V_{CEO}	250	300	Vdc
Collector-Base Voltage	V_{CB}	250	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Base Current — Continuous	I_B	0.5		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 228		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.38	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves Are Indicated By Figure 5. All Limits Are Applicable And Must Be Observed

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0) 2N5344	5	$BV_{CEO(sus)}$*	250	-	Vdc
2N5345			300	-	
Collector Cutoff Current (V_{CE} = 225 Vdc, $V_{BE(off)}$ = 1.5 Vdc) 2N5344	10, 12	I_{CEX}	-	100	μAdc
(V_{CE} = 270 Vdc, $V_{BE(off)}$ = 1.5 Vdc) 2N5345			-	100	
(V_{CE} = 225 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C) 2N5344			-	1.0	mAdc
(V_{CE} = 270 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C) 2N5345			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	-	I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	-	I_{EBO}	-	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	8	h_{FE}*	25	100	-
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			7.0	-	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.2 Adc)	9, 11, 13	$V_{CE(sat)}$	-	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.2 Adc)	11, 13	$V_{BE(sat)}$	-	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 10 MHz)	-	f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	7	C_{ob}	-	200	pF
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 100 Vdc, $V_{BE(off)}$ = 0.85 Vdc,	2, 3	t_d	-	100	ns
Rise Time I_C = 500 mAdc, I_{B1} = 50 mAdc)	2, 3	t_r	-	100	ns
Storage Time (V_{CC} = 100 Vdc, I_C = 500 mAdc,	2, 6	t_s	-	600	ns
Fall Time I_{B1} = I_{B2} = 50 mAdc)	2, 6	t_f	-	100	ns

* Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%.

FIGURE 2 — SWITCHING TIME TEST CIRCUIT

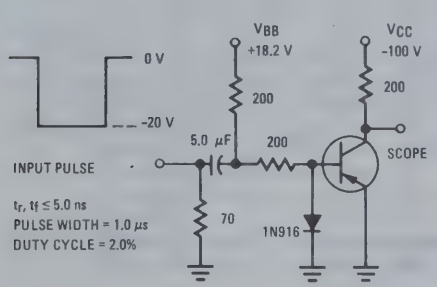


FIGURE 3 — TURN-ON TIME

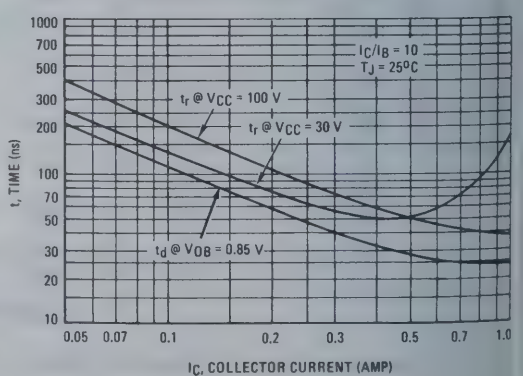


FIGURE 4 – THERMAL RESPONSE

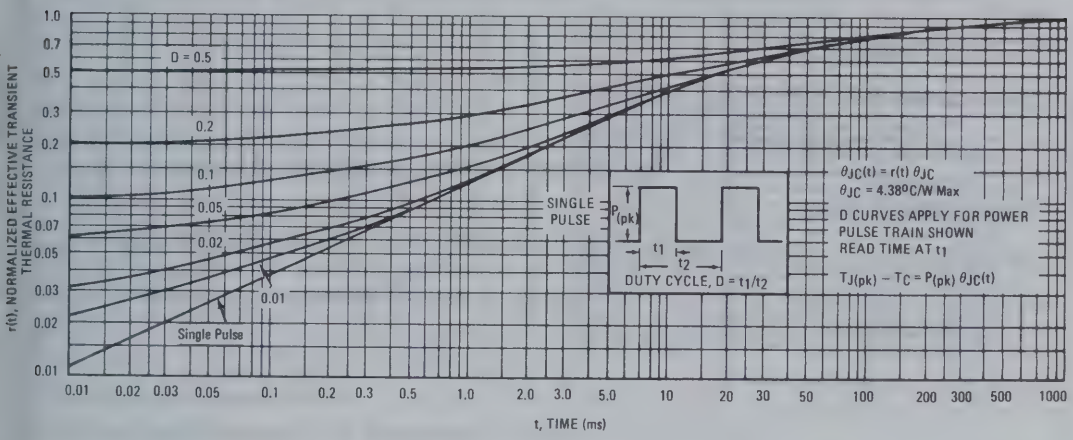
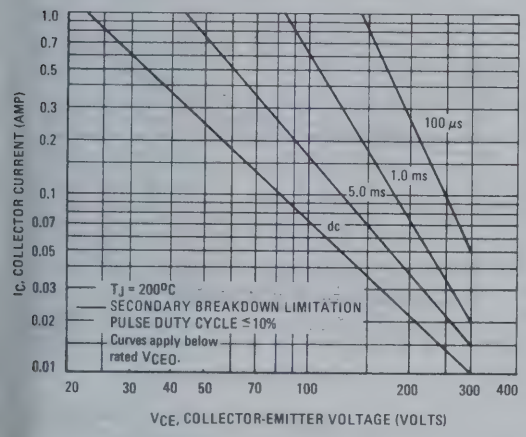


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^oC$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

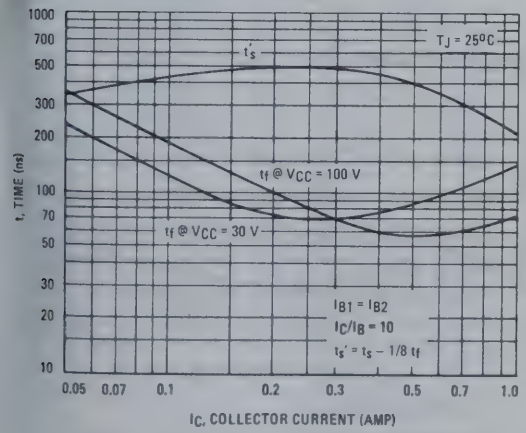
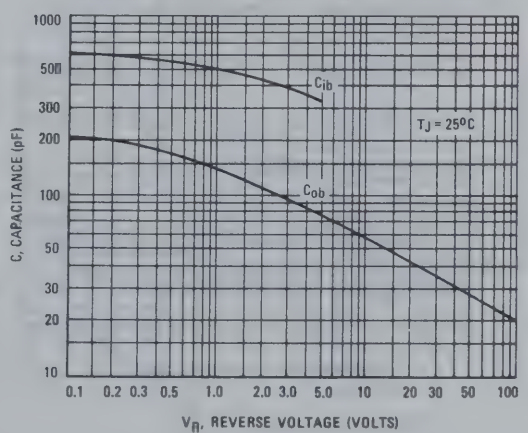


FIGURE 7 – CAPACITANCES



TYPICAL DC CHARACTERISTICS

FIGURE 8 – DC CURRENT GAIN

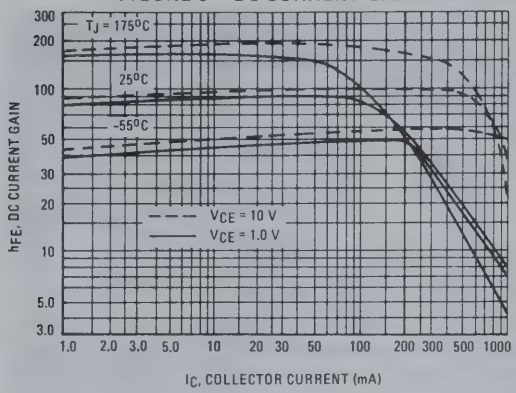


FIGURE 9 – COLLECTOR SATURATION REGION

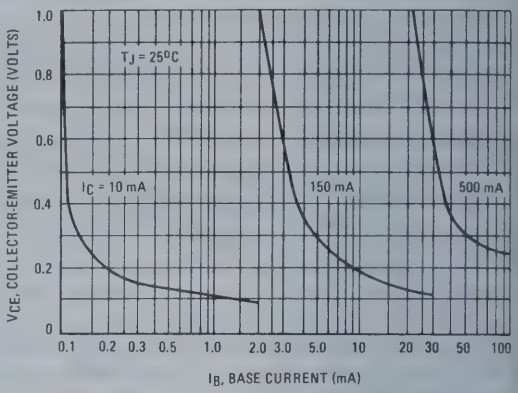


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

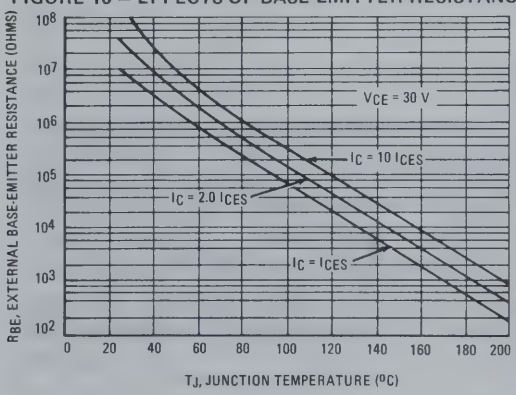


FIGURE 11 – "ON" VOLTAGES

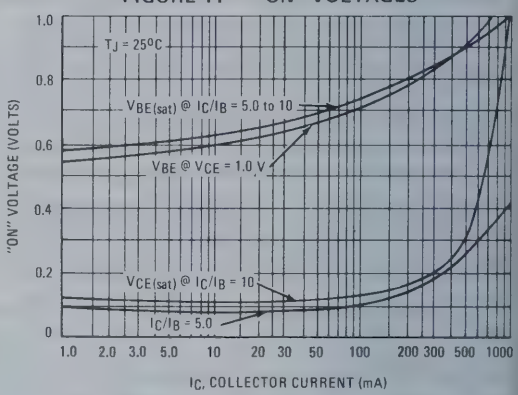


FIGURE 12 – COLLECTOR CUT-OFF REGION

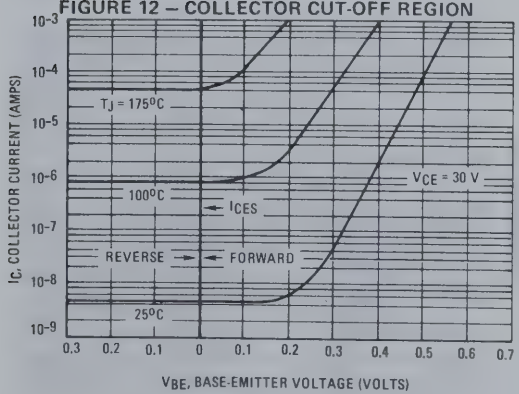
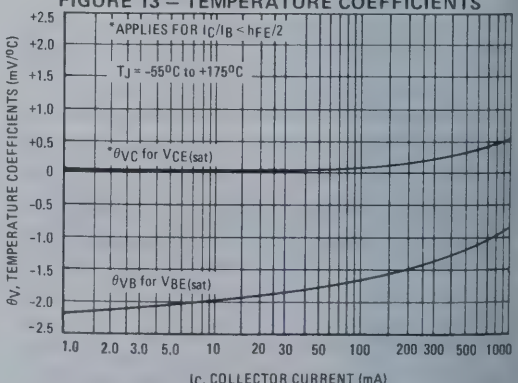


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5346 (SILICON) thru 2N5349

MEDIUM-POWER NPN SILICON TRANSISTORS

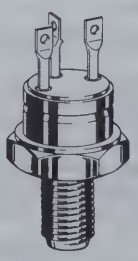
. . . designed for switching and wide-band amplifier applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 7.0 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Isolated Collector Configuration

7 AMPERE POWER TRANSISTORS

NPN SILICON

80-100 VOLTS 60 WATTS

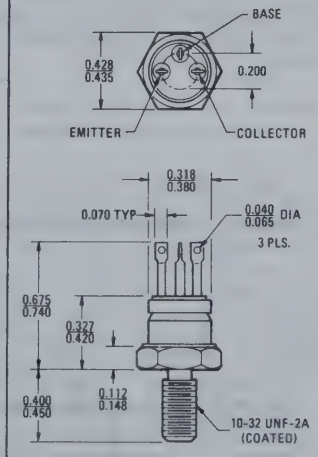


MAXIMUM RATINGS

Rating	Symbol	2N5346 2N5347	2N5348 2N5349	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C	P_D	60		Watts
Derate above 25°C		343		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

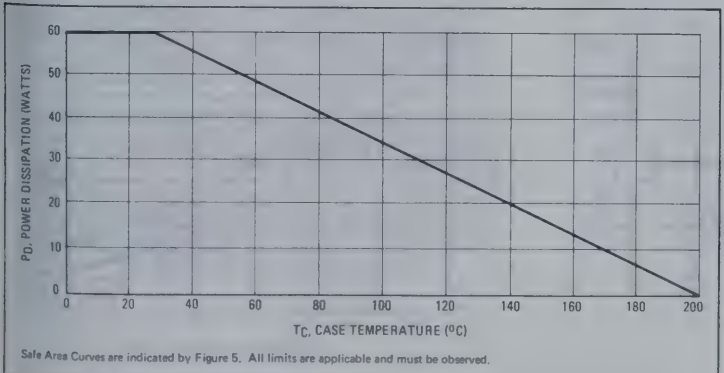
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.91	°C/W



TO-59
CASE 160

ISOLATED COLLECTOR

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 50 mAdc, I_B = 0)	2N5346, 2N5347 2N5348, 2N5349	-	$BV_{CEO(sus)}$*	80 100	- -	Vdc
Collector Cutoff Current (V_{CE} = 75 Vdc, I_B = 0)	2N5346, 2N5347	-	I_{CEO}	-	100	μAdc
(V_{CE} = 90 Vdc, I_B = 0)	2N5348, 2N5349			-	100	
Collector Cutoff Current (V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5346, 2N5347	12	I_{CEX}	-	10	μAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5348, 2N5349			-	10	
(V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5346, 2N5347			-	1.0	mAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5348, 2N5349			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		-	I_{CBO}	-	10	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)		-	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N5346, 2N5348	8	h_{FE}*	30	-	-
	2N5347, 2N5349			60	-	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N5346, 2N5348			30	120	
	2N5347, 2N5349			60	240	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N5346, 2N5348			20	-	
	2N5347, 2N5349			40	-	
Collector-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		9,11,13	$V_{CE(sat)}$*	-	0.7	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	1.2	
Base-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		11, 13	$V_{BE(sat)}$*	-	1.2	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	2.0	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		-	f_T	30	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		7	C_{ob}	-	250	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		7	C_{ib}	-	1,000	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 40 Vdc, $V_{EB(off)}$ = 3.0 Vdc,	2,3	t_d	-	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 200 mAdc)		t_r	-	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	2,6	t_s	-	2.0	μs
Fall Time	I_{B1} = I_{B2} = 200 mAdc)		t_f	-	200	ns

* Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

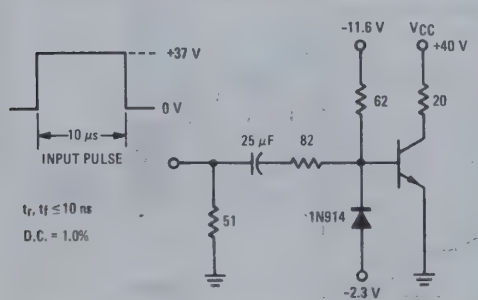


FIGURE 3 – TURN-ON TIME

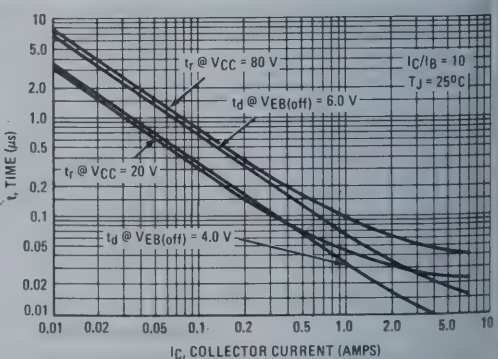


FIGURE 4 – THERMAL RESPONSE

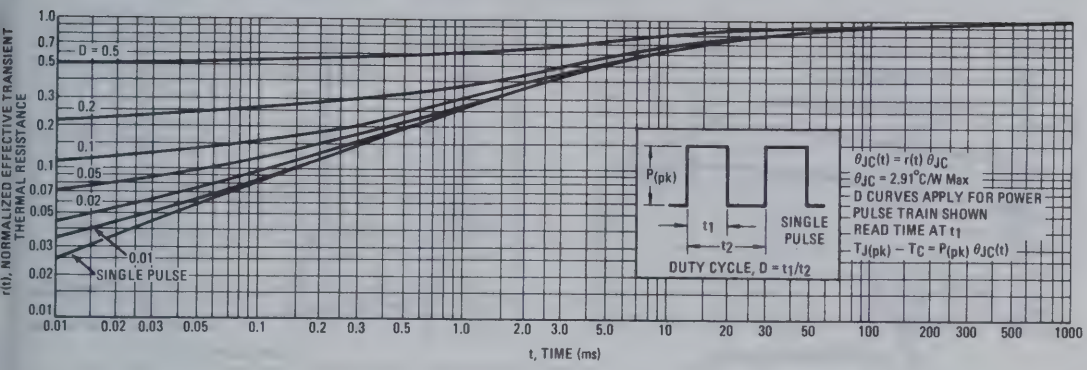
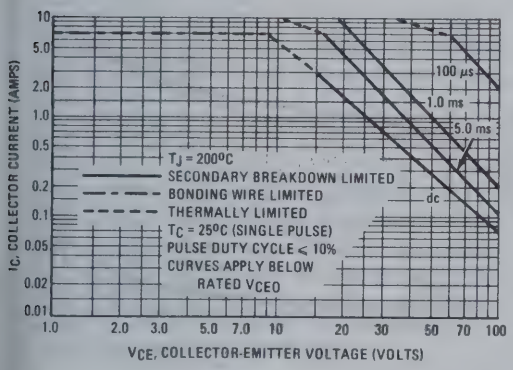


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^{\circ}C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

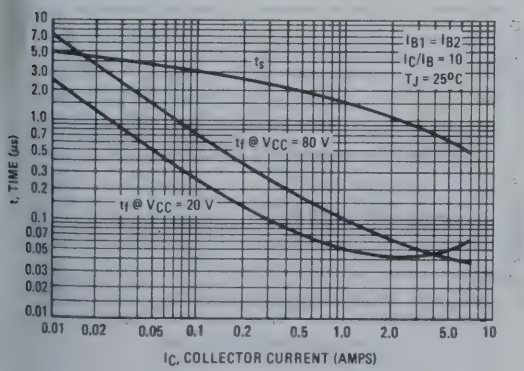


FIGURE 7 – CAPACITANCE versus VOLTAGE

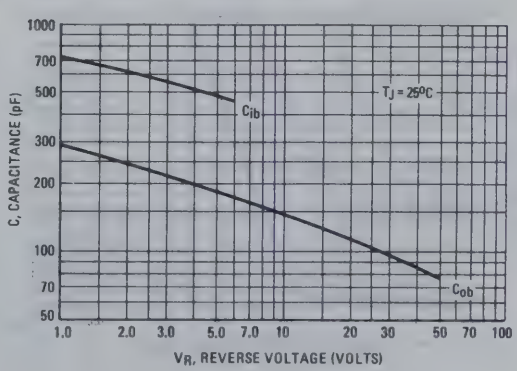


FIGURE 8 – DC CURRENT GAIN

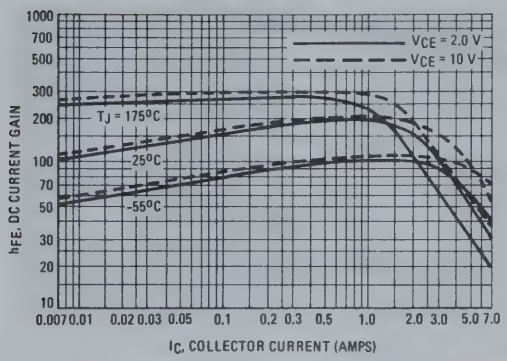


FIGURE 9 – COLLECTOR SATURATION REGION

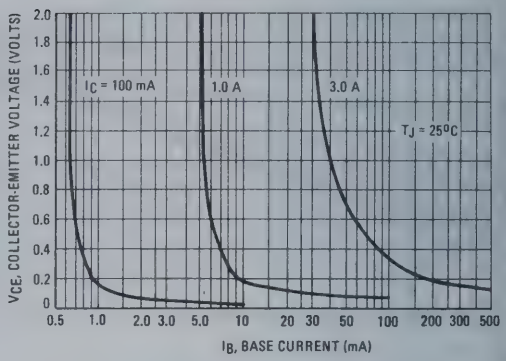


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

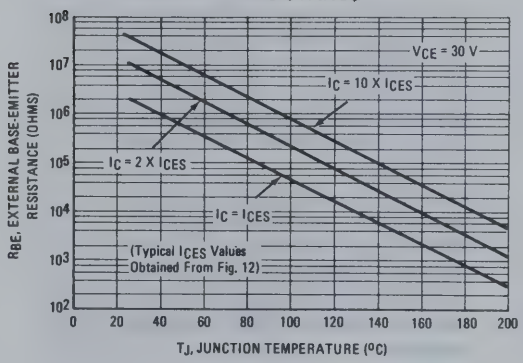


FIGURE 11 – "ON" VOLTAGES

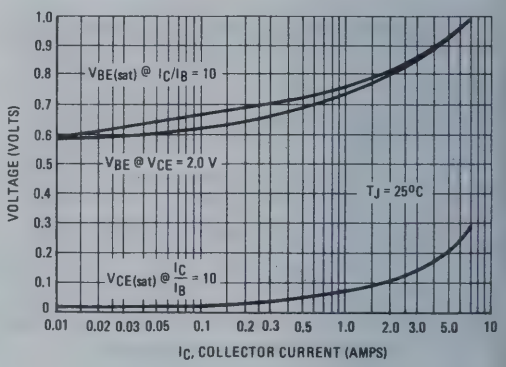


FIGURE 12 – COLLECTOR CUT-OFF REGION

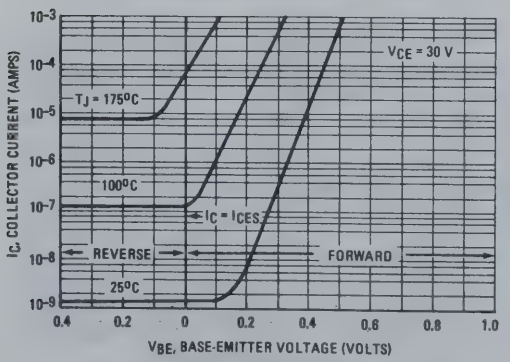
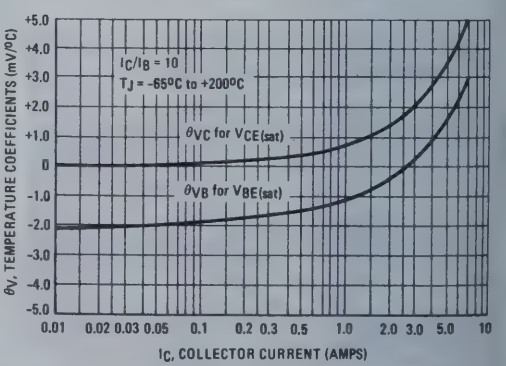


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5357 (SILICON)

PNP SILICON ANNULAR EPITAXIAL TRANSISTOR

. . . designed for high-voltage, high-speed saturated switching at collector currents of 1 Ampere or below. Ideally suited for inverters, deflection circuits and servo amplifiers.

- High Collector-Emitter Sustaining Voltage — $BV_{CEO(sus)}$ = 300 Vdc (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.3 Vdc (Typ) @ I_C = 500 mAdc
- Fast Turn-On Time — t_{on} = 60 ns (Typ) @ V_{CC} = 100 Vdc, I_C = 1.0 Adc
- Fast Turn-Off Time — t_{off} = 280 ns (Typ) @ V_{CC} = 100 Vdc, I_C = 1.0 Adc

PNP SILICON SWITCHING TRANSISTOR



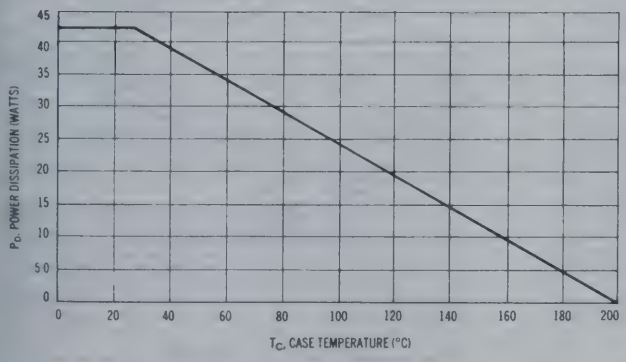
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CB}	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	3.0	Adc
Base Current - Continuous	I_B	1.0	Adc
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	30 240	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

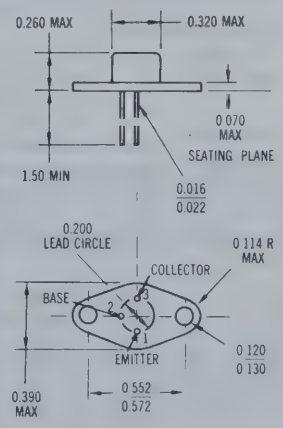
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.16	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves Are Indicated By Figure 5. All Limits Are Applicable And Must Be Observed.



Collector Connected to Case

Case 39
TO-37

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$	300	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	300	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 200 Vdc, $V_{BE(off)}$ = 0.5 Vdc, T_A = 100°C)	I_{CEX}	-	100	μAdc
(V_{CE} = 300 Vdc, $V_{BE(off)}$ = 0.5 Vdc)		-	10	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
(V_{BE} = 5.0 Vdc, I_C = 0)		-	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 500 μAdc, V_{CE} = 1.0 Vdc)	h_{FE}	45	-	-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		50	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		40	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		20	-	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)		25	100	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)		10	-	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	-	0.3	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)		-	1.0	
(I_C = 1.0 Adc, I_B = 100 mAdc)		-	3.0	
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)		-	1.3	
(I_C = 1.0 Adc, I_B = 100 mAdc)		-	1.5	
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 70 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	50	-	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	60	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	-	600	pF
SWITCHING CHARACTERISTICS				
Delay Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (See Figure 2)	t_d	-	50 ns
Rise Time		t_r	-	100 ns
Storage Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (See Figure 2)	t_s	-	600 ns
Fall Time		t_f	-	100 ns

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

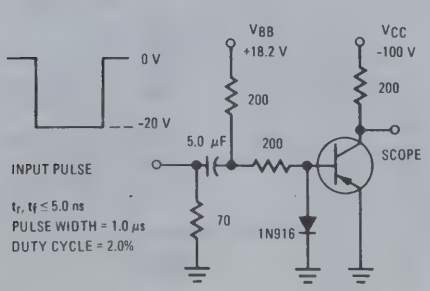


FIGURE 3 – TURN-ON TIME

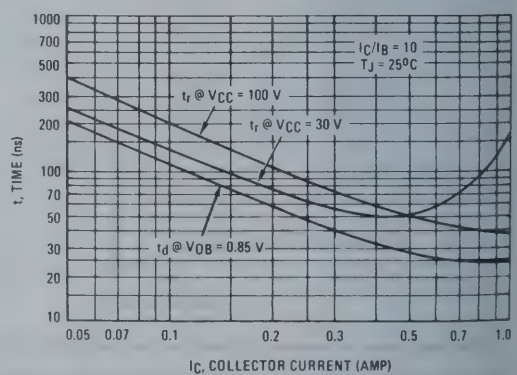


FIGURE 4 – THERMAL RESPONSE

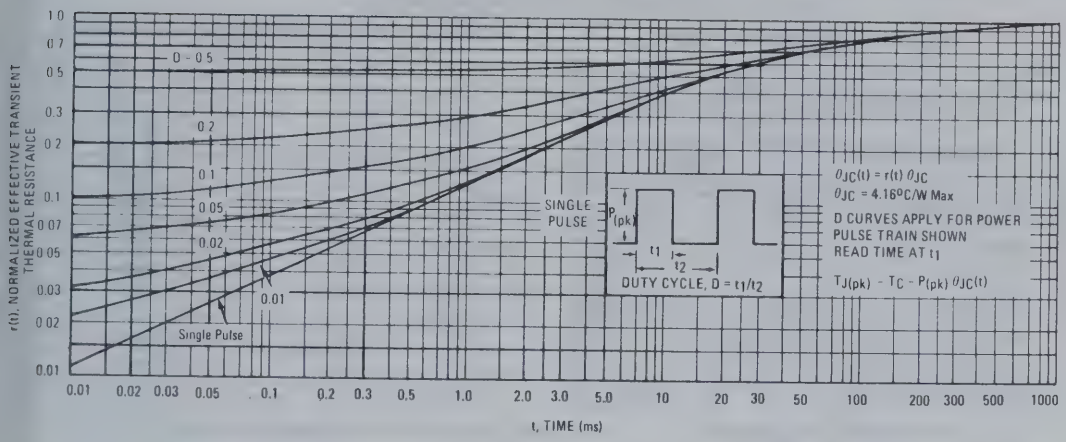
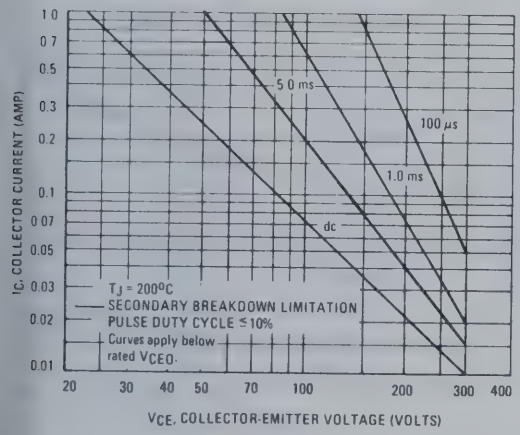


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C—V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

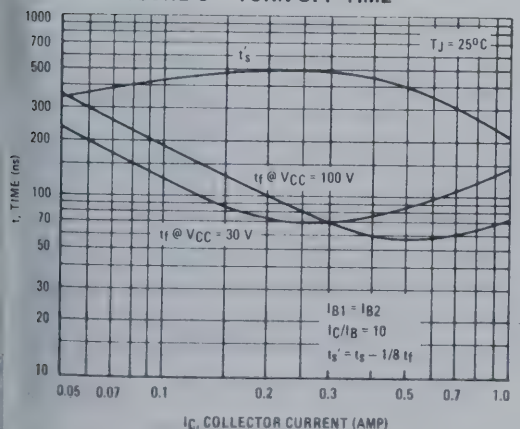
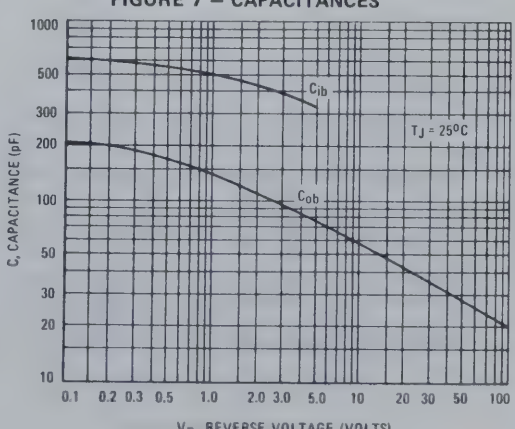


FIGURE 7 – CAPACITANCES



TYPICAL DC CHARACTERISTICS

FIGURE 8 – DC CURRENT GAIN

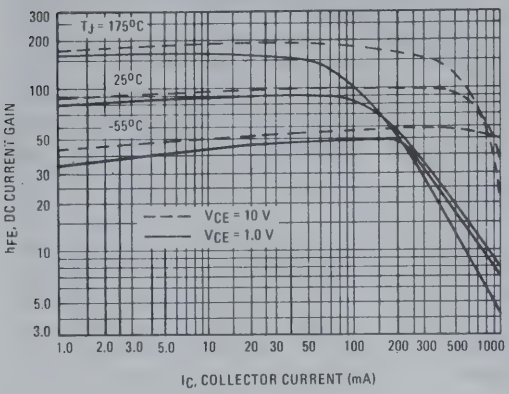


FIGURE 9 – COLLECTOR SATURATION REGION

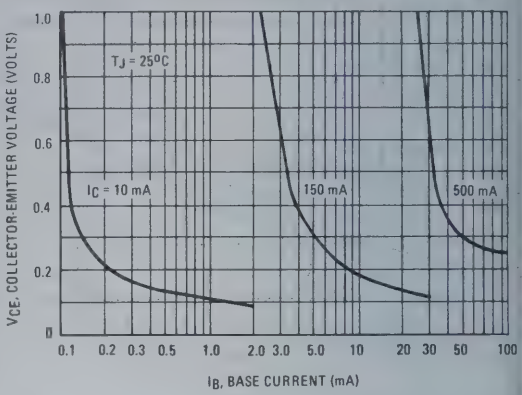


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

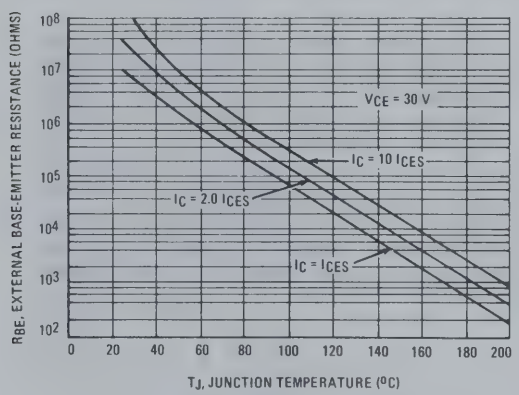


FIGURE 11 – "ON" VOLTAGES

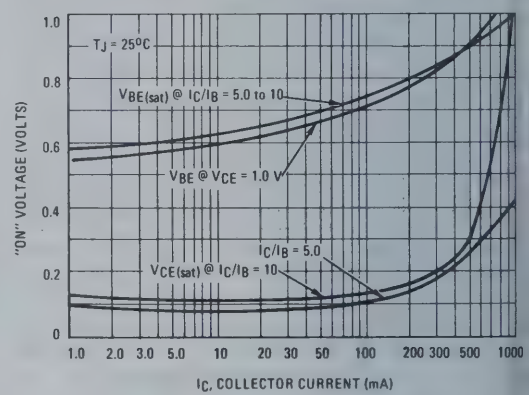


FIGURE 12 – COLLECTOR CUT-OFF REGION

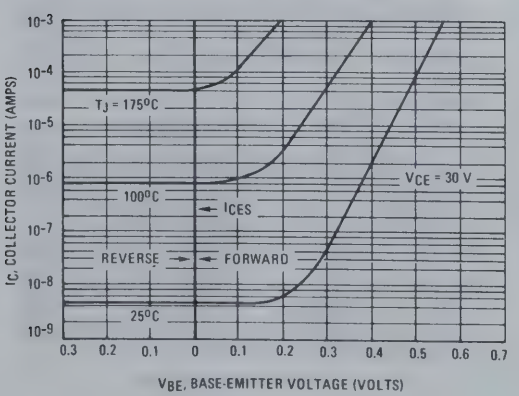
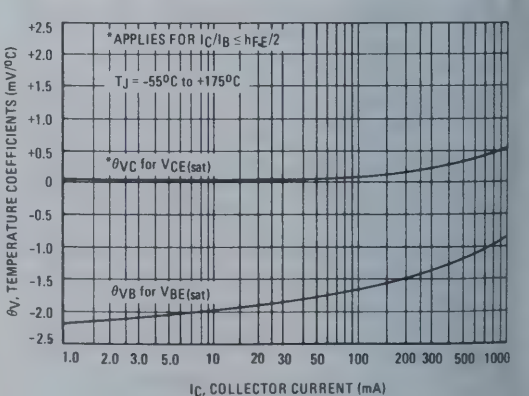


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5358 (SILICON) thru 2N5364

Silicon N-channel junction field-effect transistors depletion mode (Type A) devices designed primarily for general-purpose amplifier applications.



CASE 20(3)
(TO-72)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Forward Gate Current	$I_{G(f)}$	10	mAdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

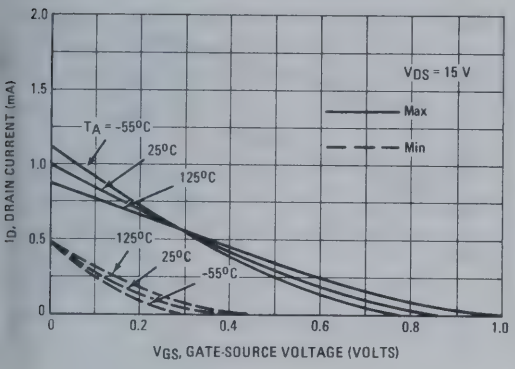
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 100 nAdc)		$V_{GS(off)}$			Vdc
	2N5358		0.5	3.0	
	2N5359		0.8	4.0	
	2N5360		0.8	4.0	
	2N5361		1.0	6.0	
	2N5362		2.0	7.0	
	2N5363		2.5	8.0	
	2N5364		2.5	8.0	
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	-	0.1	nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)			-	0.1	μAdc

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5358	I_{DSS}	0.5	1.0	mAdc
	2N5359		0.8	1.6	
	2N5360		1.5	3.0	
	2N5361		2.5	5.0	
	2N5362		4.0	8.0	
	2N5363		7.0	14	
	2N5364		9.0	18	
Gate-Source Voltage		V_{GS}			Vdc
(V_{DS} = 15 Vdc, I_D = 50 μAdc)	2N5358		0.3	1.5	
(V_{DS} = 15 Vdc, I_D = 80 μAdc)	2N5359		0.4	2.0	
(V_{DS} = 15 Vdc, I_D = 150 μAdc)	2N5360		0.5	2.5	
(V_{DS} = 15 Vdc, I_D = 250 μAdc)	2N5361		1.0	5.0	
(V_{DS} = 15 Vdc, I_D = 400 μAdc)	2N5362		1.3	5.0	
(V_{DS} = 15 Vdc, I_D = 700 μAdc)	2N5363		2.0	6.0	
(V_{DS} = 15 Vdc, I_D = 900 μAdc)	2N5364		2.0	6.0	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance		$\|y_{fs}\|$			μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5358		1000	3000	
	2N5359		1200	3600	
	2N5360		1400	4200	
	2N5361		1500	4500	
	2N5362		2000	5500	
	2N5363		2500	6000	
	2N5364		2700	6500	
Forward Transconductance		$Re(y_{fs})$			μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0 Vdc, f = 100 MHz)	2N5358		800	-	
	2N5359		900	-	
	2N5360		1400	-	
	2N5361		1700	-	
	2N5362		1900	-	
	2N5363		2100	-	
	2N5364		2200	-	
Output Admittance		$\|y_{os}\|$			μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5358, 2N5359		-	10	
	2N5360, 2N5361			20	
	2N5362, 2N5363			40	
	2N5364			60	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	2.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 1.0 Hz)		NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	-	115	$nV/\sqrt{Hz}$

DRAIN CURRENT versus GATE SOURCE VOLTAGE

FIGURE 1 – 2N5358



FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

FIGURE 2 – 2N5358

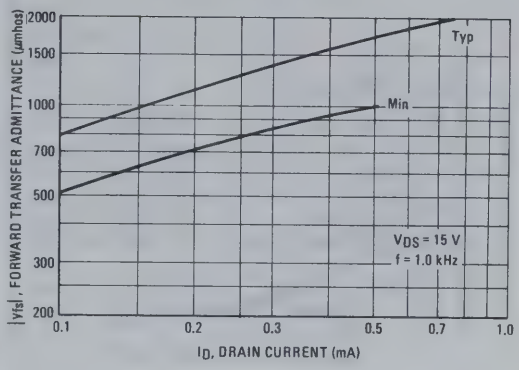


FIGURE 3 – 2N5359

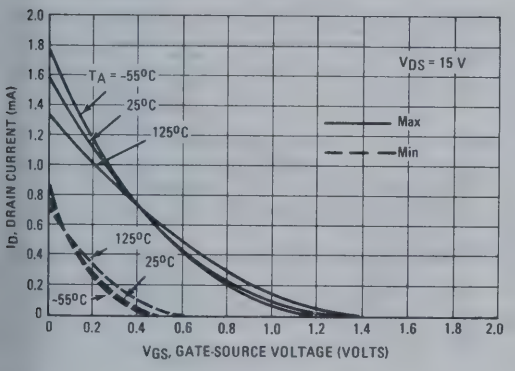


FIGURE 4 – 2N5359

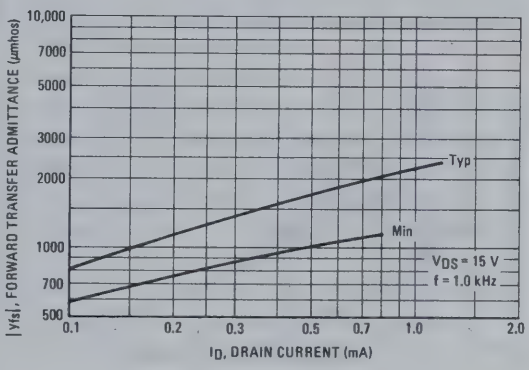


FIGURE 5 – 2N5360

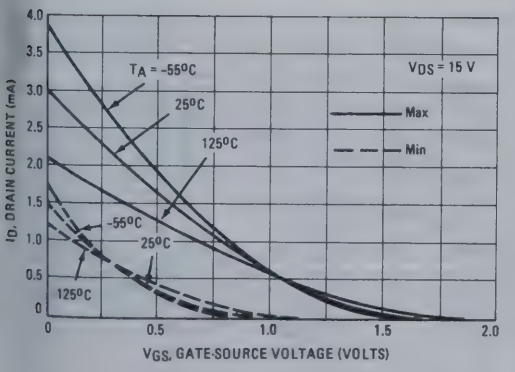
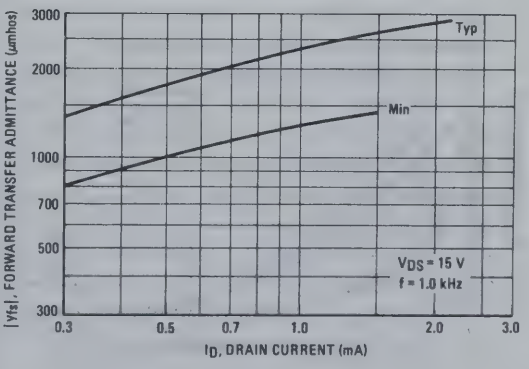
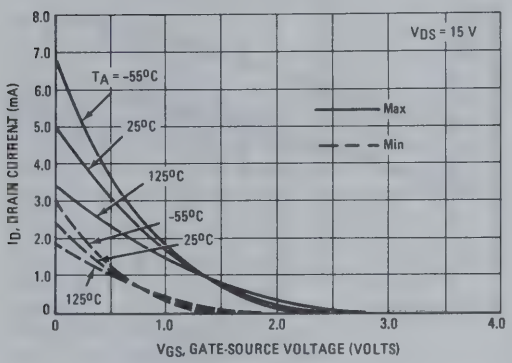


FIGURE 6 – 2N5360



DRAIN CURRENT versus GATE SOURCE VOLTAGE

FIGURE 7 – 2N5361



FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

FIGURE 8 – 2N5361

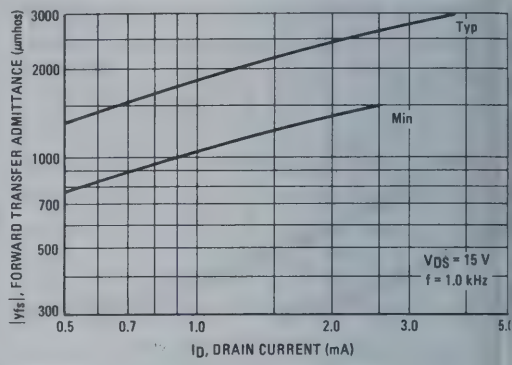


FIGURE 9 – 2N5362

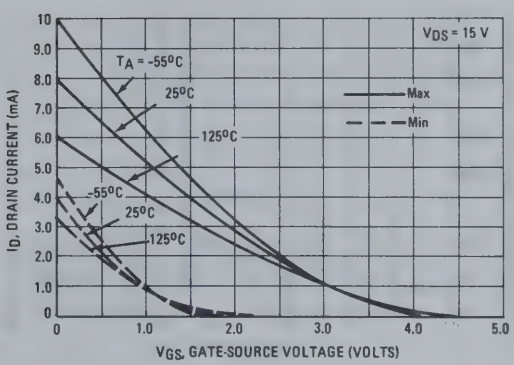


FIGURE 10 – 2N5362

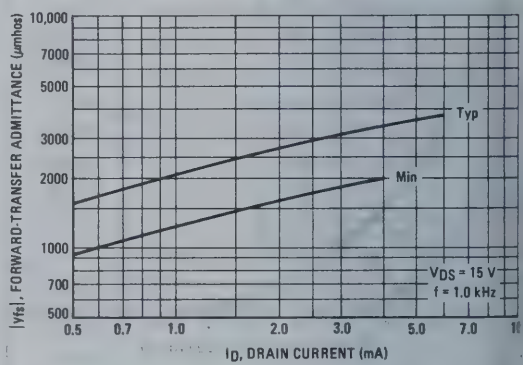


FIGURE 11 – 2N5363

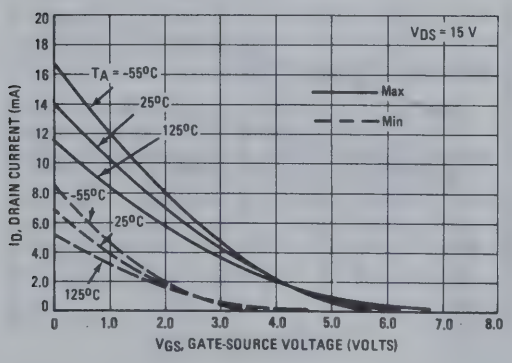
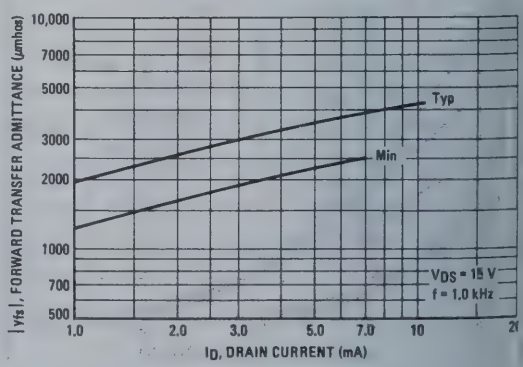
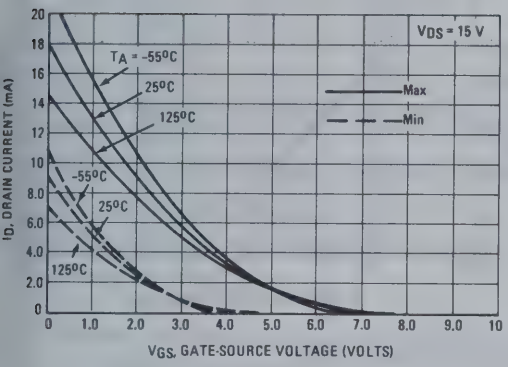


FIGURE 12 – 2N5363



DRAIN CURRENT versus
GATE-SOURCE VOLTAGE
FIGURE 13 – 2N5364



FORWARD TRANSFER ADMITTANCE
versus DRAIN CURRENT
FIGURE 14 – 2N5364

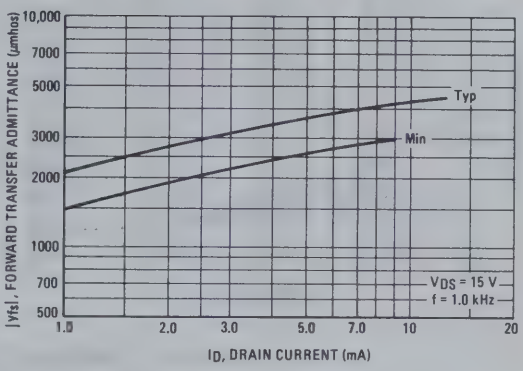


FIGURE 15 – TYPICAL DRAIN CURRENT
TEMPERATURE COEFFICIENT versus DRAIN CURRENT

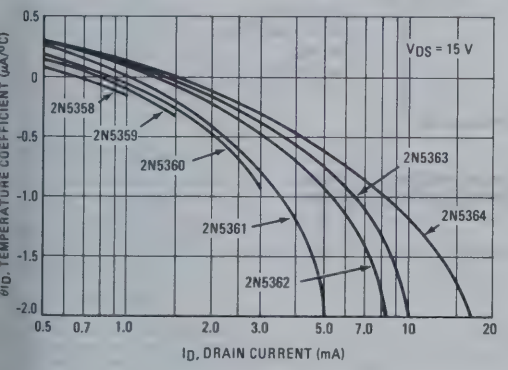


FIGURE 16 – TYPICAL FORWARD TRANSADMITTANCE
TEMPERATURE COEFFICIENT versus DRAIN CURRENT

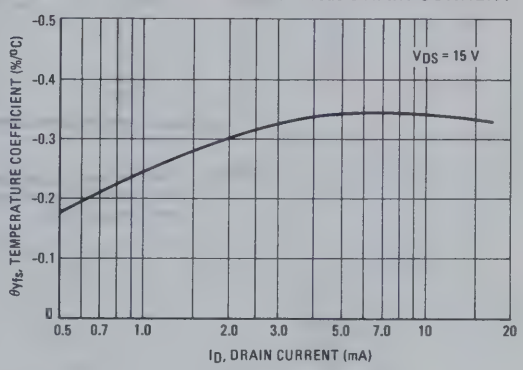


FIGURE 17 – TYPICAL OUTPUT RESISTANCE
versus DRAIN CURRENT

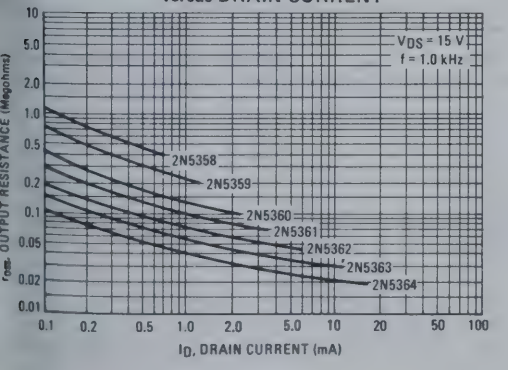


FIGURE 18 – TYPICAL CAPACITANCE
versus VOLTAGE

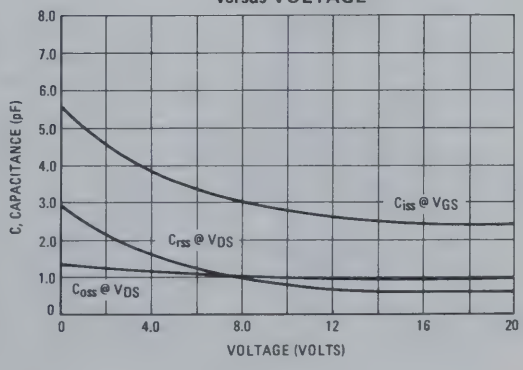


FIGURE 19 – TYPICAL NOISE FIGURE versus FREQUENCY

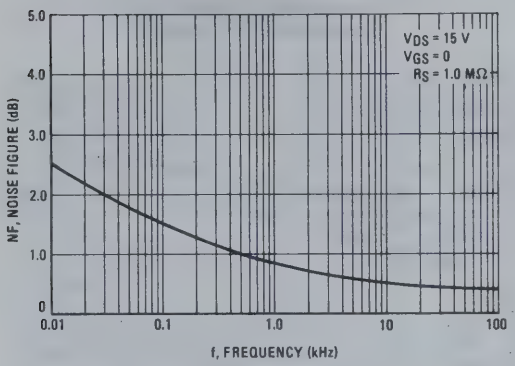


FIGURE 20 – TYPICAL NOISE FIGURE versus SOURCE RESISTANCE

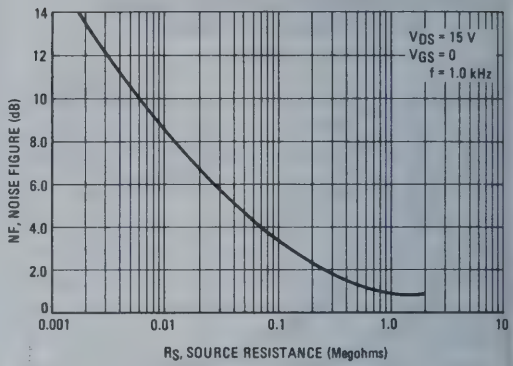
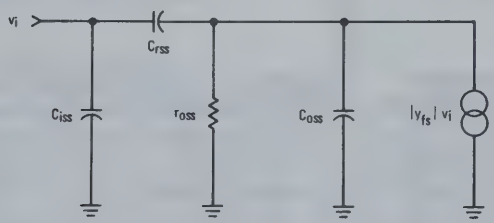


FIGURE 21 – EQUIVALENT LOW FREQUENCY CIRCUIT



Common Source
y Parameters for Frequencies
Below 30 MHz

$y_{is} = j\omega C_{iss}$
$y_{os} = j\omega C_{osp}^{*} + 1/r_{oss}$
$y_{fs} = |y_{fs}|$
$y_{rs} = -j\omega C_{rss}$

*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

NOTE: Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%).

2N5400 (SILICON)
2N5401

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose, high-voltage amplifier applications.

- High Voltage Ratings — BV_{CEO} = 120 and 150 Vdc (Min)
- Low Saturation Voltage
  ($V_{CE(sat)}$ = 0.25 V (max) @ I_C = 50 mA
- Current Gain Specified from 1.0 mAdc to 50 mAdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Excellent for Nixie Driver Applications

HIGH VOLTAGE

PNP SILICON AMPLIFIER TRANSISTORS

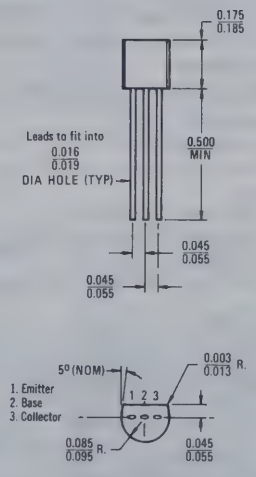


*MAXIMUM RATINGS

Rating	Symbol	2N5400	2N5401	Unit
Collector-Emitter Voltage	V_{CEO}	120	150	Vdc
Collector-Base Voltage	V_{CB}	130	160	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C	P_D	310		mW
Derate above 25°C		2.81		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



CASE 29 (1)
TO-92

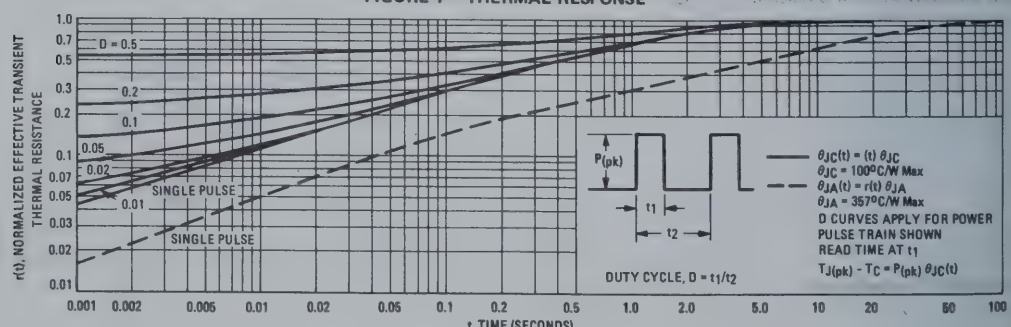
*Indicates JEDEC Registered Data

* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 1.0 mAdc, I_B = 0)	2N5400	BV_{CEO}	120	–	Vdc
	2N5401		150	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N5400	BV_{CBO}	130	–	Vdc
	2N5401		160	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N5400		–	100	
(V_{CB} = 120 Vdc, I_E = 0)	2N5401		–	50	
(V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C)	2N5400		–	100	μAdc
(V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	2N5401		–	50	
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5400		30	–	
	2N5401		50	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5400		40	180	
	2N5401		60	240	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	2N5400		40	–	
	2N5401		50	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.20	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	0.25	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	1.0	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	1.0	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N5400	f_T	100	400	MHz
	2N5401		100	300	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	6.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5400	h_{fe}	30	200	–
	2N5401		40	200	
Noise Figure (I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz)		NF	–	8.0	dB

*Indicates JEDEC Registered Data
Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%

FIGURE 1 – THERMAL RESPONSE



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 2 – CURRENT GAIN

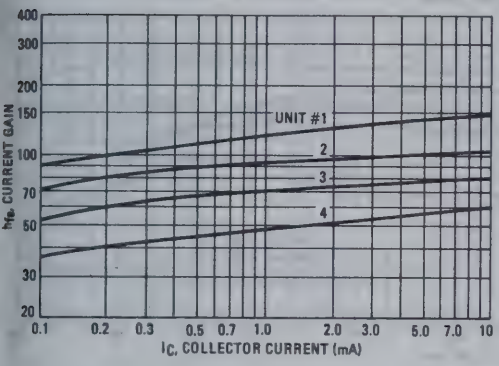


FIGURE 3 – OUTPUT ADMITTANCE

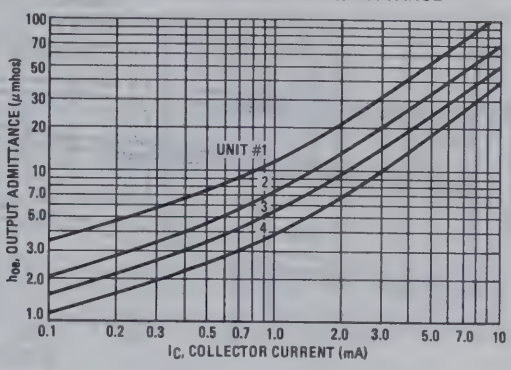


FIGURE 4 – INPUT IMPEDANCE

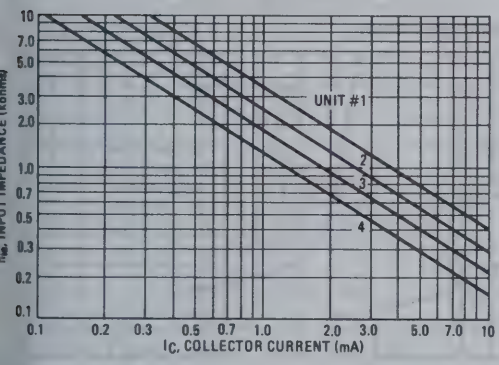


FIGURE 5 – VOLTAGE FEEDBACK RATIO

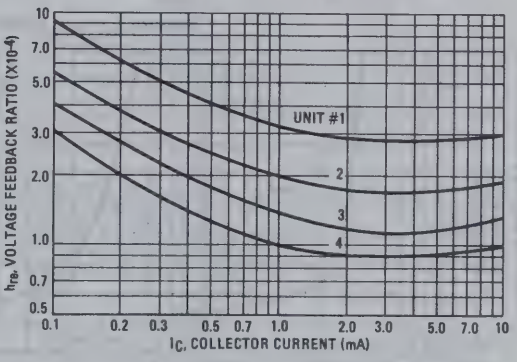
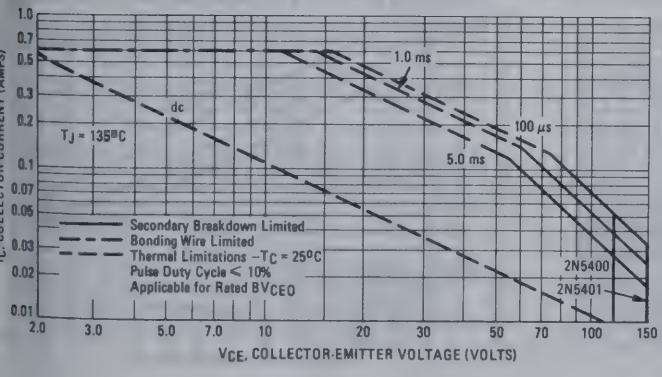


FIGURE 6 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 6 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 135°C$. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 7 – DC CURRENT GAIN

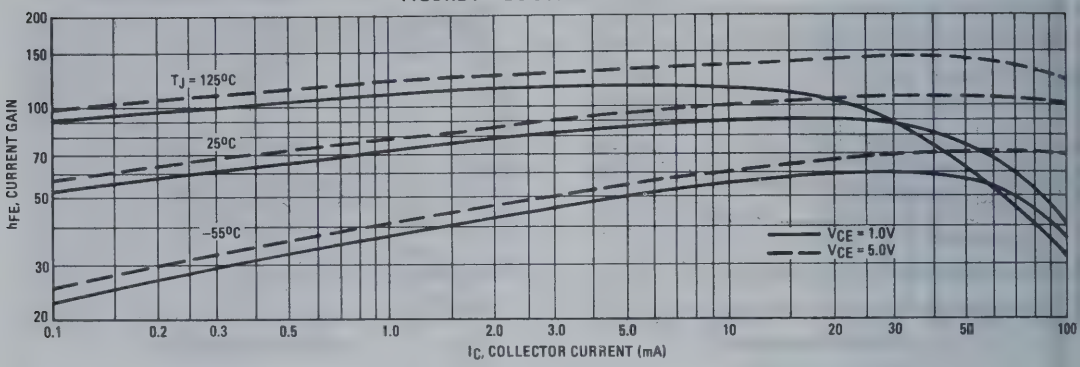


FIGURE 8 – COLLECTOR SATURATION REGION

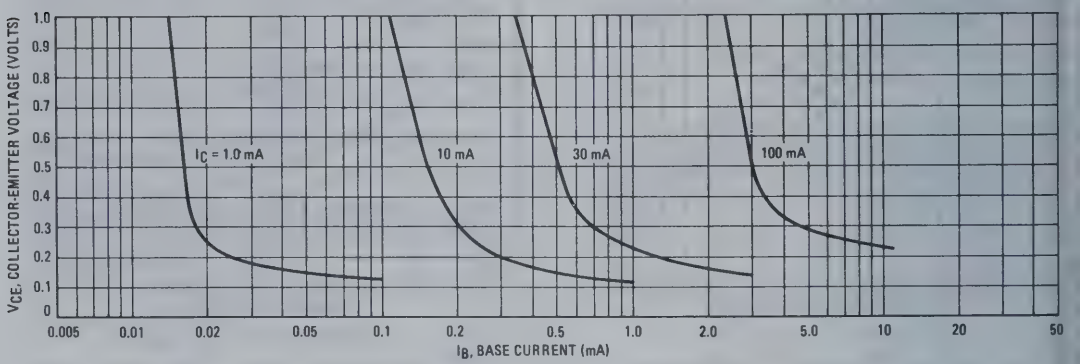


FIGURE 9 – COLLECTOR CUT-OFF REGION

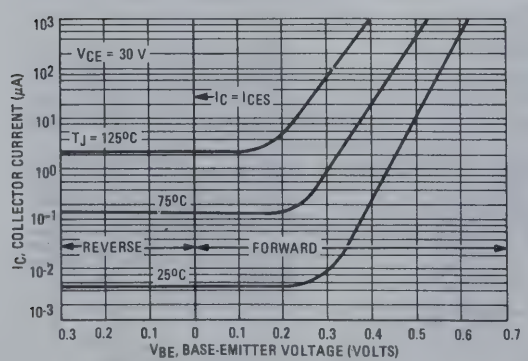


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

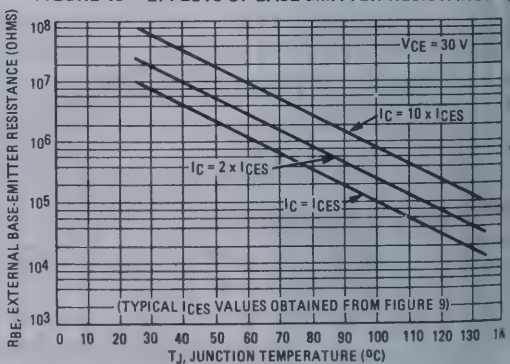


FIGURE 11 – "ON" VOLTAGES

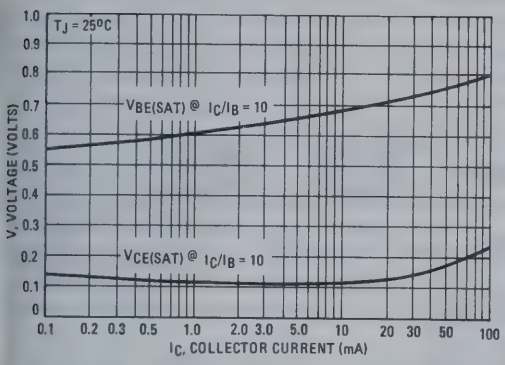


FIGURE 12 – TEMPERATURE COEFFICIENTS

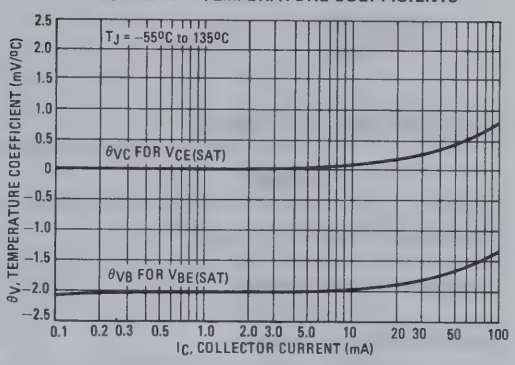


FIGURE 13 – SWITCHING TIME TEST CIRCUIT

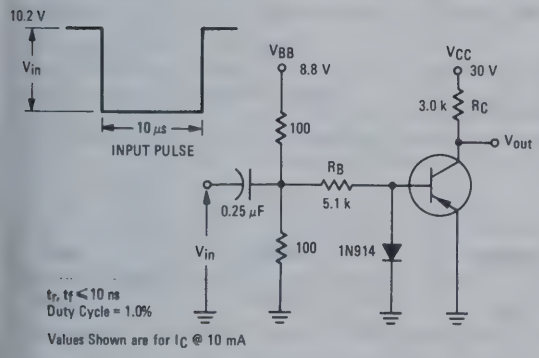


FIGURE 14 – CAPACITANCES

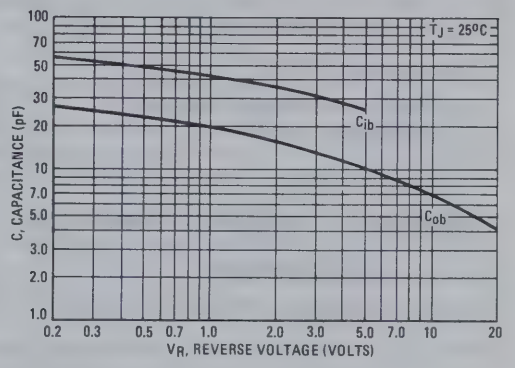


FIGURE 15 – TURN-ON TIME

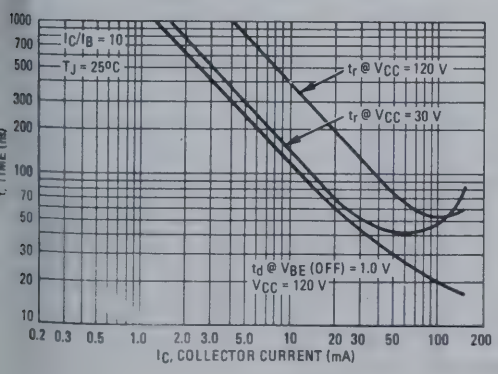
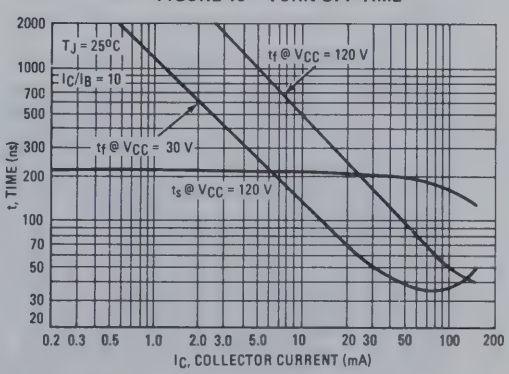
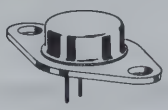


FIGURE 16 – TURN-OFF TIME



2N5427 (SILICON)
thru
2N5430



CASE 80
(TO-66)

Medium-power NPN silicon transistors designed for switching and wide-band amplifier applications.

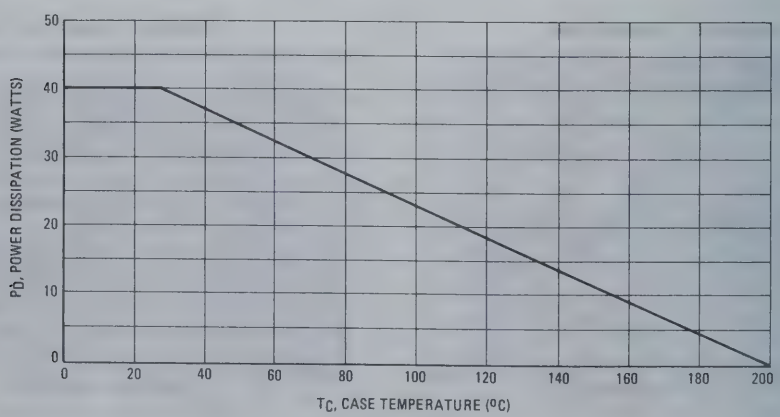
MAXIMUM RATINGS

Rating	Symbol	2N5427 2N5428	2N5429 2N5430	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	40 228		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.37	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

2N5427 thru 2N5430 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 50 mAdc, I_B = 0)	2N5427, 2N5428 2N5429, 2N5430	-	$BV_{CEO(sus)}$*	80 100	- -	Vdc
Collector Cutoff Current (V_{CE} = 75 Vdc, I_B = 0)	2N5427, 2N5428		I_{CEO}	-	100	μAdc
(V_{CE} = 90 Vdc, I_B = 0)	2N5429, 2N5430			-	100	
Collector Cutoff Current (V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5427, 2N5428	12	I_{CEX}	-	10	μAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5429, 2N5430			-	10	
(V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5427, 2N5428			-	1.0	mAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5429, 2N5430			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		-	I_{CBO}	-	10	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		-	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N5427, 2N5429 2N5428, 2N5430	8	h_{FE}*	30 60	- -	-
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N5427, 2N5429 2N5428, 2N5430			30 60	120 240	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N5427, 2N5429 2N5428, 2N5430			20 40	- -	
Collector-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		9, 11, 13	$V_{CE(sat)}$*	-	0.7	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	1.2	
Base-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		11, 13	$V_{BE(sat)}$*	-	1.2	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	2.0	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		-	f_T	30	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		7	C_{ob}	-	250	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		7	C_{ib}	-	1,000	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 40 Vdc, $V_{EB(off)}$ = 3.0 Vdc, I_C = 2.0 Adc, I_{B1} = 200 mAdc)	2,3	t_d	-	100	ns
Rise Time			t_r	-	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc, I_{B1} = I_{B2} = 200 mAdc)	2,6	t_s	-	2.0	μs
Fall Time			t_f	-	200	ns

* Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%.

FIGURE 2 — SWITCHING TIME TEST CIRCUIT

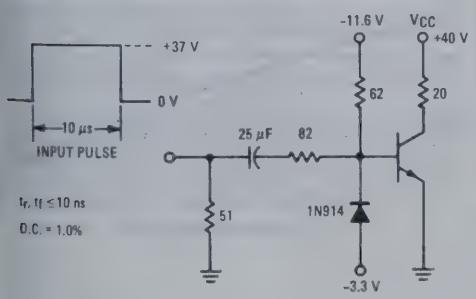


FIGURE 3 — TURN-ON TIME

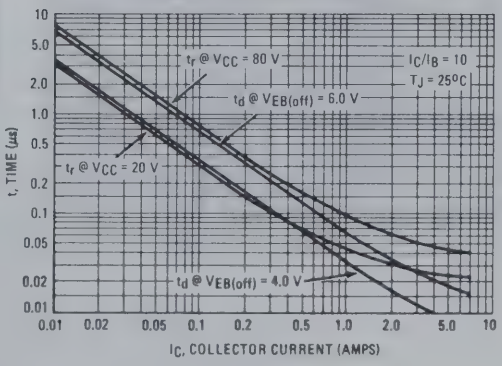


FIGURE 4 – THERMAL RESPONSE

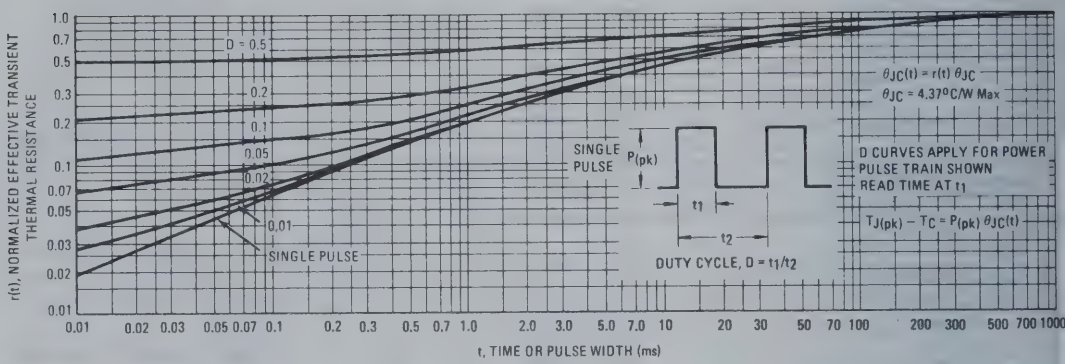
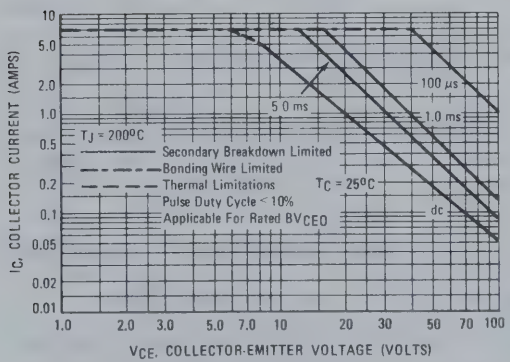


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

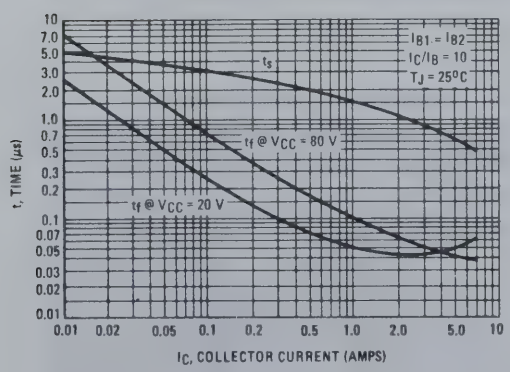


FIGURE 7 – CAPACITANCE versus VOLTAGE

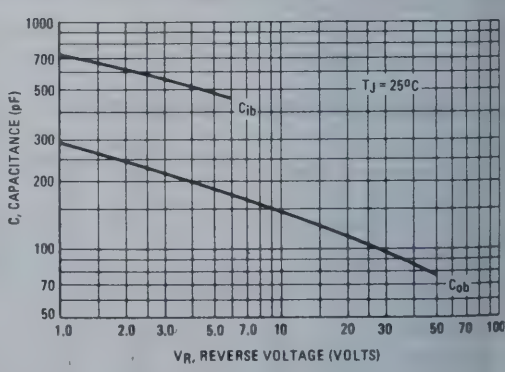


FIGURE 8 – DC CURRENT GAIN

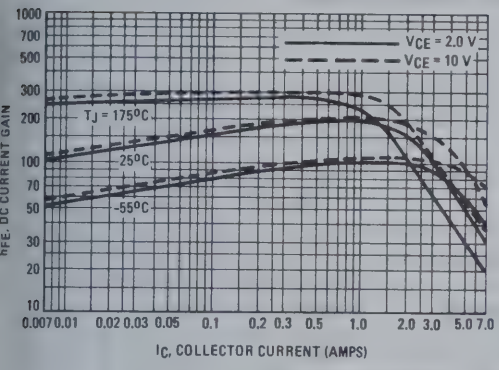


FIGURE 9 – COLLECTOR SATURATION REGION

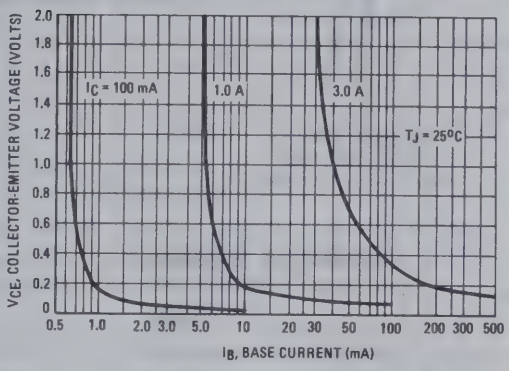


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

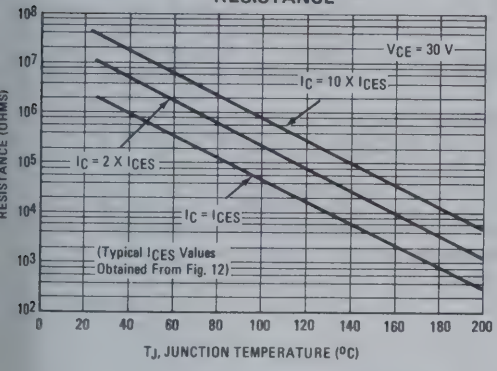


FIGURE 11 – "ON" VOLTAGES

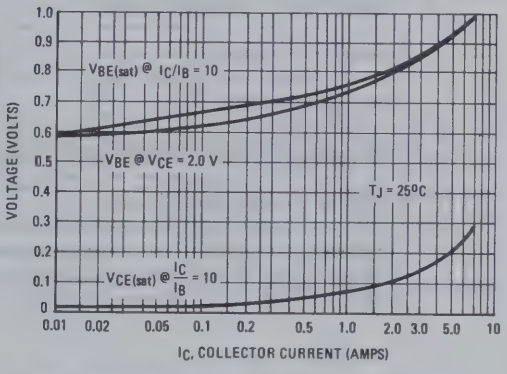


FIGURE 12 – COLLECTOR CUT-OFF REGION

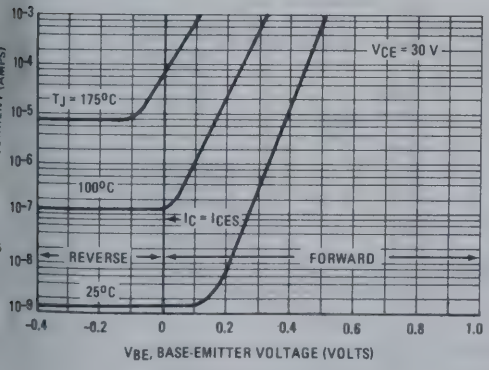
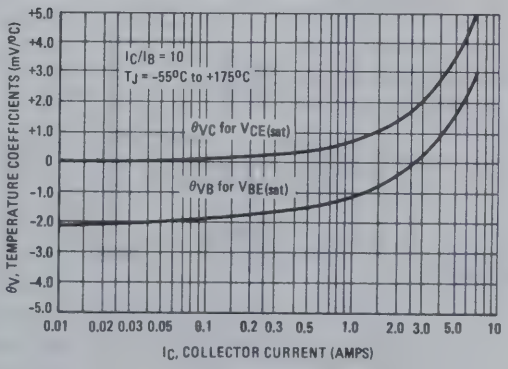


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5431 (SILICON)



CASE 22A
(TO-18 Modified)
Lead 3 connected to case

Silicon annular unijunction transistors characterized primarily for low interbase-voltage operation in sensing, pulse triggering, and timing circuits.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D*	300	mW
RMS Emitter Current	I_e	50	mA
Peak-Pulse Emitter Current **	i_e**	1.5	A
Emitter Reverse Voltage	V_{B2E}	30	V
Interbase Voltage ‡	V_{B2B1}‡	35	V
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Derate 3.0 mW/°C increase in ambient temperature.
**Duty Cycle ≤ 1.0%, PRR = 10 PPS (see figure 5).
‡Based upon power dissipation at T_A = 25°C.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

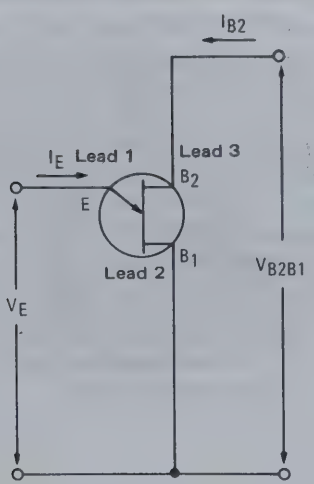
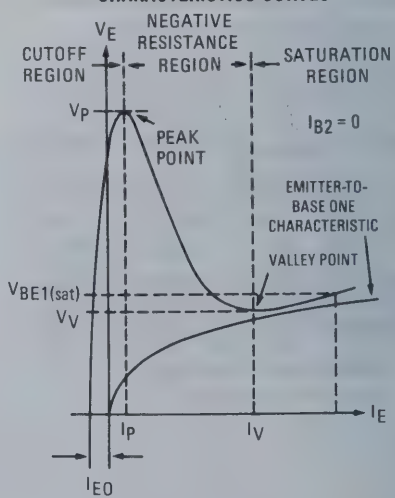


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Intrinsic Standoff Ratio ① (V_{B2B1} = 10 V)	4	η ①	0.72	0.80	-
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)		R_{BB}	6.0	8.5	kΩ
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = 0 to 100°C)		αR_{BB}	0.4	0.8	%/°C
Emitter Saturation Voltage ② (V_{B2B1} = 10 V, I_E = 50 mA)		$V_{EB1(sat)}$ ②	-	3.0	V
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	5.0	30	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)		I_{EB2O}	-	10	nA
Peak-Point Emitter Current (V_{B2B1} = 25 V)		I_P	-	0.4	μA
(V_{B2B1} = 4.0 V)			-	4.0	
Valley-Point Current ② (V_{B2B1} = 20 V, R_{B2} = 100 ohms)		I_V ②	2.0	-	mA
Base-One Peak Pulse Voltage (V_{BB} = 4.0 volts)	3	V_{OB1}	1.0	-	V

① η, Intrinsic standoff ratio, is defined in terms of the peak-point voltage, V_P, by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is about 0.49 volt at 25°C @ I_F = 10 μA and decreases with temperature at about 2.5 mV/°C. The test circuit is shown in Figure 4. Components R_1, C_1, and the UJT form a relaxation oscillator; the remaining circuitry serves as a peak-voltage detector. The forward drop of Diode D_1 compensates for V_F. To use, the "cal" button is pushed, and R_3 is adjusted to make the current meter, M_1, read full scale. When the "cal" button is released, the value of η is read directly from the meter, if full scale on the meter reads 1.0.

② Use pulse techniques: PW ≈ 300 μs, Duty Cycle ≤ 2.0% to avoid internal heating, which may result in erroneous readings.

FIGURE 3 — V_{OB1} TEST CIRCUIT

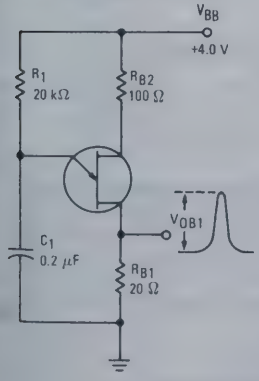
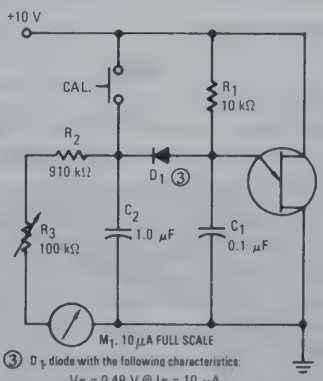


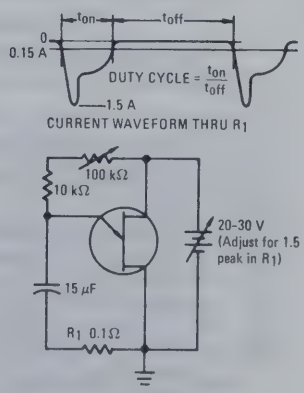
FIGURE 4 — η TEST CIRCUIT



③ D_1 diode with the following characteristics:
V_F = 0.49 V @ I_F = 10 μA
$I_R \leq$ 2.0 μA @ V_R = 20 V

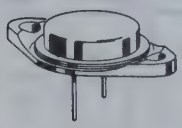
FIGURE 5 — PRR TEST CIRCUIT AND WAVEFORM

DUTY CYCLE ≤ 1.0%, PRR ≤ 10 PPS

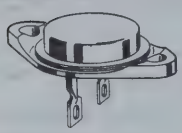


2N5435 (GERMANIUM) thru 2N5440

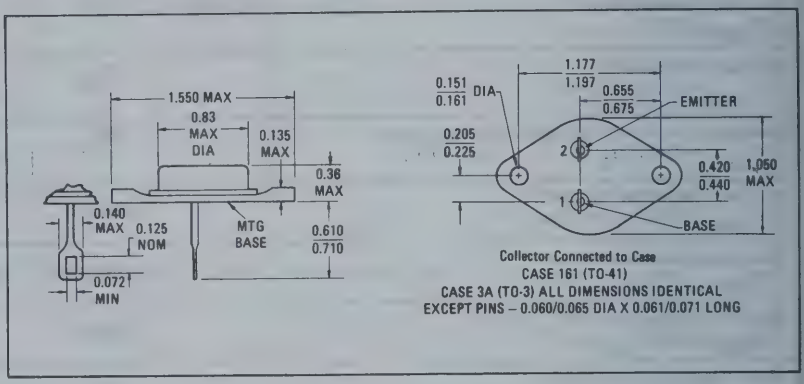
PNP germanium power switching transistors designed for high-current, fast-switching applications requiring low saturation voltage and excellent safe operating area.



CASE 3A
TO-3 Package
2N5435/5440



CASE 161
TO-41 Package
MP5435/5440



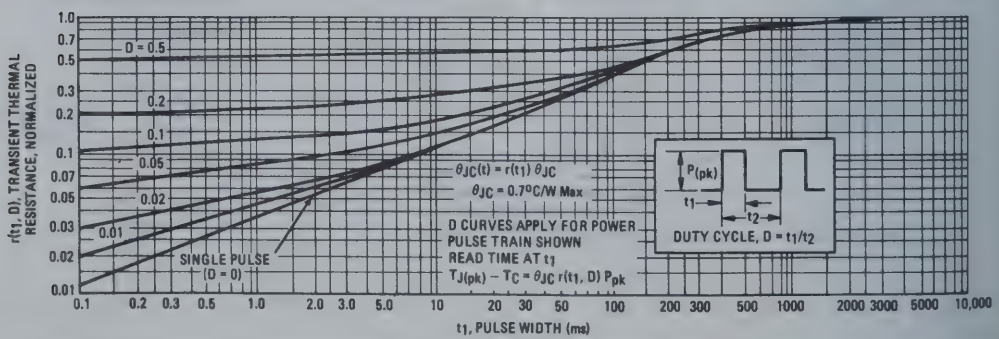
MAXIMUM RATINGS **

Rating	Symbol	2N5435 2N5438	2N5436 2N5439	2N5437 2N5440	Unit
Collector-Emitter Voltage	V_{CEO}	60	90	120	Vdc
Collector-Base Voltage	V_{CB}	80	110	140	Vdc
Emitter-Base Voltage	V_{EB}	2.5			Vdc
Collector Current — Continuous	I_C	60			Adc
Base Current — Continuous	I_B	12			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	120 1.43			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.7	°C/W

FIGURE 1 – THERMAL RESPONSE



**Maximum Ratings for MP5435 Series are the Same as the 2N5435 Series.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)**

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0)	2N5435, 2N5438	BV_{CEO}	60	-	Vdc
	2N5436, 2N5439		90	-	
	2N5437, 2N5440		120	-	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N5435, 2N5438		-	10	
(V_{CE} = 110 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N5436, 2N5439		-	10	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N5437, 2N5440		-	10	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N5435, 2N5438		-	30	
(V_{CE} = 110 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N5436, 2N5439		-	30	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N5437, 2N5440		-	30	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	200	μAdc
Emitter Cutoff Current (V_{BE} = 2.5 Vdc, I_C = 0)		I_{EBO}	-	500	mAdc
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			-
(I_C = 25 Adc, V_{CE} = 2.0 Vdc)	2N5435, 2N5436, 2N5437		20	60	
	2N5438, 2N5439, 2N5440		40	120	
(I_C = 60 Adc, V_{CE} = 2.0 Vdc)	2N5435, 2N5436, 2N5437		10	-	
	2N5438, 2N5439, 2N5440		15	-	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 60 Adc, I_B = 6.0 Adc)	2N5435, 2N5436, 2N5437		-	0.75	
	2N5438, 2N5439, 2N5440		-	0.50	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 60 Adc, I_B = 6.0 Adc)	2N5435, 2N5436, 2N5437		-	1.2	
	2N5438, 2N5439, 2N5440		-	0.9	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc, f = 100 kHz)		f_T	350	-	kHz
SWITCHING CHARACTERISTICS					
Rise Time	(I_C = 25 Adc, I_{B1} = 2.5 Adc, I_{B2} = 2.5 Adc) (See Figure 4)	t_r	-	12	μs
Storage Time		t_s	-	10	μs
Fall Time		t_f	-	8.0	μs

**Electrical Characteristics for MP5435 series are the same as the 2N5435 series.
* To avoid excessive heating of the collector junction, perform test with pulse method.

FIGURE 2 – POWER-TEMPERATURE DERATING CURVE

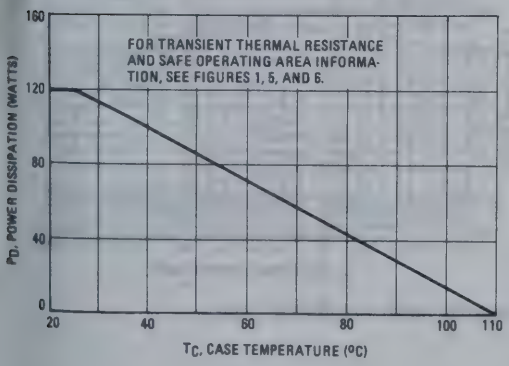


FIGURE 3 – SWITCHING TIMES

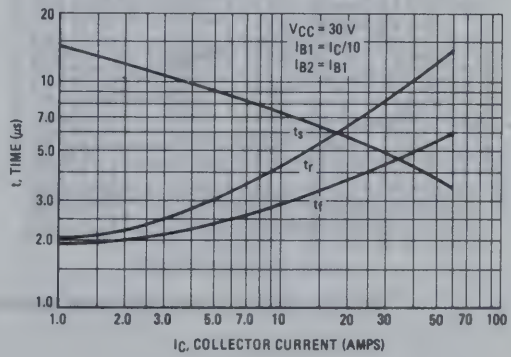


FIGURE 4 – SWITCHING TIME TEST CIRCUIT

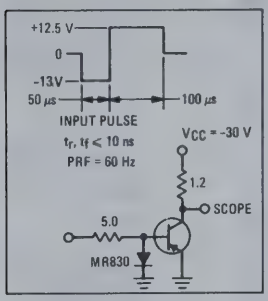
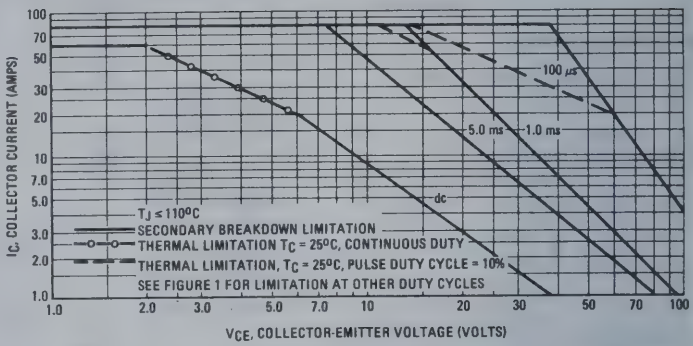


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 110°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 110°C$. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – CLAMPED INDUCTIVE SAFE OPERATING AREA

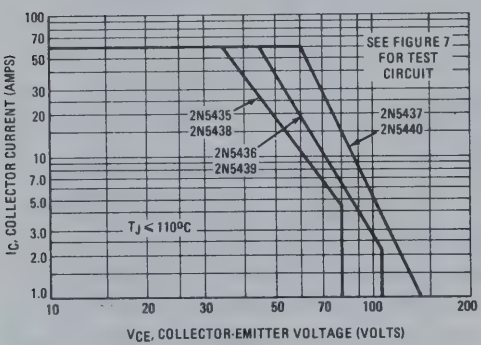


FIGURE 7 – CLAMPED INDUCTIVE SAFE OPERATING AREA TEST CIRCUIT

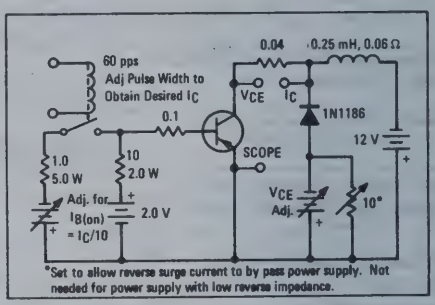


FIGURE 8 – DC CURRENT GAIN

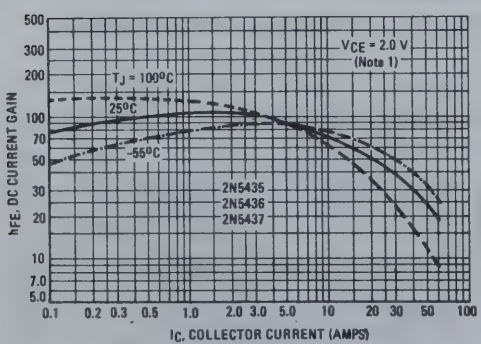
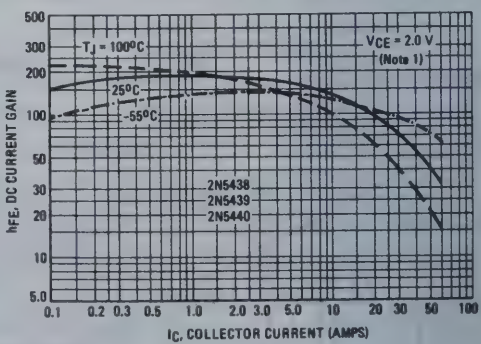


FIGURE 9 – DC CURRENT GAIN



NOTE 1: Data is obtained from pulse tests and adjusted to nullify the effect of I_{CBO}.

FIGURE 10 – COLLECTOR SATURATION REGION

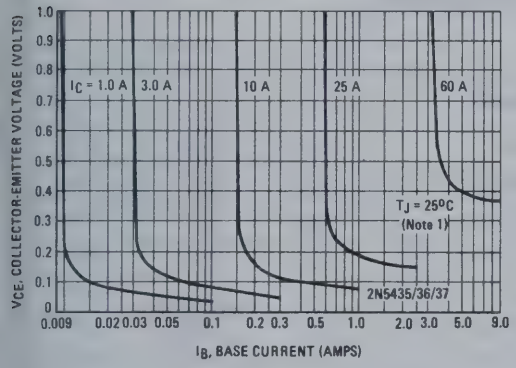


FIGURE 11 – COLLECTOR SATURATION REGION

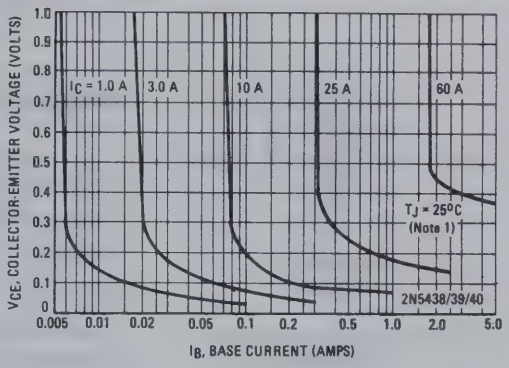


FIGURE 12 – EFFECTS OF BASE-EMITTER RESISTANCE

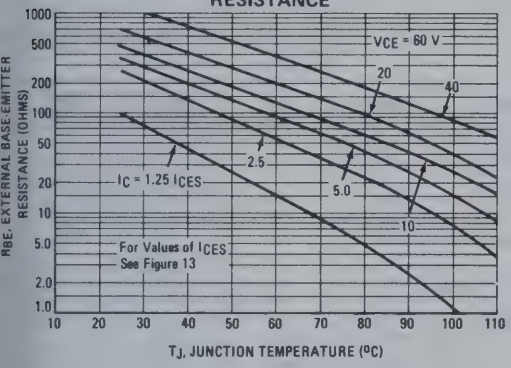


FIGURE 13 – COLLECTOR CUTOFF REGION

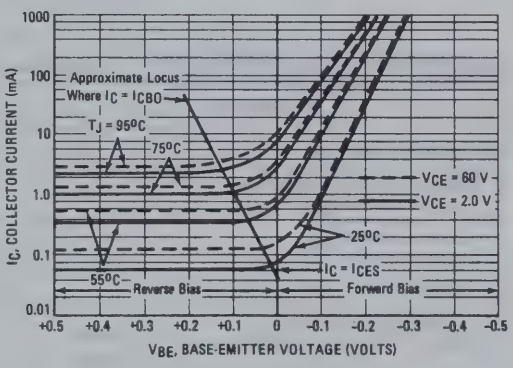


FIGURE 14 – "ON" VOLTAGES

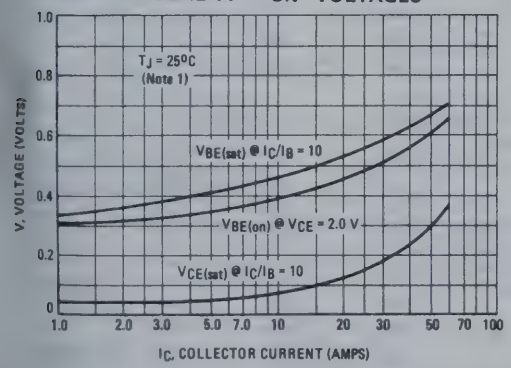
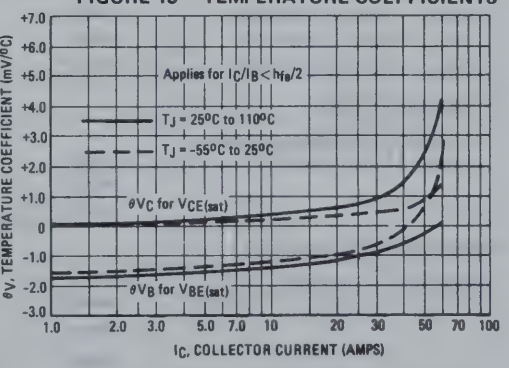


FIGURE 15 – TEMPERATURE COEFFICIENTS



2N5457 (SILICON)
2N5458
2N5459

Silicon N-channel junction field-effect transistors depletion mode (Type A) designed for general-purpose audio and switching applications.



CASE 29 (5)
(TO-92)

Drain and source may be interchanged.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating Junction Temperature	T_J	135	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)		BV_{GSS}	25	—	—	Vdc
Gate Reverse Current		I_{GSS}				nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0)			—	—	1.0	
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 100°C)			—	—	200	
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	2N5457	$V_{GS(off)}$	0.5	—	6.0	Vdc
	2N5458		1.0	—	7.0	
	2N5459		2.0	—	8.0	
Gate-Source Voltage		V_{GS}				Vdc
(V_{DS} = 15 Vdc, I_D = 100 μAdc)	2N5457		—	2.5	—	
(V_{DS} = 15 Vdc, I_D = 200 μAdc)	2N5458		—	3.5	—	
(V_{DS} = 15 Vdc, I_D = 400 μAdc)	2N5459		—	4.5	—	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5457	I_{DSS}*	1.0	3.0	5.0	mAdc
	2N5458		2.0	6.0	9.0	
	2N5459		4.0	9.0	16	
DYNAMIC CHARACTERISTICS						
Forward Transfer Admittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)	2N5457	$\|y_{fs}\|$*	1000	3000	5000	μmhos
	2N5458		1500	4000	5500	
	2N5459		2000	4500	6000	
Output Admittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)		$\|y_{os}\|$*	—	10	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)		C_{iss}	—	4.5	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)		C_{rss}	—	1.5	3.0	pF

*Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%

2N5460 (SILICON) thru 2N5465

P-channel depletion mode (Type A) junction field-effect transistors designed for use in general-purpose amplifier applications.



CASE 29(7)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	2N5460 2N5461 2N5462	2N5463 2N5464 2N5465	Unit
Drain-Gate Voltage	V_{DG}	40	60	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	60	Vdc
Forward Gate Current	$I_{G(f)}$	10		mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D	310		mW
Derate above 25°C		2.82		mW/°C
Storage Temperature Range	T_{stg}	-65 to +150		°C
Operating Junction Temperature Range	T_J	-65 to +135		°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = 10\ \mu Adc$, $V_{DS} = 0$)	2N5460, 2N5461, 2N5462	$V_{(BR)GSS}$	40	-	-	Vdc
	2N5463, 2N5464, 2N5465		60	-	-	
Gate-Source Cutoff Voltage ($V_{DS} = 15$ Vdc, $I_D = 1.0\ \mu Adc$)	2N5460, 2N5463	$V_{GS(off)}$	0.75	-	6.0	Vdc
	2N5461, 2N5464		1.0	-	7.5	
	2N5462, 2N5465		1.8	-	9.0	
Gate Reverse Current ($V_{GS} = 20$ Vdc, $V_{DS} = 0$)	2N5460, 2N5461, 2N5462	I_{GSS}	-	-	5.0	nAdc
($V_{GS} = 30$ Vdc, $V_{DS} = 0$)	2N5463, 2N5464, 2N5465		-	-	5.0	
($V_{GS} = 20$ Vdc, $V_{DS} = 0$, $T_A = 100°C$)	2N5460, 2N5461, 2N5462		-	-	1.0	μAdc
($V_{GS} = 30$ Vdc, $V_{DS} = 0$, $T_A = 100°C$)	2N5463, 2N5464, 2N5465		-	-	1.0	
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	2N5460, 2N5463	I_{DSS}	1.0	-	5.0	mAdc
	2N5461, 2N5464		2.0	-	9.0	
	2N5462, 2N5465		4.0	-	16	
Gate-Source Voltage ($V_{DS} = 15$ Vdc, $I_D = 0.1$ mAdc)	2N5460, 2N5463	V_{GS}	0.5	-	4.0	Vdc
($V_{DS} = 15$ Vdc, $I_D = 0.2$ mAdc)	2N5461, 2N5464		0.8	-	4.5	
($V_{DS} = 15$ Vdc, $I_D = 0.4$ mAdc)	2N5462, 2N5465		1.5	-	6.0	
SMALL-SIGNAL CHARACTERISTICS						
Forward Transadmittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 1.0$ kHz)	2N5460, 2N5463	$\lvert y_{fs} \rvert$	1000	-	4000	μmhos
	2N5461, 2N5464		1500	-	5000	
	2N5462, 2N5465		2000	-	6000	
Output Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 1.0$ kHz)		$\lvert y_{os} \rvert$	-	-	75	μmhos
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 1.0$ MHz)		C_{iss}	-	5.0	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 1.0$ MHz)		C_{rss}	-	1.0	2.0	pF
Common-Source Noise Figure ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $R_G = 1.0$ Megohm, $f = 100$ Hz, BW = 1.0 Hz)		NF	-	1.0	2.5	dB
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 100$ Hz, BW = 1.0 Hz)		e_n	-	60	115	$nV/\sqrt{Hz}$

DRAIN CURRENT versus GATE SOURCE VOLTAGE

FIGURE 1 – 2N5460 and 2N5463

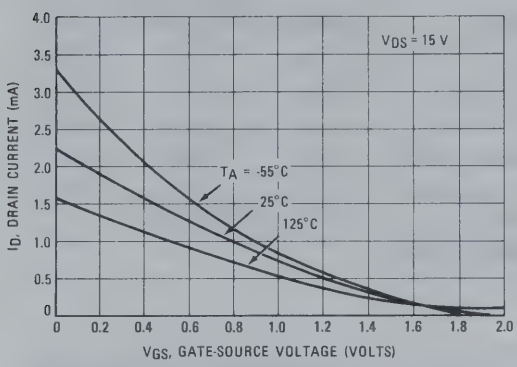


FIGURE 2 – 2N5461 and 2N5464

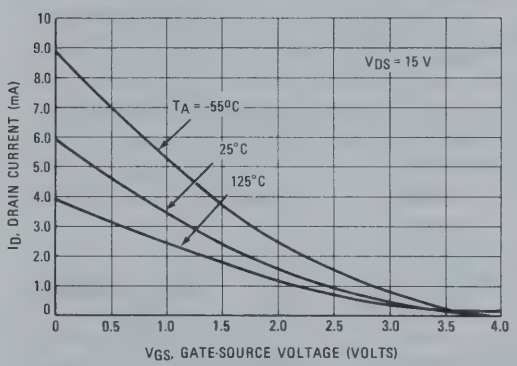
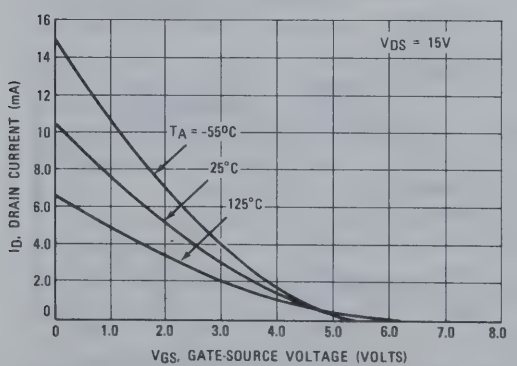


FIGURE 3 – 2N5462 and 2N5465



FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

FIGURE 4 – 2N5460 and 2N5463

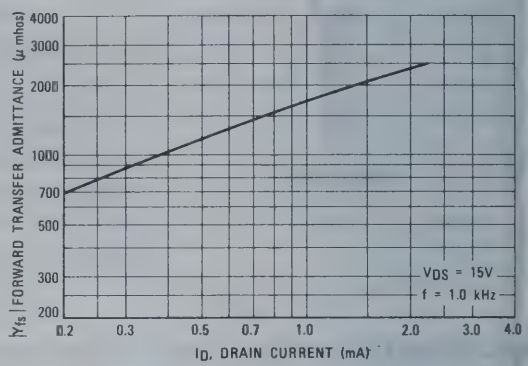


FIGURE 5 – 2N5461 and 2N5464

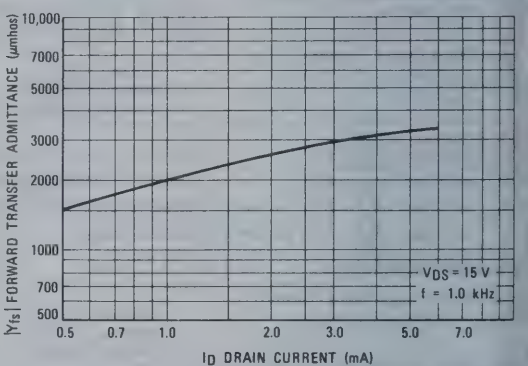


FIGURE 6 – 2N5462 and 2N5465

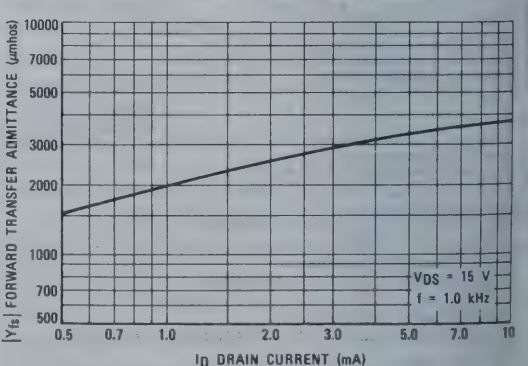


FIGURE 7 – OUTPUT RESISTANCE VERSUS DRAIN CURRENT

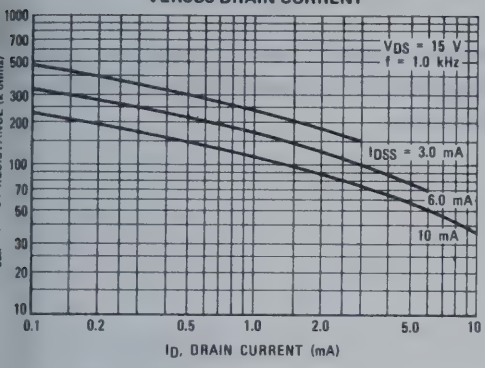


FIGURE 8 – CAPACITANCE VERSUS DRAIN-SOURCE VOLTAGE

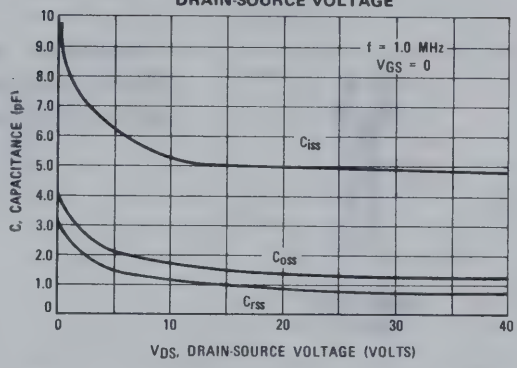


FIGURE 9 – NOISE FIGURE VERSUS FREQUENCY

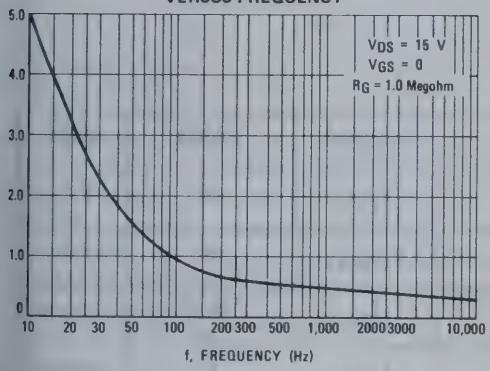


FIGURE 10 – NOISE FIGURE VERSUS SOURCE RESISTANCE

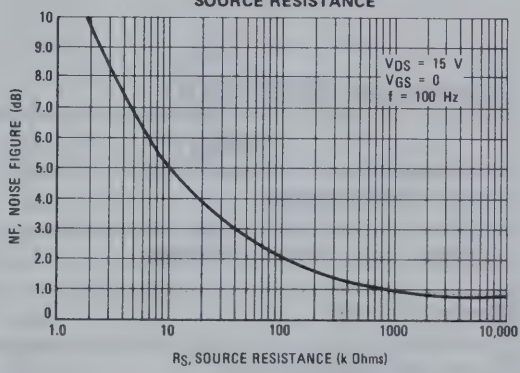
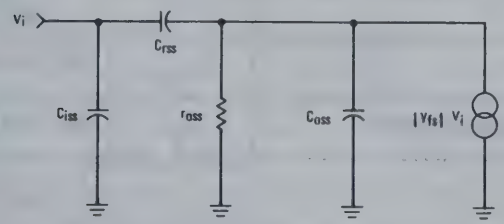


FIGURE 11 – EQUIVALENT LOW FREQUENCY CIRCUIT



Common Source y Parameters for Frequencies Below 30 MHz

$y_{is} = j\omega C_{iss}$

$y_{os} = j\omega C_{osp}^{*} + 1/r_{oss}$

$y_{fs} = |y_{fs}|$

$y_{rs} = -j\omega C_{rss}$

*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

NOTE:

1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%).

2N5471 (SILICON)
thru
2N5476



CASE 20(5)
(TO-72)

P-channel depletion mode (Type A) junction field-effect transistors designed for general-purpose amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Drain Current	I_D	5.0	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = -15 Vdc, I_D = -10 nAdc)	2N5471	$V_{GS(off)}$	0.5	4.0	Vdc
	2N5472		0.7	4.0	
	2N5473		0.9	6.0	
	2N5474		1.2	7.0	
	2N5475		1.5	8.0	
	2N5476		2.0	9.0	
Gate Reverse Current		I_{GSS}			nAdc
(V_{GS} = 10 Vdc, V_{DS} = 0)			-	0.1	
(V_{GS} = 20 Vdc, V_{DS} = 0)			-	0.5	
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)			-	1.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current* (V_{DS} = -15 Vdc, V_{GS} = 0)	2N5471	I_{DSS}*	-0.02	-0.06	mAdc
	2N5472		-0.05	-0.12	
	2N5473		-0.10	-0.25	
	2N5474		-0.20	-0.50	
	2N5475		-0.40	-1.0	
	2N5476		-0.80	-2.0	
Gate-Source Voltage		V_{GS}			Vdc
(V_{DS} = -15 Vdc, I_D = 2.0 μAdc)	2N5471		0.5	3.0	
(V_{DS} = -15 Vdc, I_D = 5.0 μAdc)	2N5472		0.7	3.5	
(V_{DS} = -15 Vdc, I_D = 10 μAdc)	2N5473		0.9	4.5	
(V_{DS} = -15 Vdc, I_D = 20 μAdc)	2N5474		1.2	6.0	
(V_{DS} = -15 Vdc, I_D = 40 μAdc)	2N5475		1.5	7.5	
(V_{DS} = -15 Vdc, I_D = 80 μAdc)	2N5476		2.0	8.0	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance* (V_{DS} = -15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5471	$\|y_{fs}\|$*	60	180	μmhos
	2N5472		90	225	
	2N5473		120	300	
	2N5474		160	400	
	2N5475		200	500	
	2N5476		260	650	
Output Admittance* (V_{DS} = -15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5471	$\|y_{os}\|$*	-	1.0	μmhos
	2N5472		-	1.0	
	2N5473		-	2.5	
	2N5474		-	2.5	
	2N5475		-	5.0	
	2N5476			10	
Input Capacitance (V_{DS} = -15 Vdc, V_{GS} = 0, 140 kHz ≤ f ≤ 1.0 MHz)		C_{iss}	-	5.0	pF
Reverse Transfer Capacitance (V_{DS} = -15 Vdc, V_{GS} = 0, 140 kHz ≤ f ≤ 1.0 MHz)		C_{rss}	-	1.0	pF
Common-Source Noise Figure (V_{DS} = -15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz, BW = 1.0 Hz)		NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = -15 Vdc, V_{GS} = 0, f = 1.0 kHz, BW = 1.0 Hz)		e_n	-	110	nV/√Hz

*Pulse Test: Pulse Width = 630 ms, Duty Cycle = 2.0%.

2N5477 (SILICON)
thru
2N5480

MEDIUM-POWER NPN SILICON TRANSISTORS

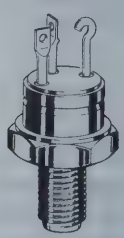
. . . designed for switching and wide-band amplifier applications.

- Low Collector Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 7.0 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Collector Common to Case

7 AMPERE POWER TRANSISTORS

NPN SILICON

80-100 VOLTS
60 WATTS

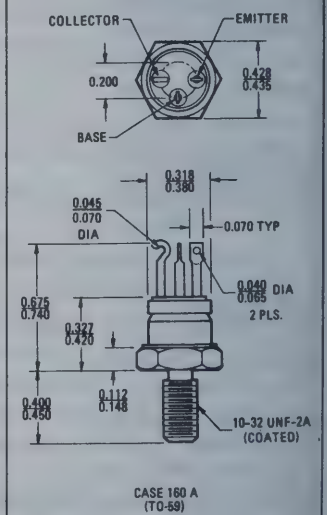


MAXIMUM RATINGS

Rating	Symbol	2N5477 2N5478	2N5479 2N5480	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	7.0		Adc
Base Current - Continuous	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C	P_D	60		Watts
Derate above 25°C		343		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

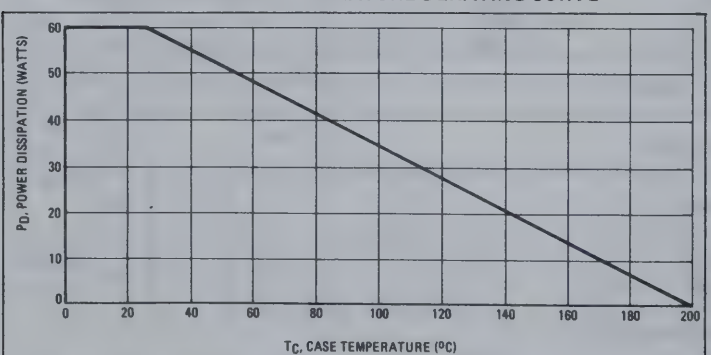
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.91	°C/W



CASE 160 A
(TO-59)

Collector Common
To Case

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 50 mAdc, I_B = 0)	2N5477, 2N5478 2N5479, 2N5480	-	$BV_{CEO(sus)}$*	80 100	- -	Vdc
Collector Cutoff Current (V_{CE} = 75 Vdc, I_B = 0)	2N5477, 2N5478	-	I_{CEO}	-	100	μAdc
(V_{CE} = 90 Vdc, I_B = 0)	2N5479, 2N5480			-	100	
Collector Cutoff Current (V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5477, 2N5478	12	I_{CEX}	-	10	μAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5479, 2N5480			-	10	
(V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5477, 2N5478			-	1.0	mAdc
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5479, 2N5480			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		-	I_{CBO}	-	10	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		-	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	2N5477, 2N5479 2N5478, 2N5480	8	h_{FE}*	30 60	- -	-
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N5477, 2N5479 2N5478, 2N5480			30 60	120 240	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N5477, 2N5479 2N5478, 2N5480			20 40	- -	
Collector-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		9, 11, 13	$V_{CE(sat)}$*	-	0.7	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	1.2	
Base-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		11, 13	$V_{BE(sat)}$*	-	1.2	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)				-	2.0	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		-	f_T	30	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		7	C_{ob}	-	250	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		7	C_{ib}	-	1,000	pF
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 40 Vdc, $V_{EB(off)}$ = 3.0 Vdc,	2,3	t_d	-	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 200 mAdc)		t_r	-	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	2,6	t_s	-	2.0	μs
Fall Time	I_{B1} = I_{B2} = 200 mAdc)		t_f	-	200	ns

* Pulse Test: Pulse Width = 300 μs, Duty Cycle ≈ 2.0%.

FIGURE 2 — SWITCHING TIME TEST CIRCUIT

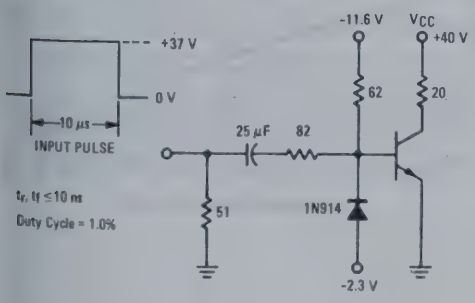


FIGURE 3 — TURN-ON TIME

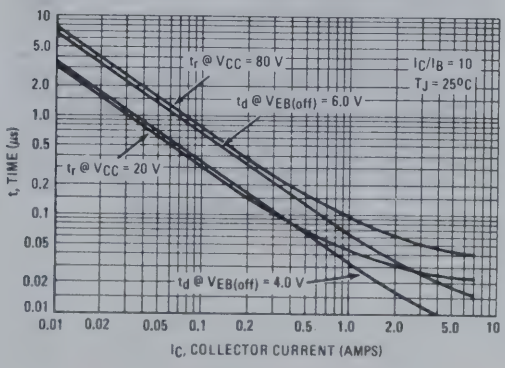


FIGURE 4 – THERMAL RESPONSE

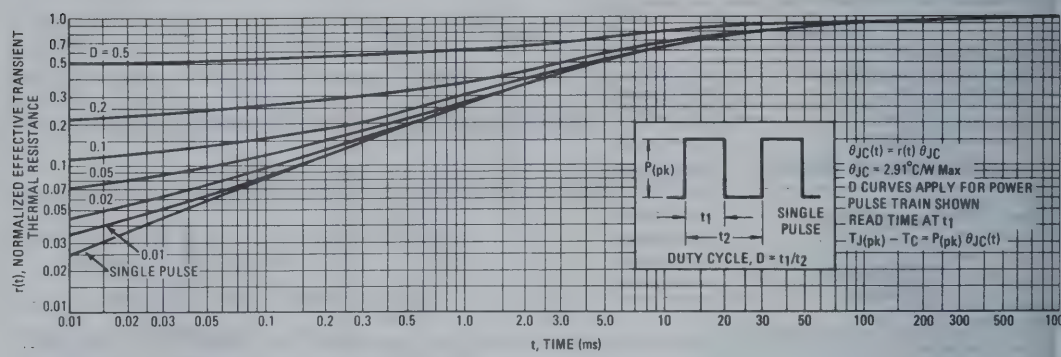
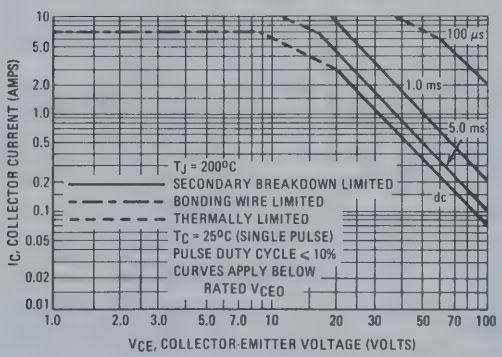


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 – TURN-OFF TIME

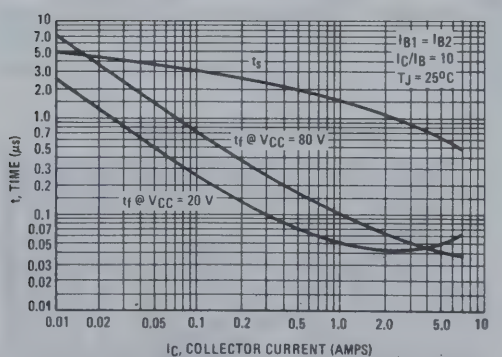


FIGURE 7 – CAPACITANCE versus VOLTAGE

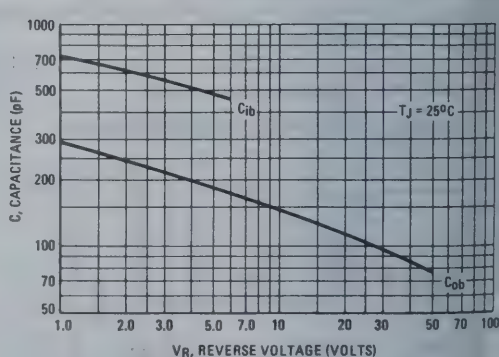


FIGURE 8 – DC CURRENT GAIN

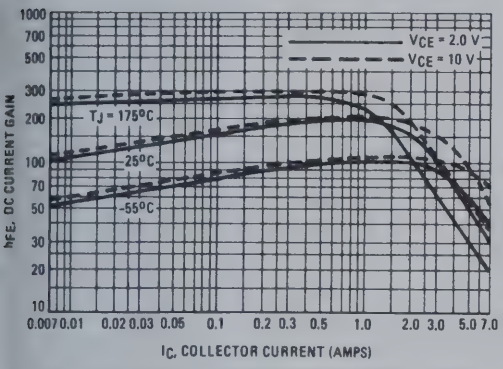


FIGURE 9 – COLLECTOR SATURATION REGION

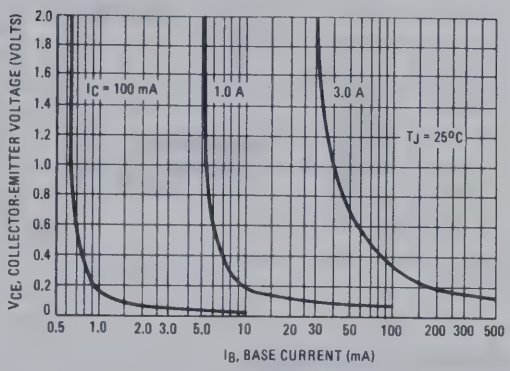


FIGURE 10 – EFFECTS OF BASE EMITTER RESISTANCE

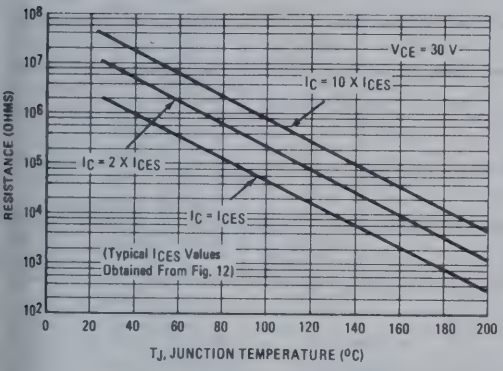


FIGURE 11 – "ON" VOLTAGES

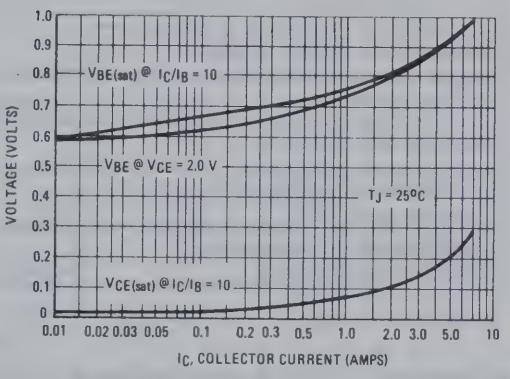


FIGURE 12 – COLLECTOR CUT-OFF REGION

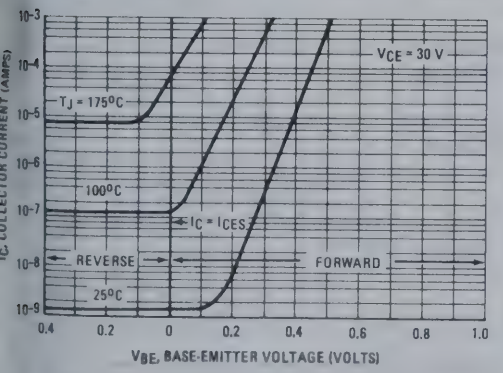
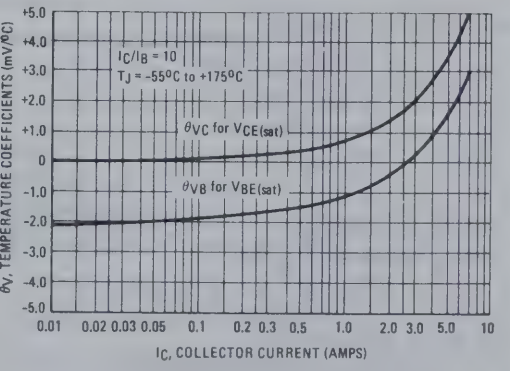


FIGURE 13 – TEMPERATURE COEFFICIENTS



2N5484 (SILICON)
thru
2N5486

N-channel depletion mode (Type A) junction field-effect transistors designed for VHF/UHF amplifier applications.



CASE 29 (5)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Drain Current	I_D	30	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

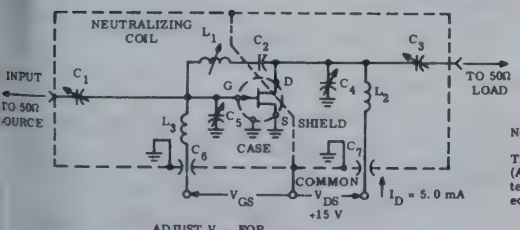
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = -1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	-	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	2N5484	$V_{GS(off)}$	0.3	-	3.0	Vdc
	2N5485		0.5	-	4.0	
	2N5486		2.0	-	6.0	
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0)		I_{GSS}	-	-	1.0	nAdc
(V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 100°C)			-	-	0.2	μAdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5484	I_{DSS}	1.0	-	5.0	mAdc
	2N5485		4.0	-	10	
	2N5486		8.0	-	20	

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS						
Forward Transadmittance		$\|y_{fs}\|$				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5484		3000	-	6000	
	2N5485		3500	-	7000	
	2N5486		4000	-	8000	
Forward Transconductance		$Re(y_{fs})$				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5484		2500	-	-	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5485		3000	-	-	
	2N5486		3500	-	-	
Output Admittance		$\|y_{os}\|$				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5484		-	-	50	
	2N5485		-	-	60	
	2N5486		-	-	75	
Output Conductance		$Re(y_{os})$				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5484		-	-	75	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5485, 2N5486		-	-	100	
Input Conductance		$Re(y_{is})$				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5484		-	-	100	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	2N5485, 2N5486		-	-	1000	
Input Capacitance		C_{iss}				pF
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)			-	-	5.0	
Reverse Transfer Capacitance		C_{rss}				pF
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)			-	-	1.0	
Output Capacitance		C_{oss}				pF
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)			-	-	2.0	
Common-Source Noise Figure		NF				dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)	All Types		-	-	2.5	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 100 MHz)	2N5484		-	-	3.0	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 200 MHz)	2N5484		-	4.0	-	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 100 MHz)	2N5485, 2N5486		-	-	2.0	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, $R_G \approx$ 1.0 k ohm, f = 400 MHz)	2N5485, 2N5486		-	-	4.0	
Insertion Power Gain		G_{ps}				dB
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 100 MHz)	2N5484		16	-	25	
(V_{DS} = 15 Vdc, I_D = 1.0 mAdc, f = 200 MHz)	2N5484		-	14	-	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz)	2N5485, 2N5486		18	-	30	
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz)	2N5485, 2N5486		10	-	20	

FIGURE 1 – 100 MHz AND 400 MHz NEUTRALIZED AMPLIFIER



ADJUST V_{GS} FOR
I_D = 5.0 mA
V_{GS} < 0 VOLTS

NOTE:

The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

Reference Designation	VALUE 100 MHz	VALUE 400 MHz
C_1	1-12 pF	0.8-8.0 pF
C_2	1000 pF	27 pF
C_3	1-12 pF	0.8-8.0 pF
C_4	1-12 pF	0.8-8.0 pF
C_5	1-12 pF	0.8-8.0 pF
C_6	0.0015 μF	0.001 μF
C_7	0.0015 μF	0.001 μF
L_1	3.0 μH*	0.2 μH**
L_2	0.25 μH*	0.03 μH**
L_3	0.14 μH*	0.022 μH**

* L_1 17 turns (approximately - depending upon circuit layout), AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L_2 4 1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I. D. (AIR CORE).

L_3 3 1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I. D. (AIR CORE).

** L_1 6 turns (approximately - depending upon circuit layout), AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L_2 1 turn, AWG #16 enameled copper wire, 3/8" I. D. (AIR CORE).

L_3 1/2 turn, AWG #16 enameled copper wire, 1/4" I. D. (AIR CORE).

2N5550 (SILICON)
2N5551

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose, high-voltage amplifier applications.

- High Voltage Ratings — BV_{CEO} = 140 and 160 Vdc (Min)
- Low Saturation Voltage
  $V_{CE(sat)}$ = 0.25 V (max) @ I_C = 50 mA, 2N5550
  = 0.20 V (max) @ I_C = 50 mA, 2N5551
- Current Gain Specified from 1.0 mAdc to 50 mAdc
- One-Piece, Injection Molded Unibloc Package for High Reliability
- Excellent for Nixie Driver Applications

HIGH VOLTAGE
NPN SILICON AMPLIFIER TRANSISTORS

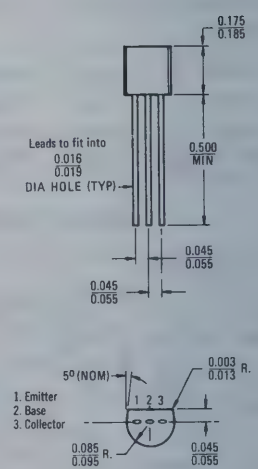


*MAXIMUM RATINGS

Rating	Symbol	2N5550	2N5551	Unit
Collector-Emitter Voltage	V_{CEO}	140	160	Vdc
Collector-Base Voltage	V_{CB}	160	180	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



CASE 29 (1)
TO-92

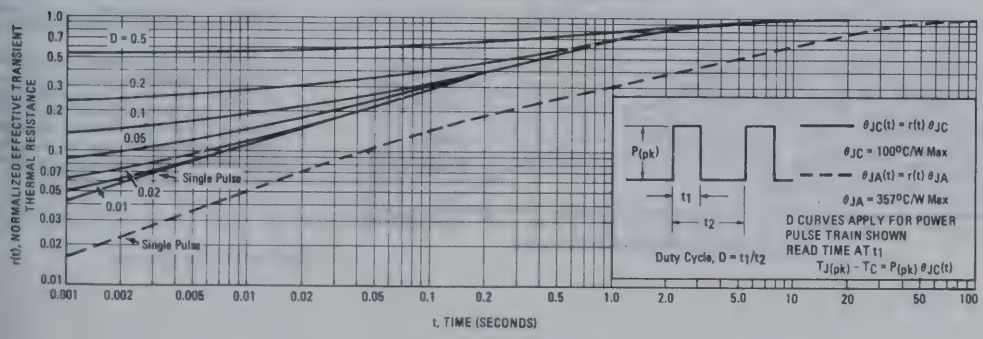
* Indicates JEDEC Registered Data

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 1.0 mAdc, I_B = 0)	2N5550	BV_{CEO}	140	–	Vdc
	2N5551		160	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N5550	BV_{CBO}	160	–	Vdc
	2N5551		180	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N5550		–	100	
(V_{CB} = 120 Vdc, I_E = 0)	2N5551		–	50	
(V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C)	2N5550		–	100	μAdc
(V_{CB} = 120 Vdc, I_E = 0, T_A = 100°C)	2N5551		–	50	
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N5550		60	–	
	2N5551		80	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N5550		60	250	
	2N5551		80	250	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	2N5550		20	–	
	2N5551		30	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	Both Types		–	0.15	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N5550		–	0.25	
	2N5551		–	0.20	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	Both Types		–	1.0	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N5550		–	1.2	
	2N5551		–	1.0	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	100	300	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N5550	C_{ib}	–	30	pF
	2N5551		–	20	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	50	200	–
Noise Figure		NF			dB
(I_C = 250 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm,	2N5550		–	10	
f = 10 Hz to 15.7 kHz)	2N5551		–	8.0	

*Indicates JEDEC Registered Data
Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%

FIGURE 1 – THERMAL RESPONSE



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 2 – CURRENT GAIN

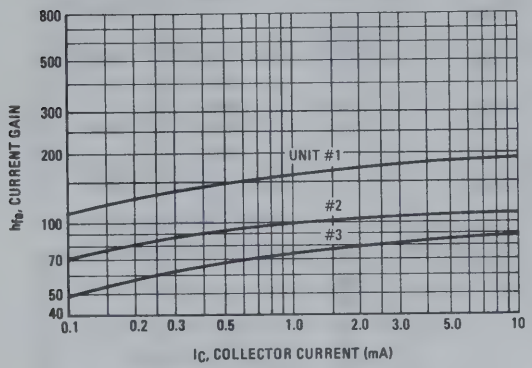


FIGURE 3 – OUTPUT ADMITTANCE

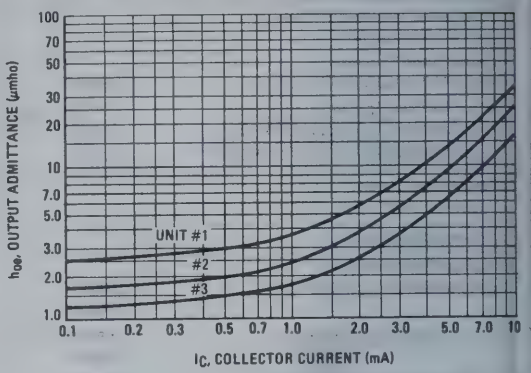


FIGURE 4 – INPUT IMPEDANCE

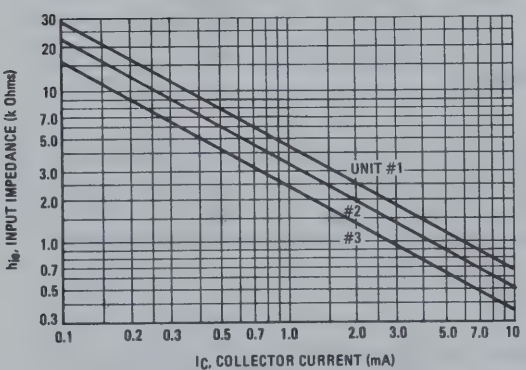


FIGURE 5 – VOLTAGE FEEDBACK RATIO

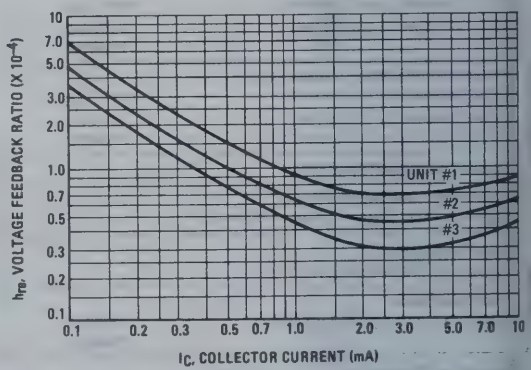
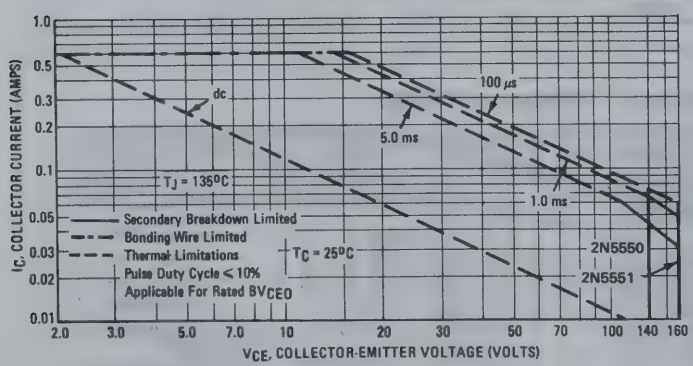


FIGURE 6 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 6 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq$ 135°C. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 7 – DC CURRENT GAIN

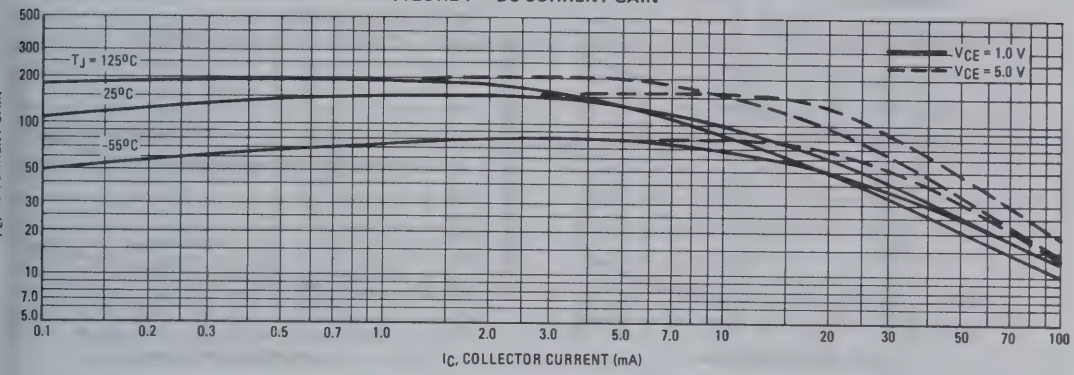


FIGURE 8 – COLLECTOR SATURATION REGION

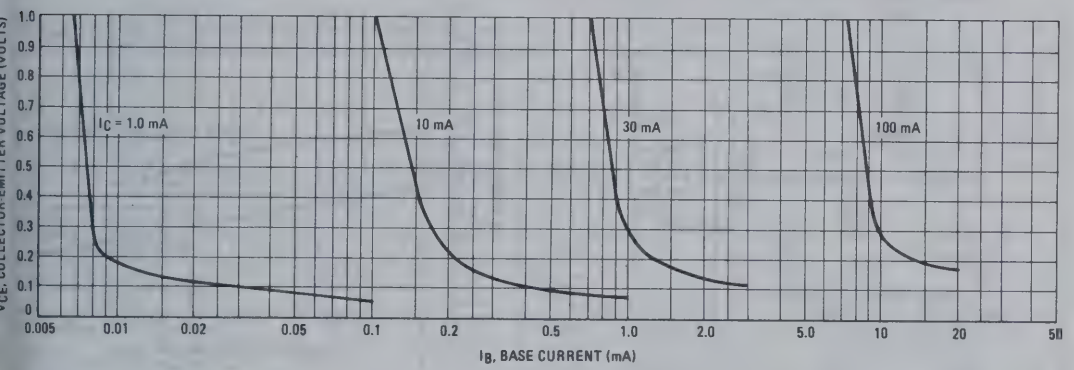


FIGURE 9 – COLLECTOR CUT-OFF REGION

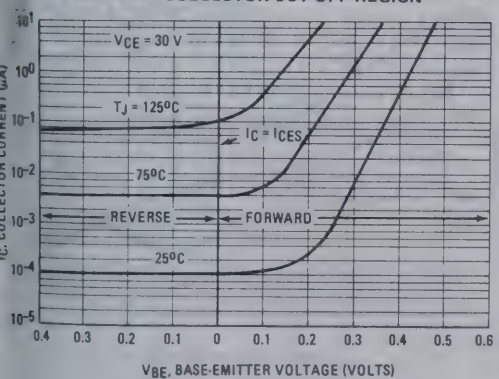


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

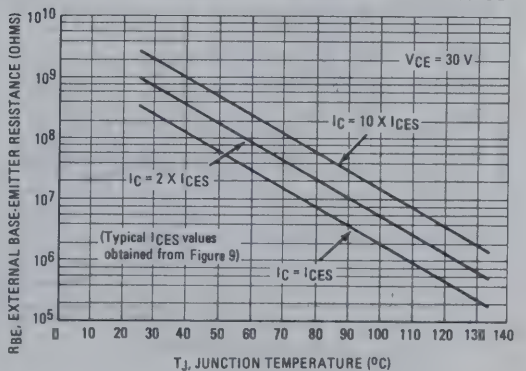


FIGURE 11 – "ON" VOLTAGES

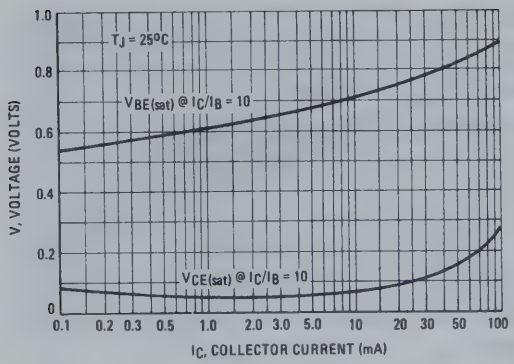


FIGURE 12 – TEMPERATURE COEFFICIENTS

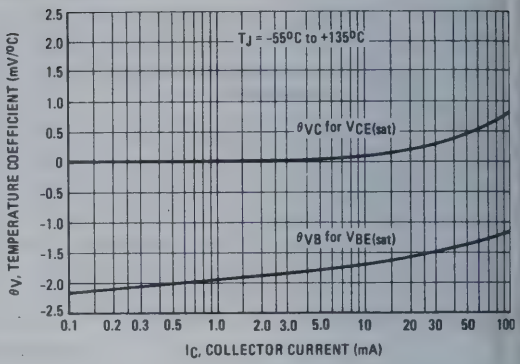


FIGURE 13 – SWITCHING TIME TEST CIRCUIT

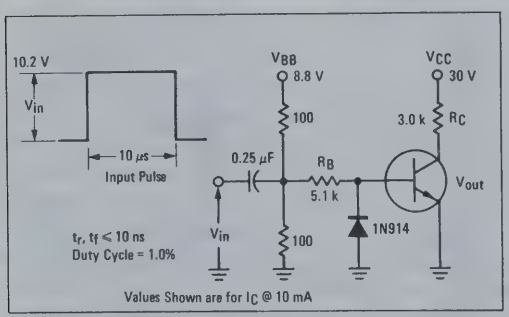


FIGURE 14 – CAPACITANCES

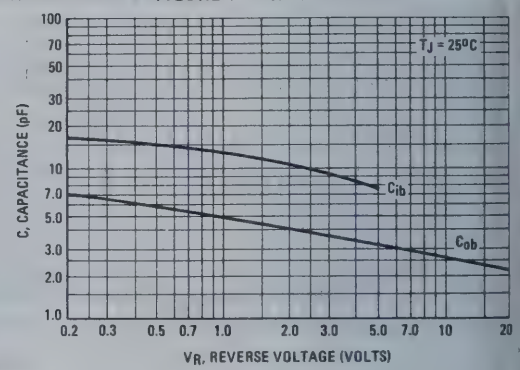


FIGURE 15 – TURN-ON TIME

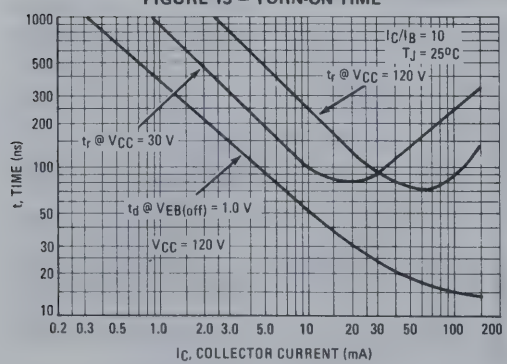
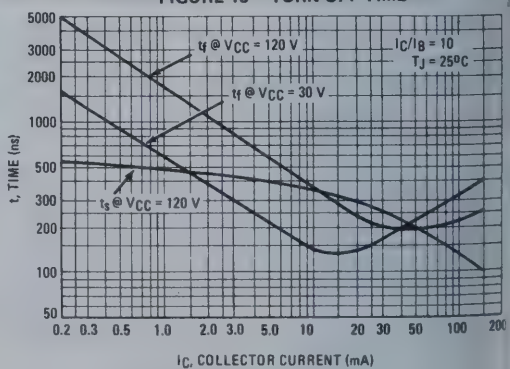


FIGURE 16 – TURN-OFF TIME



2N5555 (SILICON)

SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTOR

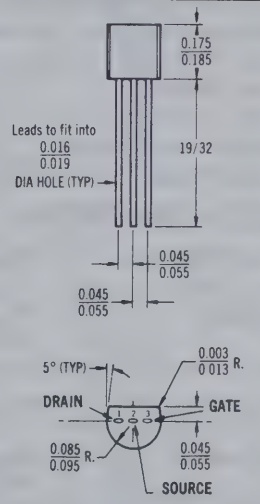
Depletion Mode (Type A) Junction Field-Effect Transistor designed for high-speed switching applications.

- Low Drain-Source "On" Resistance — $r_{ds(on)}$ = 150 Ohms (Max)
- Low Reverse Transfer Capacitance — C_{rss} = 1.2 pF (Max) @ f = 1.0 MHz
- Fast Turn-On Time — $t_{(on)}$ = 10 ns (Max)

N-CHANNEL
JUNCTION FIELD-EFFECT
TRANSISTOR

TYPE A





CASE 29 (5)
(TO-92)

Drain and Source may be Interchanged.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

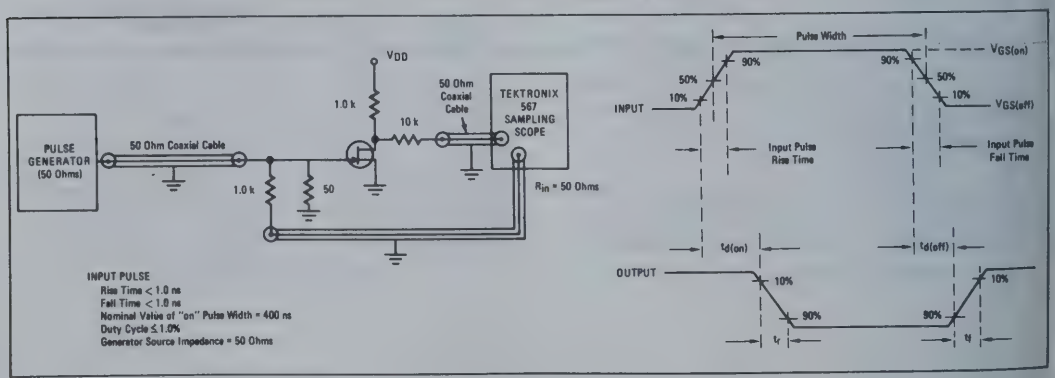
2N5555 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	-	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	-	1.0	nAdc
Drain Cutoff Current (V_{DS} = 12 Vdc, V_{GS} = 10 Vdc)	$I_{D(off)}$	-	10	nAdc
(V_{DS} = 12 Vdc, V_{GS} = 10 Vdc, T_A = 100°C)		-	2.0	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	15	-	mAdc
Gate-Source Forward Voltage ($I_{G(f)}$ = 1.0 mAdc, V_{DS} = 0)	$V_{GS(f)}$	-	1.0	Vdc
Drain-Source "ON" Voltage (I_D = 7.0 mAdc, V_{GS} = 0)	$V_{DS(on)}$	-	1.5	Vdc
Static Drain-Source "ON" Resistance (I_D = 0.1 mAdc, V_{GS} = 0)	$r_{DS(on)}$	-	150	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Small-Signal Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	-	150	Ohms
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	C_{rss}	-	1.2	pF
SWITCHING CHARACTERISTICS				
Turn-On Delay Time	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 7.0 mAdc,	$t_{d(on)}$	-	5.0	ns
Rise Time	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = -10 Vdc) (See Figure 1)	t_r	-	5.0	ns
Turn-Off Delay Time	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 7.0 mAdc,	$t_{d(off)}$	-	15	ns
Fall Time	$V_{GS(on)}$ = 0, $V_{GS(off)}$ = -10 Vdc) (See Figure 1)	t_f	-	10	ns

*Pulse Test: Pulse Width < 300 μs, Duty Cycle < 3.0%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



2N5556 (SILICON) thru 2N5558

SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) devices designed for low-noise amplifier applications.

- Low Noise Figure – NF = 1.0 dB (Max) @ 100 Hz
- Low Gate Leakage Current – I_{GSS} = 0.1 nAdc (Max)
- Low Input Capacitance – C_{iss} = 6.0 pF (Max)

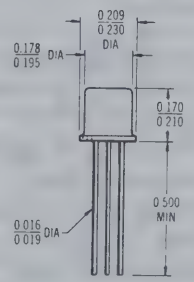
SILICON N-CHANNEL
JUNCTION FIELD-EFFECT
TRANSISTORS

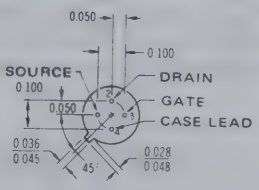
TYPE A



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

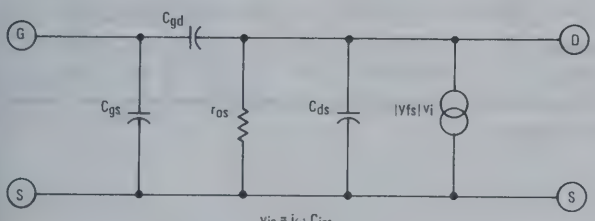




CASE 20(1)
(TO-72)

Drain and Source
may be interchanged.

FIGURE 1 – EQUIVALENT LOW FREQUENCY CIRCUIT



$Y_{is} = j\omega C_{iss}$
$Y_{os} = 1/r_{oss} + j\omega C_{oss}$
$Y_{fs} = |y_{fs}|$
$Y_{rs} = -j\omega C_{rss}$

$C_{iss} = C_{gd} + C_{gs}$
$C_{rss} = C_{gd}$
$C_{oss} = C_{gd} + C_{ds}$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	-	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 nAdc)	2N5556	$V_{GS(off)}$	0.2	-	4.0	Vdc
	2N5557		0.8	-	5.0	
	2N5558		1.5	-	6.0	
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)		I_{GSS}	-	-	-0.1	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 150°C)			-	-	-100	
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5556	I_{DSS}*	0.5	-	2.5	mAdc
	2N5557		2.0	-	5.0	
	2N5558		4.0		10	
DYNAMIC CHARACTERISTICS						
Forward Transadmittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{fs}\|$*	1500	3500	6500	μmhos
Output Admittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$*	-	-	20	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	4.5	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	1.2	3.0	pF
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 500 k ohms, f = 10 Hz, BW = 1.0 Hz)		NF	-	-	1.0	dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 100 k ohms, f = 100 Hz, BW = 1.0 Hz)			-	-	1.0	
Equivalent Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 10 Hz, BW = 1.0 Hz)		e_n	-	20	35	nV/√Hz
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)			-	10	20	

*Pulse Test: Pulse Width = 630 ms, Duty Cycle = 10%.

2N5581 (SILICON)
2N5582

NPN SILICON ANNULAR STAR SWITCHING TRANSISTORS

. . . designed for high-speed switching circuits and dc to VHF amplifier applications.

- TO-46 Equivalents to the 2N2221A and 2N2222A
- Low Leakage Current –
  I_{CBO} = 1.0 nAdc (Typ) @ V_{CB} = 60 Vdc
- DC Current Gain Specified over a Wide Current Range –
  h_{FE} from 0.1 to 500 mAdc
- Low Saturation Voltage –
  $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 150 mAdc
- High Current-Gain Bandwidth Product –
  f_T = 300 MHz (Min) @ I_C = 20 mAdc – 2N5582
- High Voltage Ratings –
  BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
  BV_{CBO} = 75 Vdc (Min) @ I_C = 10 μAdc

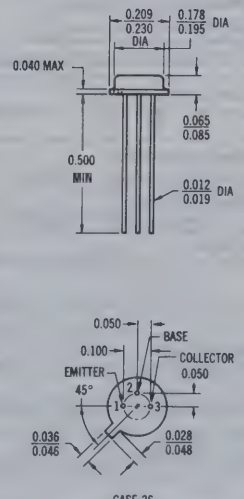
NPN SILICON ANNULAR STAR SWITCHING TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	40	Vdc
*Collector-Base Voltage	V_{CB}	75	Vdc
*Emitter-Base Voltage	V_{EB}	6.0	Vdc
*Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 3.33	Watts mW/°C
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 11.43	Watts mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

*Indicates JEDEC Registered Data.



CASE 26
TO-46 PACKAGE

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
*Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		–	BV_{CEO}	40	–	Vdc
*Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		–	BV_{CBO}	75	–	Vdc
*Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		–	BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		–	I_{CEX}	–	10	nAdc
Collector Cutoff Current *(V_{CB} = 60 Vdc, I_E = 0)		–	I_{CBO}	–	0.01	μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)				–	10	
*Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		–	I_{EBO}	–	10	nAdc
ON CHARACTERISTICS						
* DC Current Gain (Note 1)			h_{FE}			–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N5581	–		20	–	
	2N5582			35	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N5581	–		25	–	
	2N5582			50	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N5581	–		35	–	
	2N5582			75	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = –55°C)	2N5581	–		15	–	
	2N5582			35	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N5581	3		20	–	
	2N5582			50	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N5581	–		40	120	
	2N5582			100	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N5581	–		25	–	
	2N5582			40	–	
* Collector-Emitter Saturation Voltage (Note 1)		4	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)				–	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)				–	1.0	
* Base-Emitter Saturation Voltage (Note 1)		5	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)				0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)				–	2.0	
DYNAMIC CHARACTERISTICS/SMALL-SIGNAL CHARACTERISTICS						
*Current-Gain—Bandwidth Product		7	f_T			MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N5581			250	–	
	2N5582			300	–	
*Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		15	C_{cb}	–	8.0	pF
*Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		15	C_{eb}	–	25	pF
Input Impedance		11, 12	h_{ie}			k ohms
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5581			1.0	3.5	
	2N5582			2.0	8.0	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5581			0.2	1.0	
	2N5582			0.25	1.25	
Voltage Feedback Ratio		9, 10	h_{re}			–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5581			–	$5x10^{-4}$	
	2N5582			–	$8x10^{-4}$	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5581			–	$2.5x10^{-4}$	
	2N5582			–	$4x10^{-4}$	
Small-Signal Current Gain		9, 10	h_{fe}			–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5581			30	150	
	2N5582			50	300	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5581			50	300	
	2N5582			75	375	

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

ELECTRICAL CHARACTERISTICS (Continued)

Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5581 2N5582	11, 12	h_{oe}	3.0 5.0	15 35	μmhos
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N5581 2N5582			10 25	100 200	
Collector-Base Time Constant (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 31.8 MHz)		7	$r_b' C_c$	–	150	ps

SWITCHING CHARACTERISTICS

* Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc,	1	t_d	–	10	ns
* Rise Time	I_C = 150 mAdc, I_{B1} = 15 mAdc)		t_r	–	25	ns
* Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc,	2, 16	t_s	–	225	ns
* Fall Time	I_{B1} = I_{B2} = 15 mAdc)		t_f	–	60	ns
Active Region Time Constant (I_C = 150 mAdc, V_{CE} = 30 Vdc)		17	τ_A	–	2.5	ns

*Indicates JEDEC Registered Data.

FIGURE 1 – DELAY TIME AND RISE TIME EQUIVALENT TEST CIRCUIT

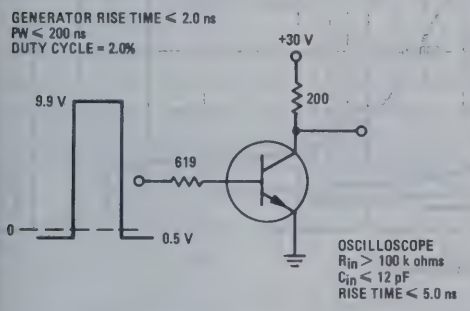
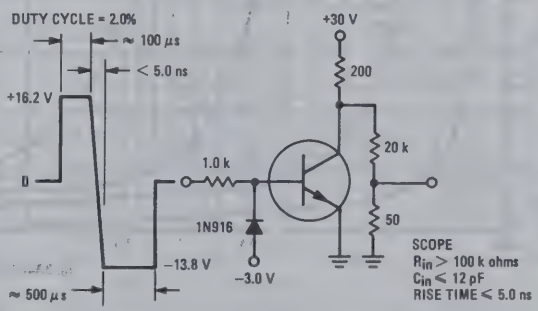


FIGURE 2 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



STATIC CHARACTERISTICS

FIGURE 3 – TYPICAL CURRENT GAIN CHARACTERISTICS

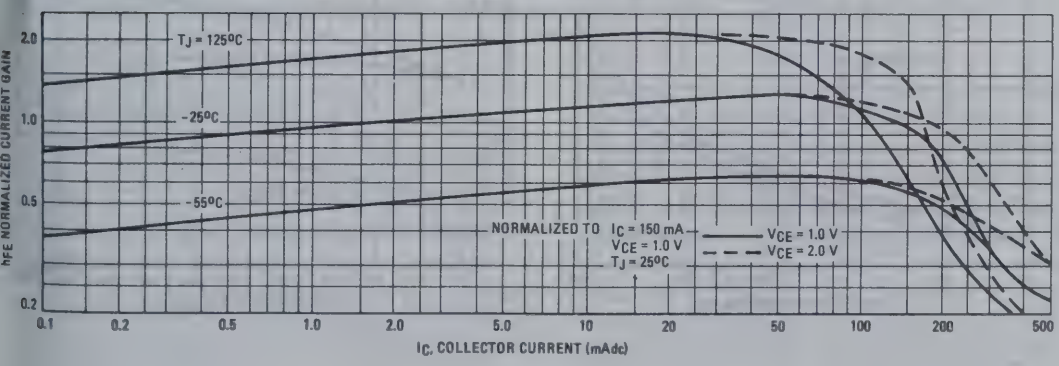
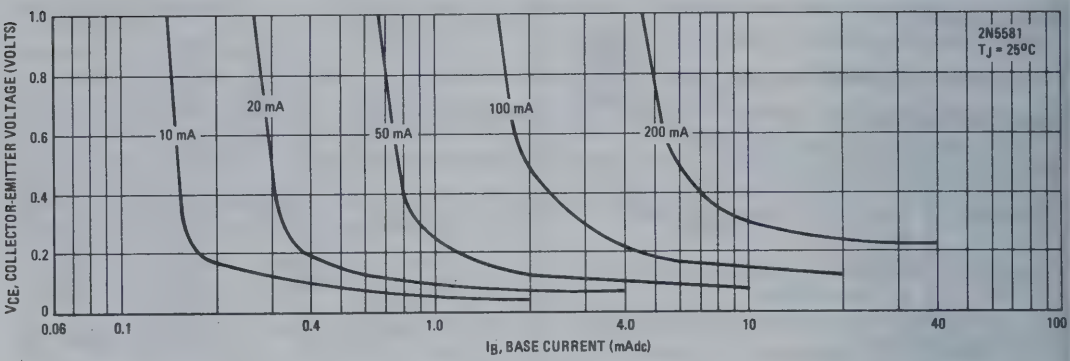


FIGURE 4 – COLLECTOR SATURATION VOLTAGE CHARACTERISTICS



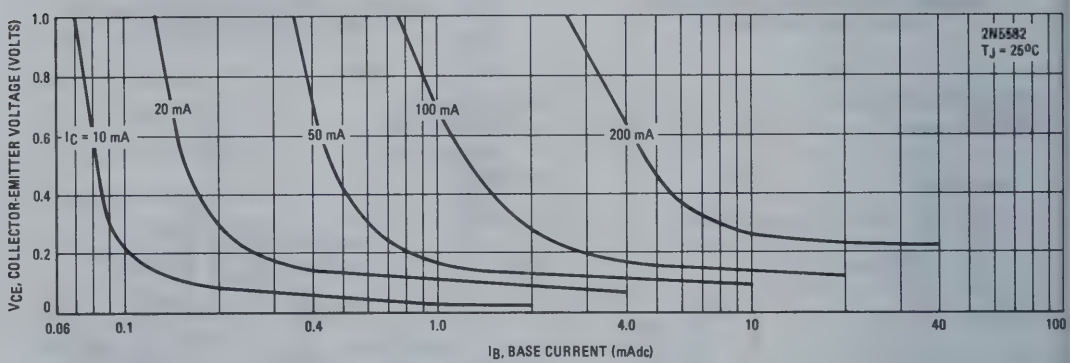


FIGURE 5 – BASE SATURATION VOLTAGE versus COLLECTOR CURRENT

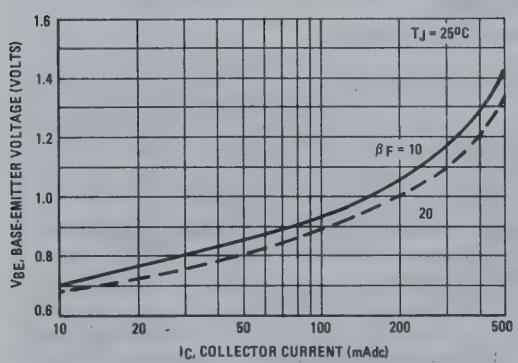


FIGURE 6 – TEMPERATURE COEFFICIENTS

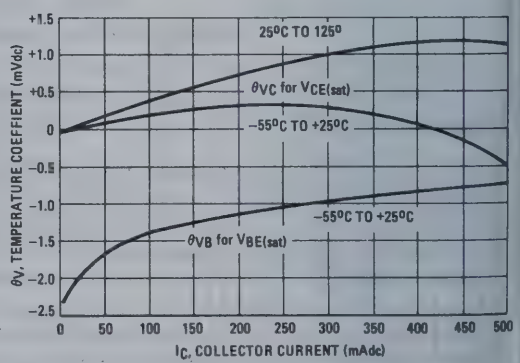


FIGURE 7 – CURRENT GAIN–BANDWIDTH PRODUCT AND COLLECTOR BASE TIME CONSTANT versus COLLECTOR CURRENT

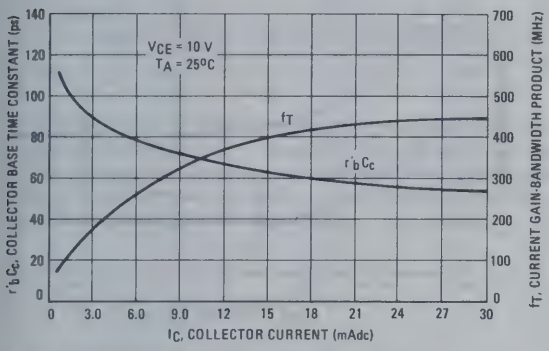
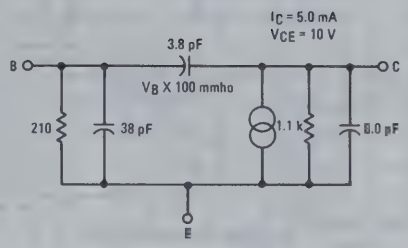


FIGURE 8 – EQUIVALENT CIRCUIT AT 30 MHz



SMALL SIGNAL FORWARD CURRENT GAIN AND VOLTAGE FEEDBACK RATIO versus COLLECTOR CURRENT

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 9 – 2N5581

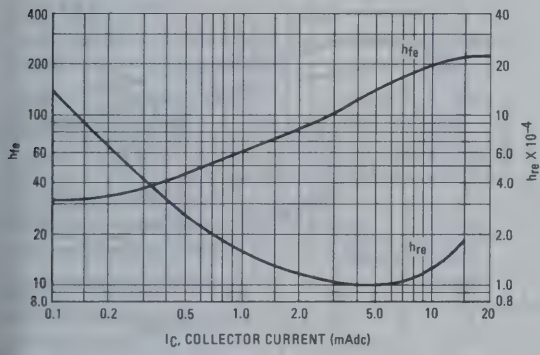
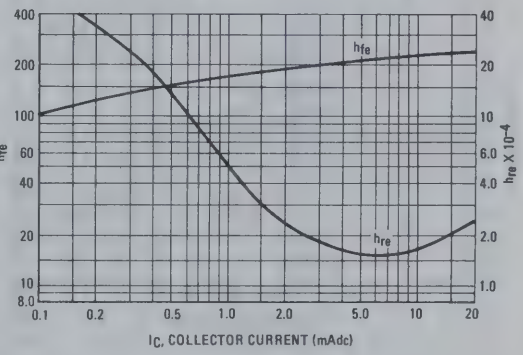


FIGURE 10 – 2N5582



SMALL SIGNAL INPUT IMPEDANCE AND OUTPUT CONDUCTANCE versus COLLECTOR CURRENT

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 11 – 2N5581

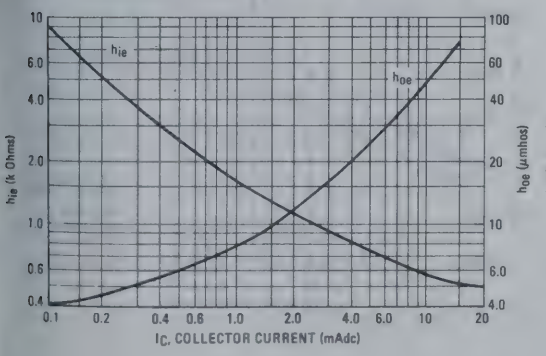


FIGURE 12 – 2N5582

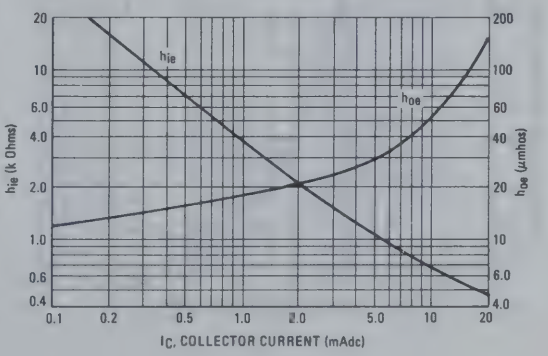


FIGURE 13 – 1.0 kHz NOISE FIGURE versus SOURCE IMPEDANCE

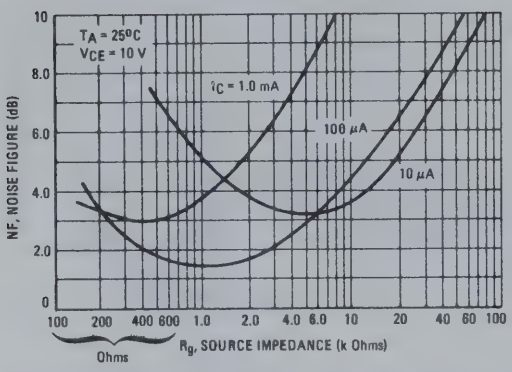


FIGURE 14 – NOISE FIGURE versus FREQUENCY

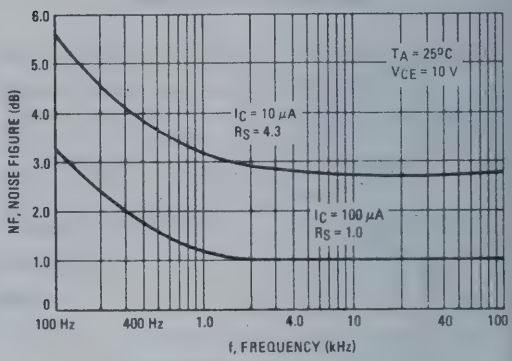


FIGURE 15 – CAPACITANCE VARIATIONS versus VOLTAGE

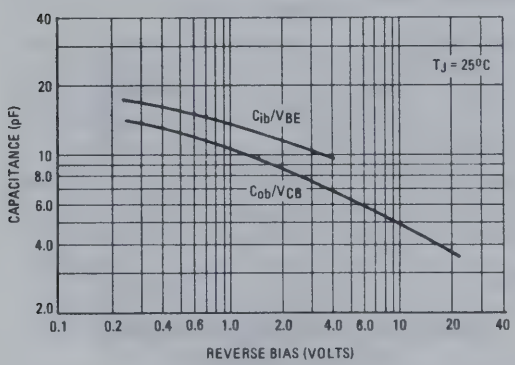


FIGURE 16 – STORAGE AND FALL TIME versus COLLECTOR CURRENT

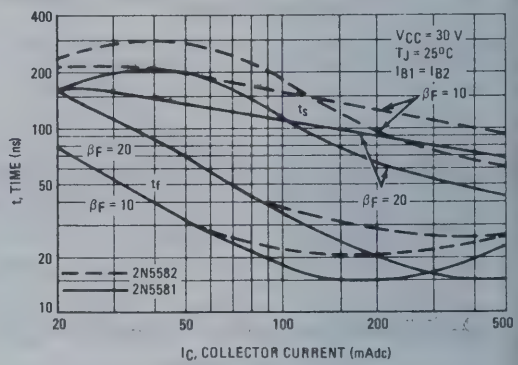


FIGURE 17 – ACTIVE REGION TIME CONSTANT versus COLLECTOR CURRENT

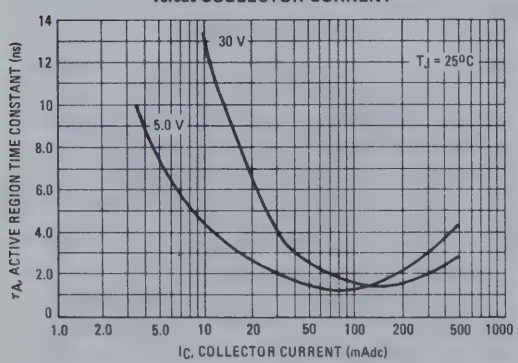
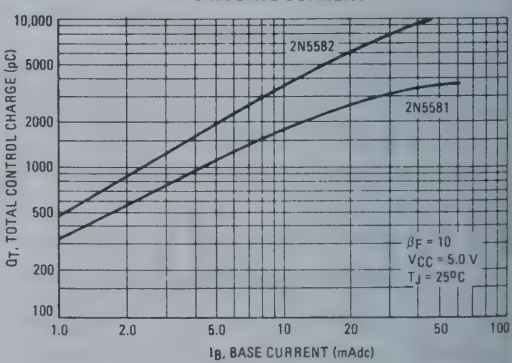


FIGURE 18 – TOTAL CONTROL CHARGE versus BASE CURRENT



2N5583 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for applications in high frequency amplifiers and non-saturated switching circuits. Large signal capabilities, low-noise and high gain-bandwidth product characteristics of the 2N5583 provide excellent performance in a variety of small signal and linear amplifier applications. Ideal for C A T V circuits.

- High Current-Gain—Bandwidth Product —
  f_T = 1300 (Min) @ I_C = 100 mAdc
- Low Collector-Base Time Constant —
  $r_b'C_c$ = 8.0 ps (Typ) @ I_C = 50 mAdc

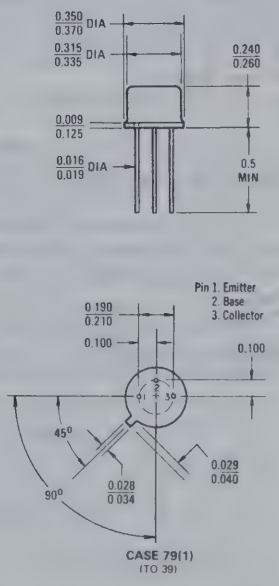
PNP SILICON AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	30	Vdc
*Collector-Base Voltage	V_{CB}	30	Vdc
*Emitter-Base Voltage	V_{EB}	3.0	Vdc
*Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

*Indicates JEDEC Registered Data.



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Figure No.	Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**						
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 10 mAdc, I_B = 0)	–	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	–	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	–	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	4	I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	–	I_{EBO}	–	–	0.5	μAdc
***ON CHARACTERISTICS**						
DC Current Gain (Note 1) (I_C = 40 mAdc, V_{CE} = 2.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc) (I_C = 300 mAdc, V_{CE} = 5.0 Vdc)	1	h_{FE}	 20 25 15	 40 40 22	 – 100 –	–
Collector-Emitter Saturation Voltage (Note 1) (I_C = 100 mAdc, I_B = 10 mAdc)	2,3	$V_{CE(sat)}$	–	0.6	0.8	Vdc
Base-Emitter On Voltage (Note 1) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	3	$V_{BE(on)}$	–	0.84	1.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
*Current-Gain—Bandwidth Product (I_C = 40 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	7	f_T	 1000 1300	 1300 1500	 – –	MHz
*Collector-Base Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 100 kHz)	5	C_{cb}	–	2.5	5.0	pF
*Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	5	C_{eb}	–	18	35	pF
Collector-Base Time Constant (I_C = 50 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	8	$r_b'C_c$	–	8.0	–	ps
SWITCHING CHARACTERISTICS						
Delay Time (V_{CC} = 31.4 Vdc, I_C = 150 mAdc, R_C = 160 Ohms, R_E = 26.6 Ohms) (See Figure 10 for more detail)	9	t_d	–	1.0	–	ns
Rise Time	9	t_r	–	2.1	–	ns
Fall Time	9	t_f	–	1.8	–	ns

*Indicates JEDEC Registered Data.
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.

FIGURE 1 – DC CURRENT GAIN

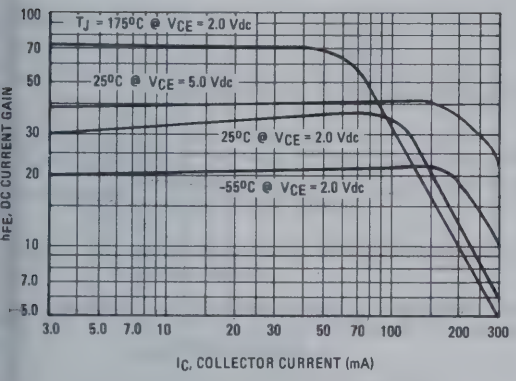


FIGURE 2 – COLLECTOR SATURATION REGION

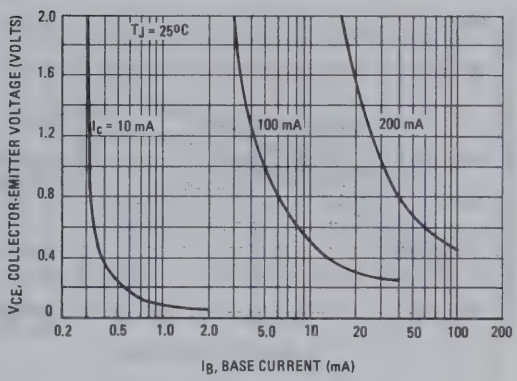


FIGURE 3 – "ON" VOLTAGES

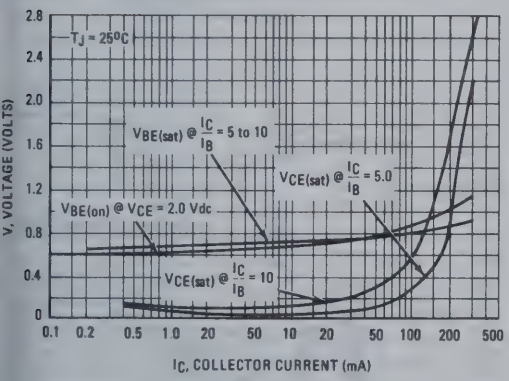


FIGURE 4 – COLLECTOR CURRENT versus BASE VOLTAGE

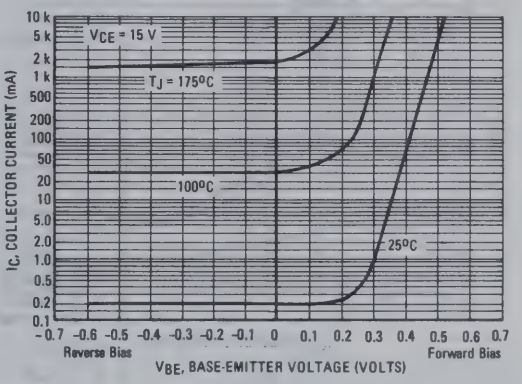


FIGURE 5 – CAPACITANCES

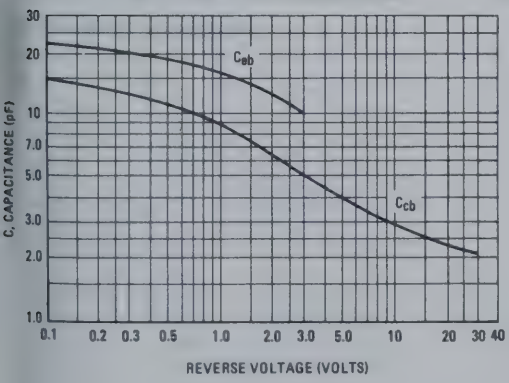


FIGURE 6 – TEMPERATURE COEFFICIENTS

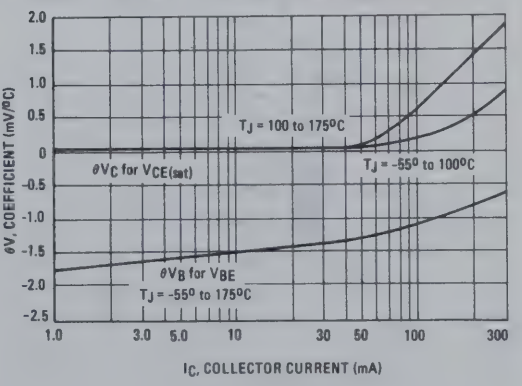


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

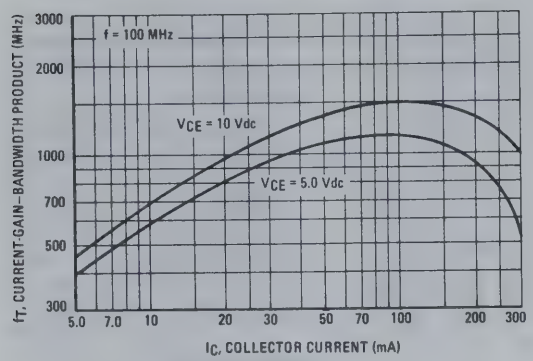


FIGURE 8 – COLLECTOR-BASE TIME CONSTANT

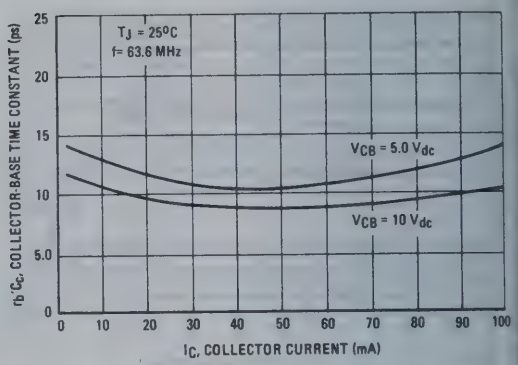


FIGURE 9 – SWITCHING TIMES

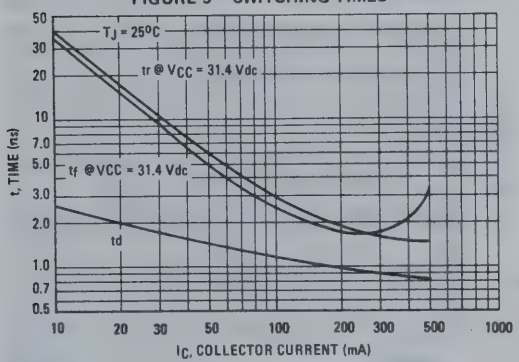
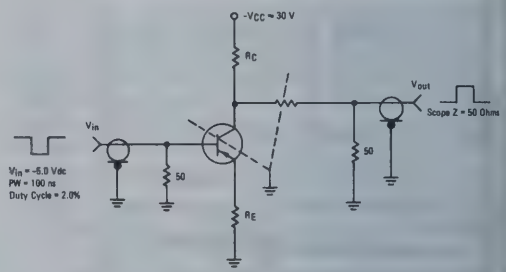


FIGURE 10 – SWITCHING TIMES TEST CIRCUIT



IC mA	RC Ohms	RE Ohms	VCC Volts
50	526	80	34.4
150	160	26.6	31.4
300	78	13.3	30.6
500	46.5	8.0	30.3

2N5589 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 13.6 volt, VHF large signal power amplifier applications required in military and industrial equipment operating to 240 MHz.

- Low lead inductance stripline package for easier design and increased broadband capability.
- Balanced Emitter Construction for increased Safe Operating Area. The 2N5589 is designed to withstand an Open or Shorted Load at rated Output Power.
- Specified 13.6 Volt, 175 MHz Characteristics –
  Output Power = 3.0 Watts
  Minimum Gain = 8.2 dB
  Efficiency = 50%

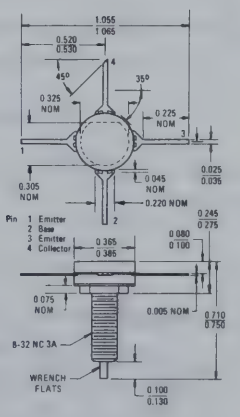
NPN SILICON RF POWER TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	0.6	Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	15 86	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.



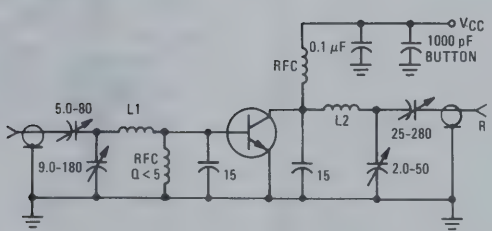
CASE 144B-02

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	36	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	15	30	pF
FUNCTIONAL TEST					
Power Input (Figure 1) (P_{out} = 3.0 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	P_{in}	–	0.35	0.45	Watt
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 3.0 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	G_{PE}	8.2	–	–	dB
Collector Efficiency (Figure 1) (P_{out} = 3.0 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	η	50	–	–	%

*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.

FIGURE 1 – 175 MHz TEST CIRCUIT



All capacitance values in pF unless otherwise indicated
L1 – 1-3/8" length of #14 AWG Wire
L2 – 2 Turns #16 AWG Wire, 1/4" Dia. 1-1/2" Long

POWER OUTPUT versus FREQUENCY

FIGURE 2

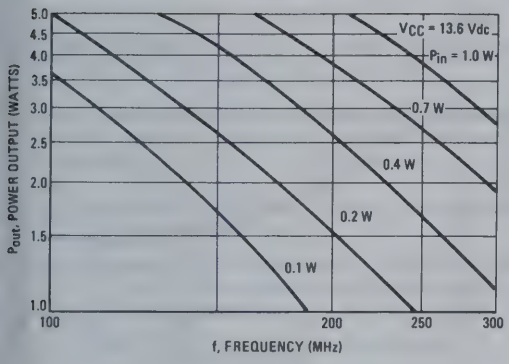


FIGURE 3

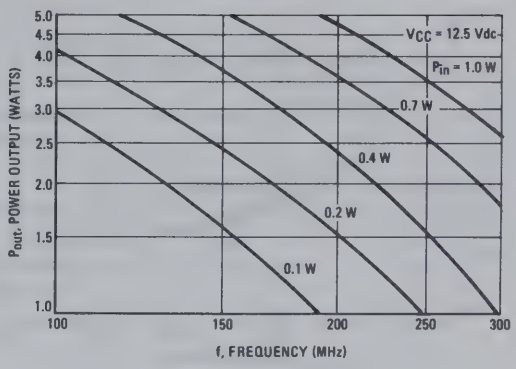


FIGURE 4 — POWER OUTPUT versus POWER INPUT

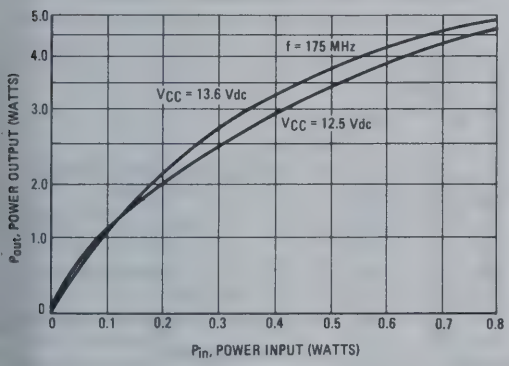
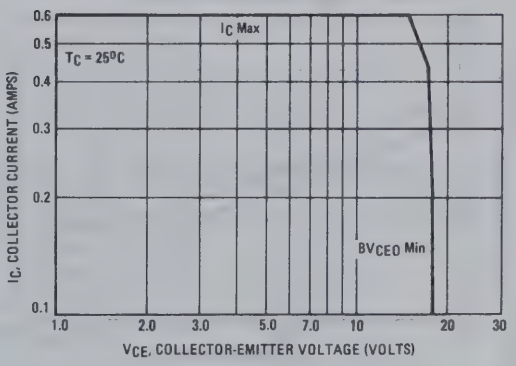


FIGURE 5 — DC SAFE OPERATING AREA



PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 6

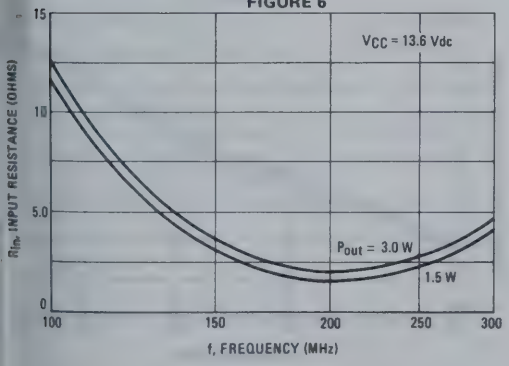
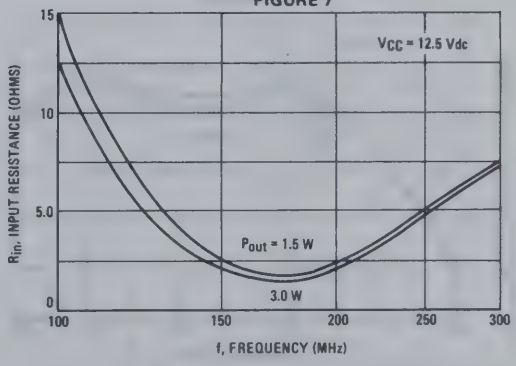


FIGURE 7



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 8

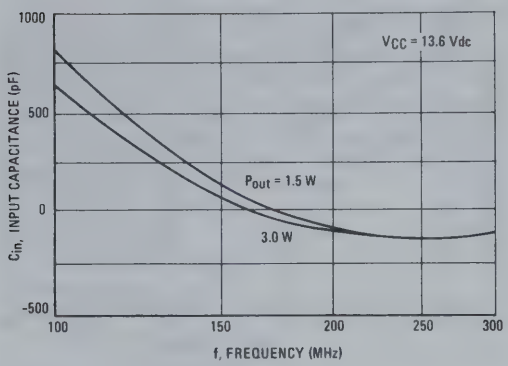
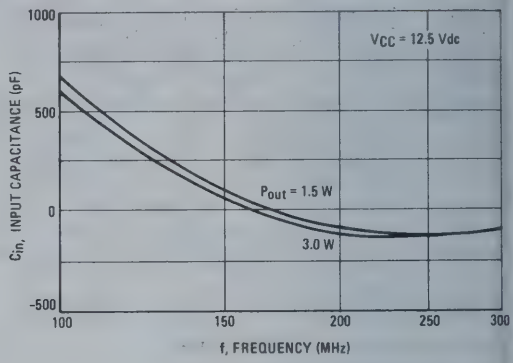


FIGURE 9



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 10

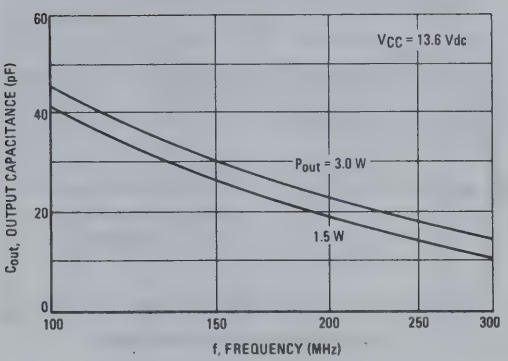
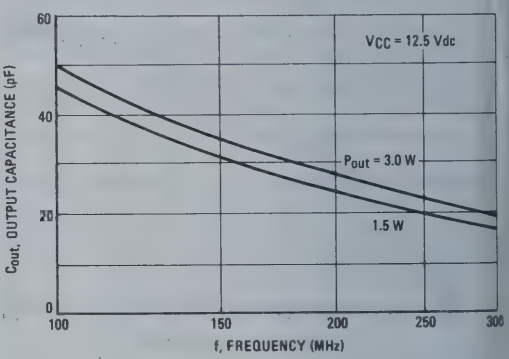


FIGURE 11



SERIES INPUT IMPEDANCE versus FREQUENCY

FIGURE 12

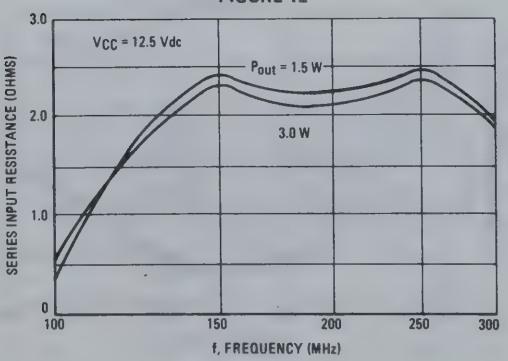
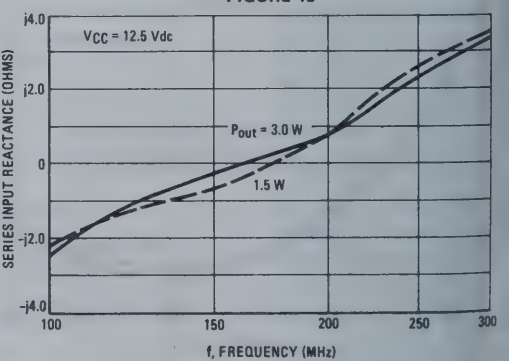


FIGURE 13



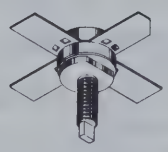
2N5590 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 13.6 volt, VHF large signal power amplifier applications required in military and industrial equipment operating to 240 MHz.

- Low lead inductance stripline package for easier design and increased broadband capability.
- Balanced Emitter Construction for increased Safe Operating Area. The 2N5590 is designed to withstand an Open or Shorted Load at rated Output Power.
- Specified 13.6 Volt, 175 MHz Characteristics –
  Output Power = 10 Watts
  Minimum Gain = 5.2 dB
  Efficiency = 50%

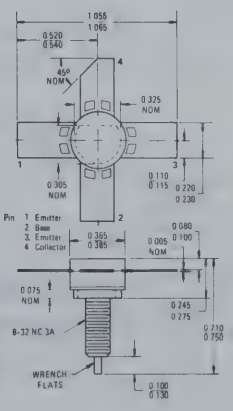
NPN SILICON RF POWER TRANSISTOR



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	2.0	Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	30 171	Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	^oC

*Indicates JEDEC Registered Data.



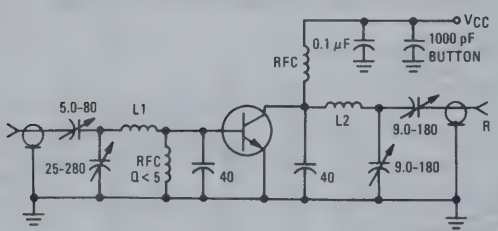
CASE 145A-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Sustaining Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	18	–	–	Vdc
*Collector-Emitter Sustaining Voltage (Note 1) (I_C = 200 mAdc, R_{BE} = 0)	$V_{CES(sus)}$	36	–	–	Vdc
*Emitter-Base Breakdown Voltage (I_E = 2.5 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
*DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
*Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	35	70	pF
FUNCTIONAL TEST					
*Power Input (Figure 1) (P_{out} = 10 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	P_{in}	–	–	3.0	Watts
*Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 10 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	G_{PE}	5.2	–	–	dB
Collector Efficiency (Figure 1) (P_{out} = 10 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	η	50	–	–	%

*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.

FIGURE 1 – 175 MHz TEST CIRCUIT



All capacitance values in pF unless otherwise indicated
L1 – 1-3/8" length of #14 AWG Wire
L2 – 1 Turn #14 AWG Wire, 3/8" Dia. 1-1/2" Long

POWER OUTPUT versus FREQUENCY

FIGURE 2

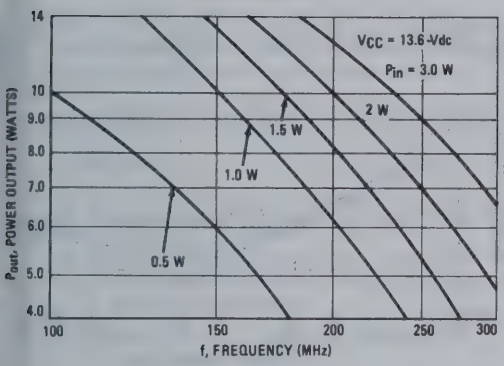


FIGURE 3

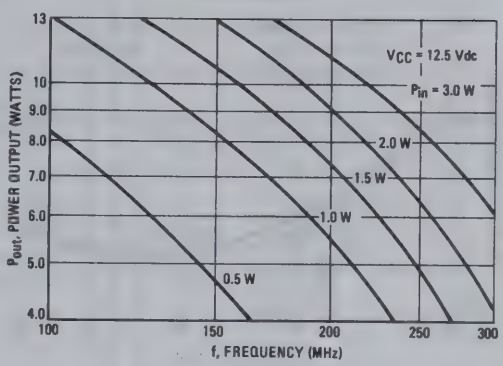


FIGURE 4 – POWER OUTPUT versus POWER INPUT

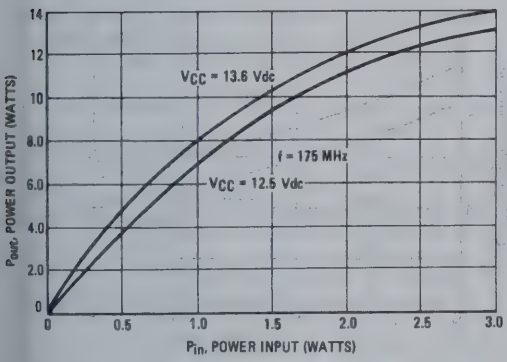
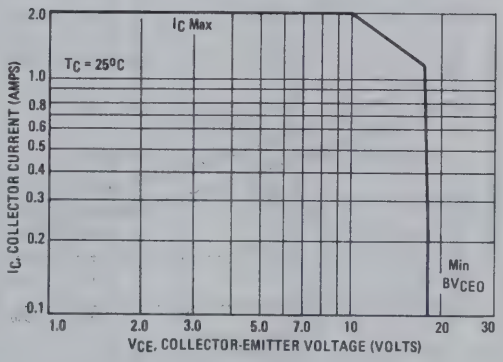


FIGURE 5 – DC SAFE OPERATING AREA



PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 6

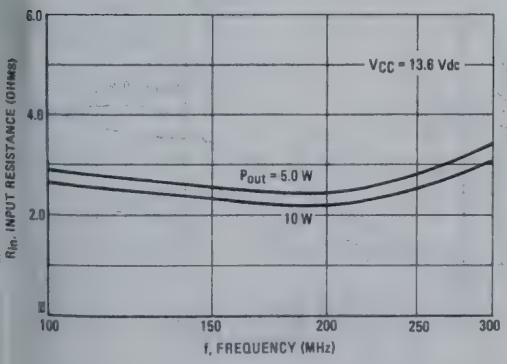
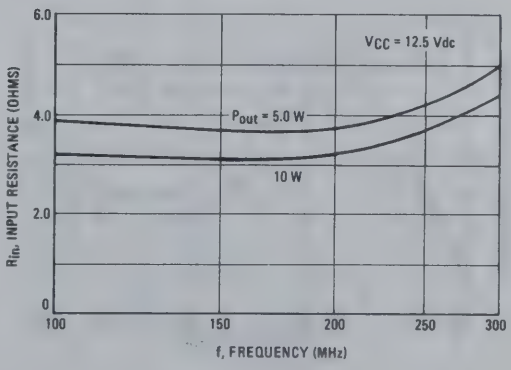


FIGURE 7



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 8

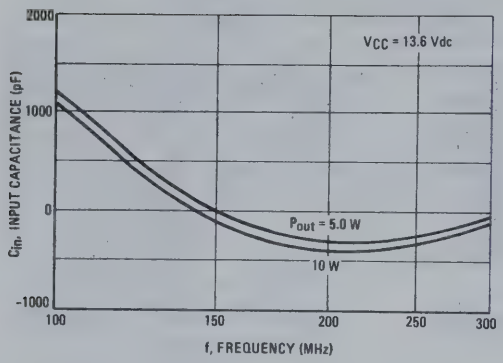
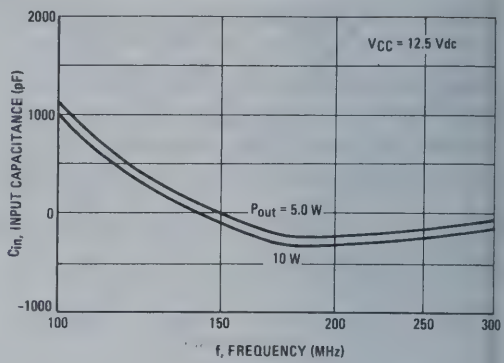


FIGURE 9



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 10

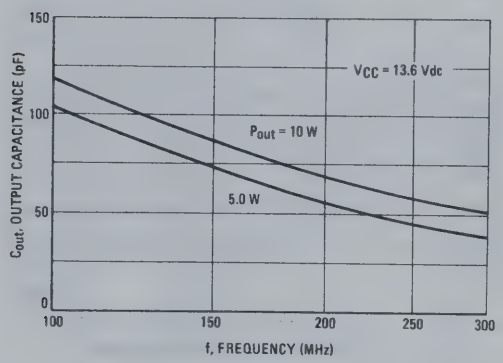
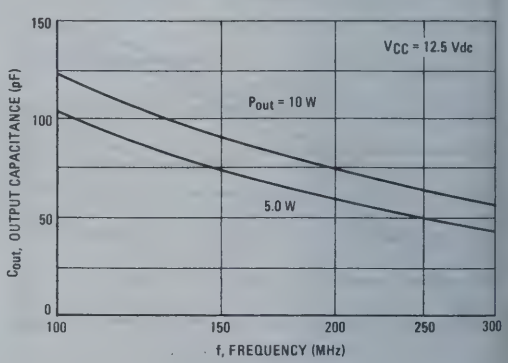


FIGURE 11



SERIES INPUT IMPEDANCE versus FREQUENCY

FIGURE 12

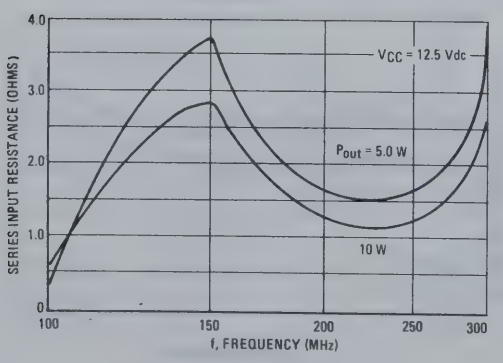
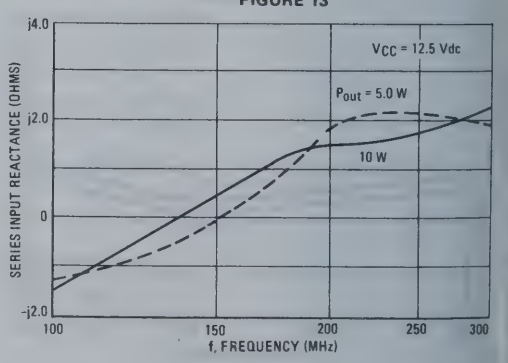


FIGURE 13



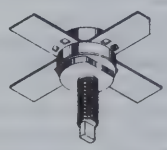
2N5591 (SILICON)

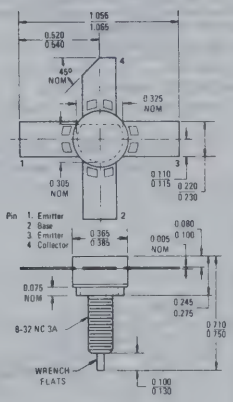
NPN SILICON RF POWER TRANSISTOR

. . . designed for 13.6 volt, VHF large signal power amplifier applications required in military and industrial equipment operating to 240 MHz.

- Low lead inductance stripline package for easier design and increased broadband capability.
- Balanced Emitter Construction for increased Safe Operating Area. The 2N5591 is designed to withstand an Open or Shorted Load at rated Output Power.
- Specified 13.6 Volt, 175 MHz Characteristics —
  Output Power = 25 Watts
  Minimum Gain = 4.4 dB
  Efficiency = 50%

NPN SILICON RF POWER TRANSISTOR





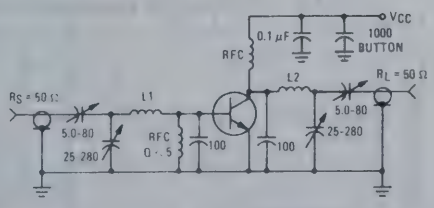
CASE 145A-01

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	4.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	70 400	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	^oC

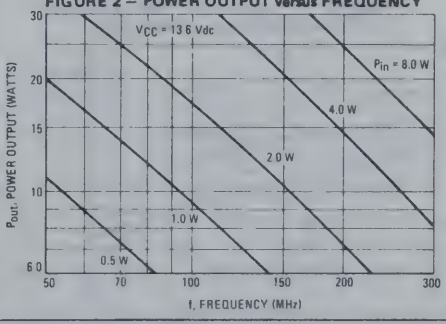
*Indicates JEDEC Registered Data.

FIGURE 1 — 175 MHz TEST CIRCUIT



ALL CAPACITORS IN pF UNLESS OTHERWISE INDICATED
L1 — #14 AWG STRAIGHT WIRE, 1-3/8" LONG
L2 — 1 TURN #14 AWG WIRE, 3/8" DIA. 1-1/2" LONG

FIGURE 2 — POWER OUTPUT versus FREQUENCY



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Sustaining Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	18	–	–	Vdc
*Collector-Emitter Sustaining Voltage (Note 1) (I_C = 200 mAdc, V_{BE} = 0)	$V_{CES(sus)}$	36	–	–	Vdc
*Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
***ON CHARACTERISTICS**					
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
***DYNAMIC CHARACTERISTICS**					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	90	120	pF
*** FUNCTIONAL TEST**					
Power Input (Figure 1) (P_{out} = 25 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	P_{in}	–	–	9.0	Watts
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 25 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	G_{PE}	4.4	–	–	dB
Collector Efficiency (Figure 1) (P_{out} = 25 W, V_{CE} = 13.6 Vdc, f = 175 MHz)	η	50	–	–	%

*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.

FIGURE 3 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

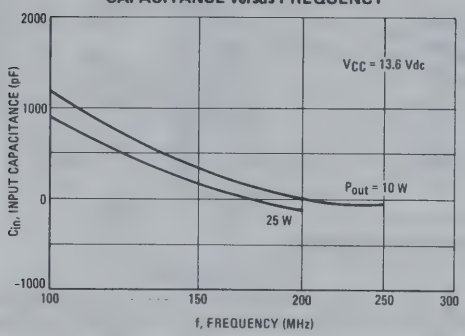


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

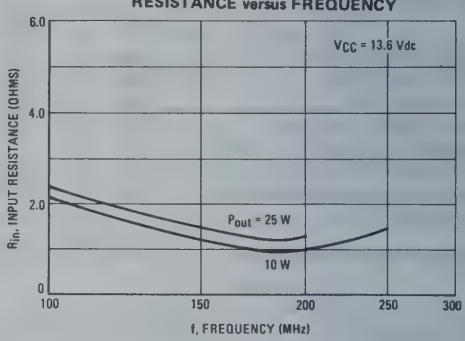


FIGURE 5 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

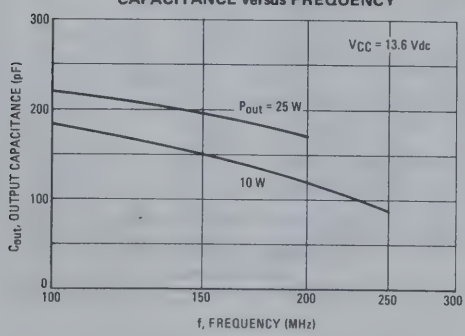
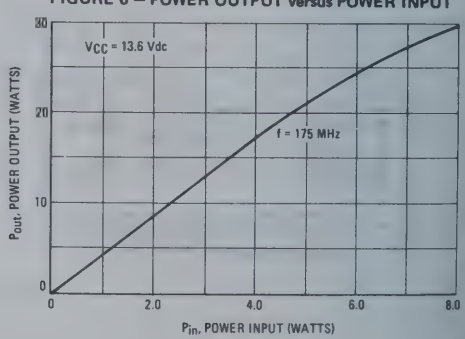


FIGURE 6 – POWER OUTPUT versus POWER INPUT



2N5629 (SILICON)
2N5630
2N5631

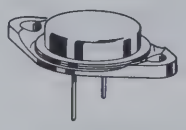
HIGH-POWER NPN SILICON TRANSISTORS

. . . for use in untuned amplifiers and switching circuit applications.

- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 140 Vdc – 2N5631
- High DC Current Gain –
  h_{FE} = 25 (Min) @ I_C = 8.0 Adc – 2N5629
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 10 Adc

16 AMPERE
POWER TRANSISTORS
NPN SILICON

100-120-140 VOLTS
200 WATTS



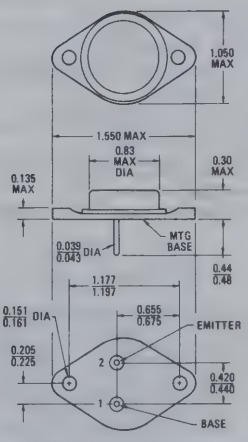
*MAXIMUM RATINGS

Rating	Symbol	2N5629	2N5630	2N5631	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	140	Vdc
Collector-Base Voltage	V_{CB}	100	120	140	Vdc
Emitter-Base Voltage	V_{EB}	7.0			Vdc
Collector Current – Continuous Peak	I_C	16 20			Adc
Base Current – Continuous	I_B	5.0			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.14			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

*THERMAL CHARACTERISTICS

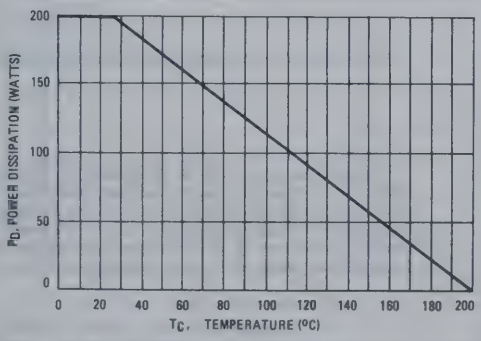
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W

*Indicates JEDEC Registered Data.



CASE 11
TO-3
Collector Connected to Case

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. All Limits are applicable and must be observed.

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N5629		100	–	
	2N5630		120	–	
	2N5631		140	–	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N5629		–	5.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N5630		–	5.0	
(V_{CE} = 70 Vdc, I_B = 0)	2N5631		–	5.0	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc)			–	1.0	
(V_{CE} = Rated V_{CB}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			–	5.0	
Collector-Base Cutoff Current		I_{CBO}	–	1.0	mAdc
(V_{CB} = Rated V_{CB}, I_E = 0)					
Emitter-Base Cutoff Current		I_{EBO}	–	1.0	mAdc
(V_{BE} = 7.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)	2N5629		25	100	
	2N5630		20	80	
	2N5631		15	60	
(I_C = 16 Adc, V_{CE} = 2.0 Vdc)	All Types		4.0	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)	All Types		–	1.0	
(I_C = 16 Adc, I_B = 4.0 Adc)			–	2.0	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$	–	1.8	Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)					
Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$	–	1.5	Vdc
(I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product		f_T	1.0	–	MHz
(I_C = 1.0 Adc, V_{CE} = 20 Vdc, f = 0.5 MHz)					
Output Capacitance		C_{ob}	–	500	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)					
Small-Signal Current Gain		h_{fe}	15	–	–
(I_C = 4.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)					

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

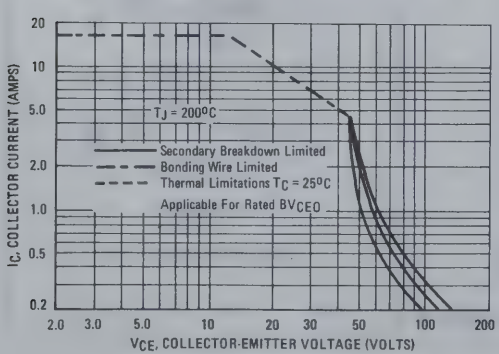


FIGURE 2 – DC SAFE OPERATING AREA

The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

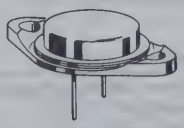
2N5632 (SILICON)
2N5633
2N5634

HIGH-POWER NPN SILICON TRANSISTORS

. . . for use in untuned amplifiers and switching circuit applications.

- High Collector-Emitter Voltage –
  V_{CEO} = 140 Vdc – 2N5634
- High DC Current Gain –
  h_{FE} = 25 (Min) @ I_C = 5.0 Adc – 2N5632
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 7.5 Adc

10 AMPERE
POWER TRANSISTORS
NPN SILICON
100-120-140 VOLTS
150 WATTS



*MAXIMUM RATINGS

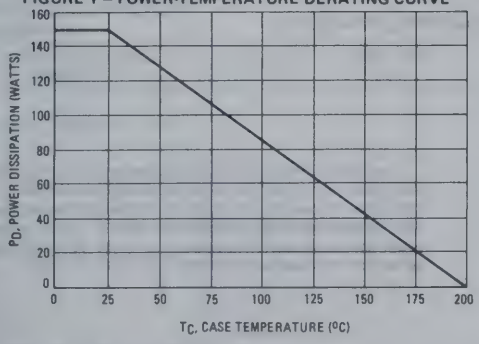
Rating	Symbol	2N5632	2N5633	2N5634	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	140	Vdc
Collector-Base Voltage	V_{CB}	100	120	140	Vdc
Emitter-Base Voltage	V_{EB}	← 7.0 →			Vdc
Collector Current – Continuous – Peak	I_C	← 10 → ← 15 →			Adc
Base Current – Continuous	I_B	← 5.0 →			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 150 → 0.857			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

*THERMAL CHARACTERISTICS

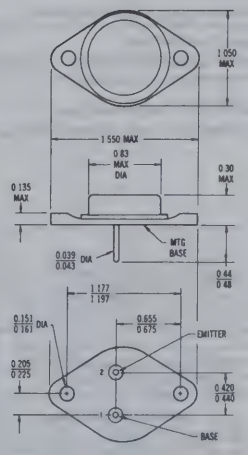
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe area limits are indicated by Figure 2.
Both limits are applicable and must be observed.



CASE 11
TO-3
Collector Connected to Case

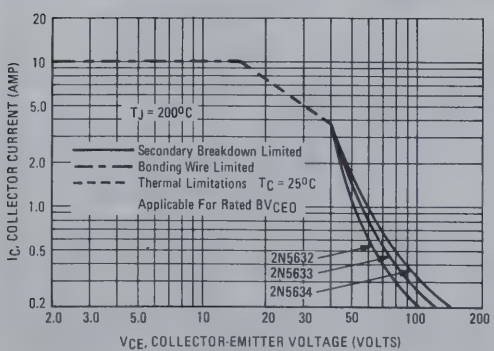
***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N5632		100	–	
	2N5633		120	–	
	2N5634		140	–	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 50 Vdc, I_B = 0)	2N5632		–	5.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N5633		–	5.0	
(V_{CE} = 70 Vdc, I_B = 0)	2N5634		–	5.0	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = Rated V_{CB}, V_{BE} = –1.5 Vdc)			–	1.0	
(V_{CE} = Rated V_{CB}, V_{BE} = –1.5 Vdc, T_C = 150°C)			–	5.0	
Collector Base Cutoff Current		I_{CBO}	–	1.0	mAdc
(V_{CB} = Rated V_{CB}, I_E = 0)					
Emitter-Base Cutoff Current		I_{EBO}	–	1.0	mAdc
(V_{BE} = 7.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N5632		25	100	
	2N5633		20	80	
	2N5634		15	60	
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)	All Types		5.0	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 7.5 Adc, I_B = 0.75 Adc)			–	1.0	
(I_C = 10 Adc, I_B = 2.0 Adc)			–	2.0	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$	–	2.0	Vdc
(I_C = 7.5 Adc, I_B = 0.75 Adc)					
Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$	–	1.5	Vdc
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product		f_T	1.0	–	MHz
(I_C = 1.0 Adc, V_{CE} = 20 Vdc, f = 0.5 MHz)					
Output Capacitance		C_{ob}	–	300	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)					
Small Signal Current Gain		h_{fe}	15	–	–
(V_{CE} = 10 Vdc, I_C = 2.0 Adc, f = 1.0 kHz)					

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

2N5635 (SILICON)
2N5636
2N5637

NPN SILICON RF POWER TRANSISTORS

. . . designed for VHF/UHF amplifier applications. These devices are suitable for use in 28 volt systems to 470 MHz. These transistors are ideal for 225-400 MHz communications equipment.

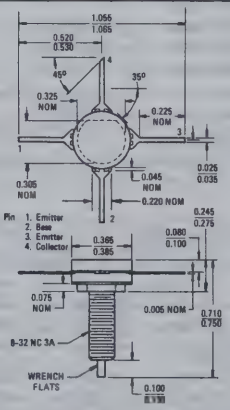
- Balanced Emitter Construction to provide the designer with the device technology that assures ruggedness and resists transistor damage caused by load mismatch.
- Low inductance strip line packaging for easier and better broadband designs.
- Ceramic Package
- Choice of Power Levels at 400 MHz, 28 Vdc —
  2N5635 — 2.5 Watts — 6.2 dB (Min) Gain
  2N5636 — 7.5 Watts — 5.7 dB (Min) Gain
  2N5637 — 20 Watts — 4.6 dB (Min) Gain

NPN SILICON RF POWER TRANSISTORS

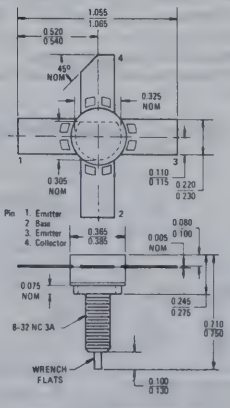


2N5635
2N5636

2N5637



CASE 144B-02
2N5635, 2N5636



2N5637 CASE 145A-01

*MAXIMUM RATINGS

Rating	Symbol	2N5635	2N5636	2N5637	Unit
Collector-Emitter Voltage	V_{CEO}	← 35 →			Vdc
Collector-Base Voltage	V_{CB}	← 60 →			Vdc
Emitter-Base Voltage	V_{EB}	← 4.0 →			Vdc
Collector Current	I_C	1.0	1.5	3.0	Adc
Total Device Dissipation @ $T_A = 25^oC$	P_D	7.5	15	30	Watts
Derate above 25^oC		43	86	171	mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			^oC

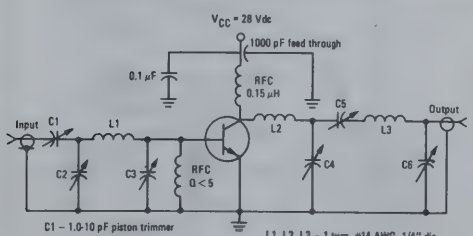
*Indicates JEDEC Registered Data.

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (Note 1)		BV_{CEO}				Vdc
(I_C = 100 mAdc, I_B = 0)	2N5635		35	–	–	
(I_C = 200 mAdc, I_B = 0)	2N5636,2N5637		35	–	–	
Collector-Emitter Breakdown Voltage (Note 1)		BV_{CES}				Vdc
(I_C = 100 mAdc, V_{BE} = 0)	2N5635		60	–	–	
(I_C = 200 mAdc, V_{BE} = 0)	2N5636,2N5637		60	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	2N5635		4.0	–	–	
(I_E = 5.0 mAdc, I_C = 0)	2N5636		4.0	–	–	
(I_E = 10 mAdc, I_C = 0)	2N5637		4.0	–	–	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 30 Vdc, I_E = 0)	2N5635		–	–	0.1	
	2N5636		–	–	1.0	
	2N5637		–	–	1.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	2N5635		5.0	–	–	
(I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	2N5636		5.0	–	–	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	2N5637		5.0	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	2N5635		–	5.0	10	
	2N5636		–	10	20	
	2N5637		–	20	30	
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain		G_{PE}				dB
(P_{out} = 2.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5635		6.2	9.2	–	
(P_{out} = 7.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5636		5.7	7.0	–	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5637		4.6	5.8	–	
Power Output		P_{out}				Watts
(P_{in} = 0.6 Watt, V_{CE} = 28 Vdc, f = 400 MHz)	2N5635		2.5	3.2	–	
(P_{in} = 2.0 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5636		7.5	8.4	–	
(P_{in} = 7.0 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5637		20	22	–	
Collector Efficiency		η				%
(P_{out} = 2.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5635		50	–	–	
(P_{out} = 7.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5636		50	–	–	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	2N5637		60	–	–	

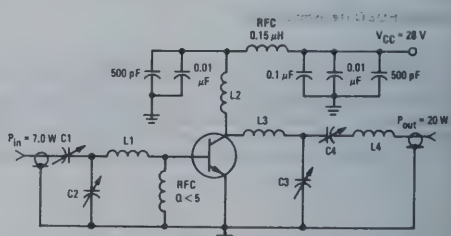
*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.

FIGURE 1 – 400 MHz TEST CIRCUIT (2N5635,2N5636)



C1 – 1.0-10 pF piston trimmer
C2, C3, C4, C5 – 1.0-30 pF piston trimmer
C6 – 1.0-20 pF piston trimmer
L1, L2, L3 – 1 turn, #14 AWG, 1/4" dia.

FIGURE 2 – 400 MHz TEST CIRCUIT (2N5637)



C1 – 1.0-30 pF piston trimmer
C2, C3, C4 – 1.0-10 pF piston trimmer
L1 – 12 nH, #14 straight wire, 3/4" long
L2 – 30 nH, 3 Turns #16 AWG, ¼" O. D., ½" L.
L3 – 40 nH, 1 Turn #16 AWG, 3/8 O. D.
L4 – 10 nH, 1/4" wide, 3/8" long Cu Strap

TYPICAL PERFORMANCE DATA

POWER OUTPUT versus FREQUENCY

FIGURE 3

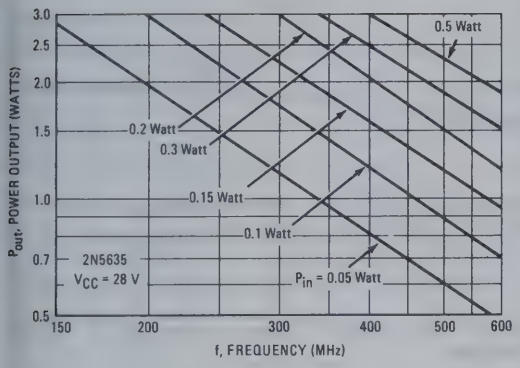


FIGURE 4

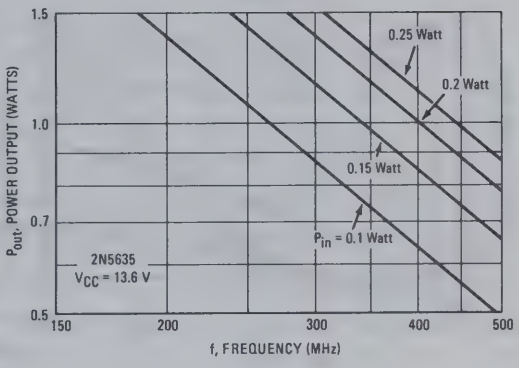


FIGURE 5

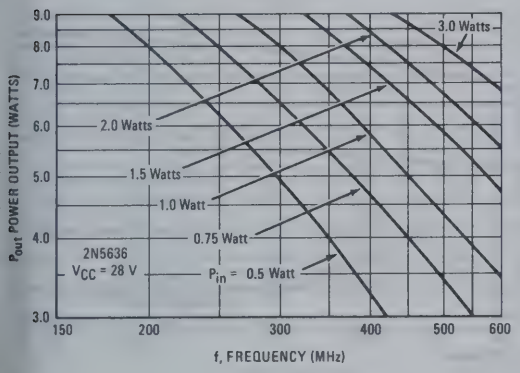


FIGURE 6

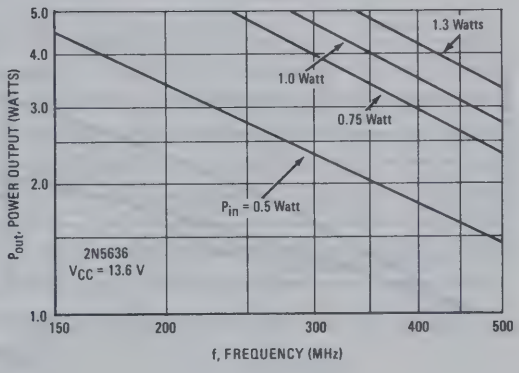


FIGURE 7

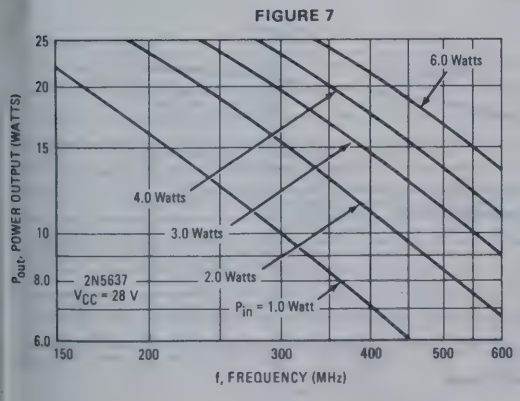
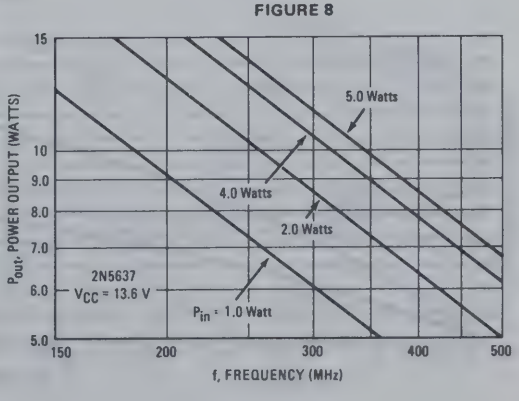


FIGURE 8



TYPICAL PERFORMANCE DATA

POWER OUTPUT versus POWER INPUT

FIGURE 9

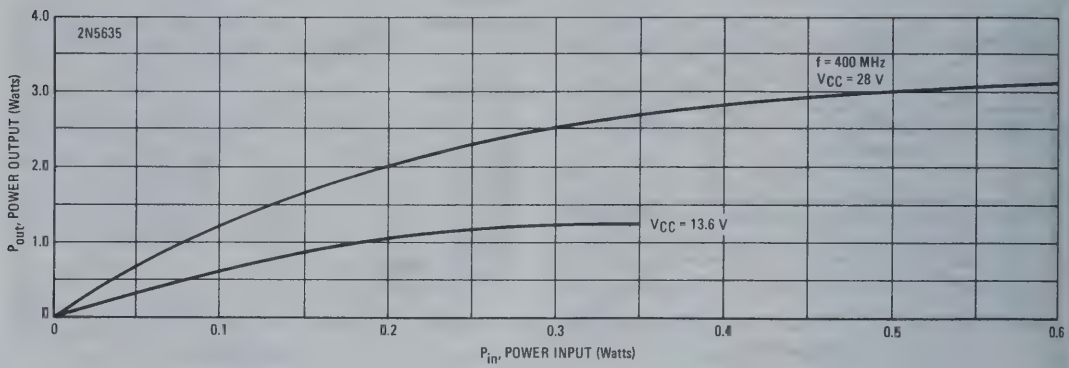


FIGURE 10

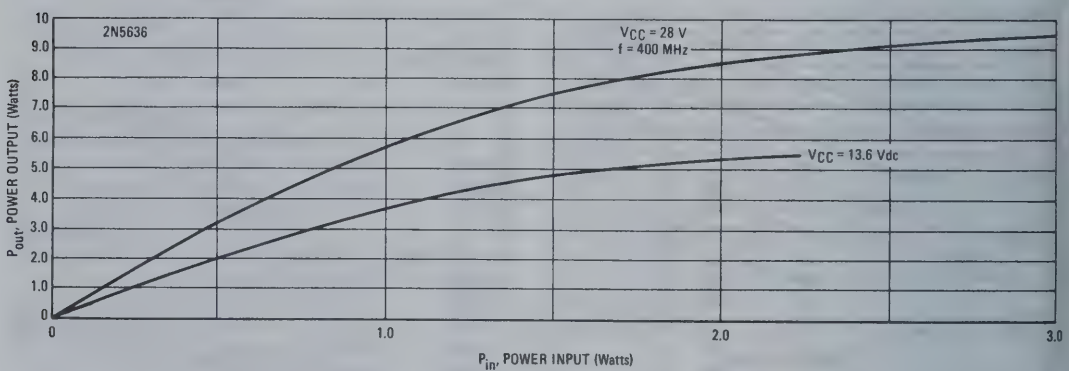
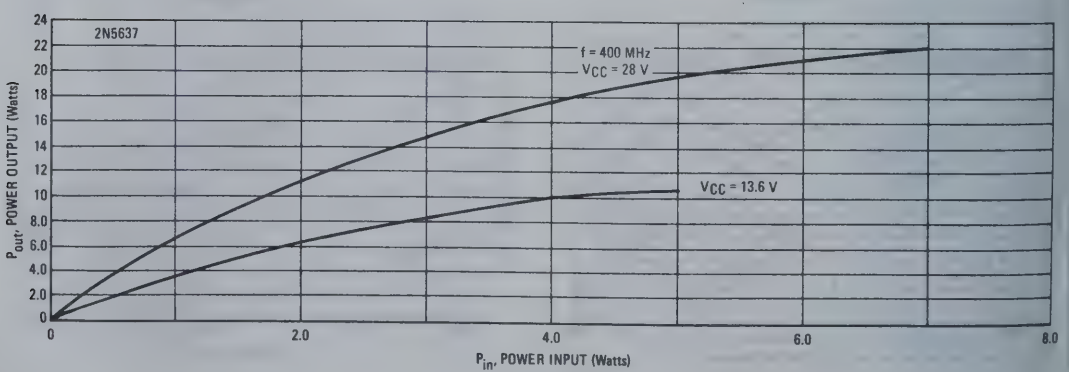


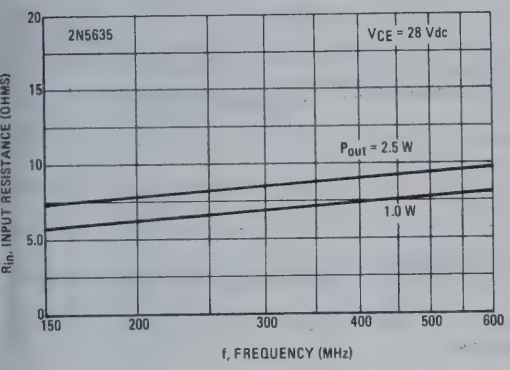
FIGURE 11



CIRCUIT DESIGN DATA

PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 12



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 13

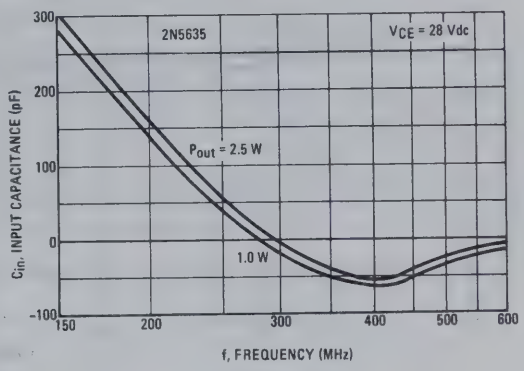


FIGURE 14

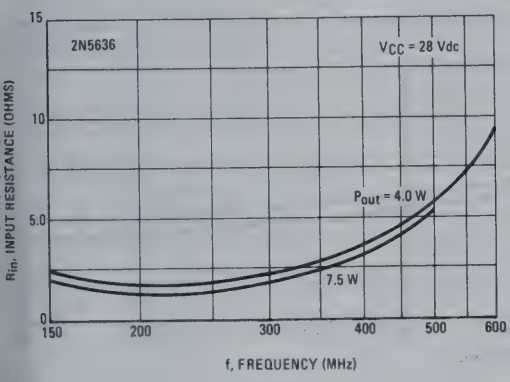


FIGURE 15

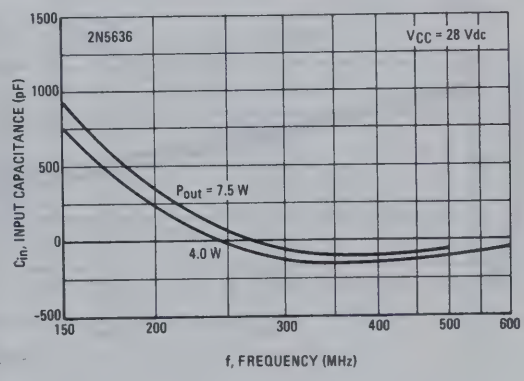


FIGURE 16

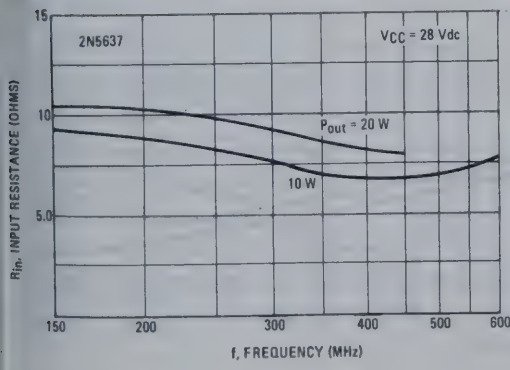
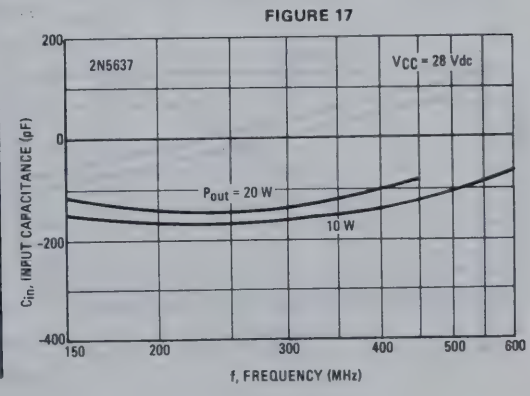


FIGURE 17



CIRCUIT DESIGN DATA

LARGE SIGNAL OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 18

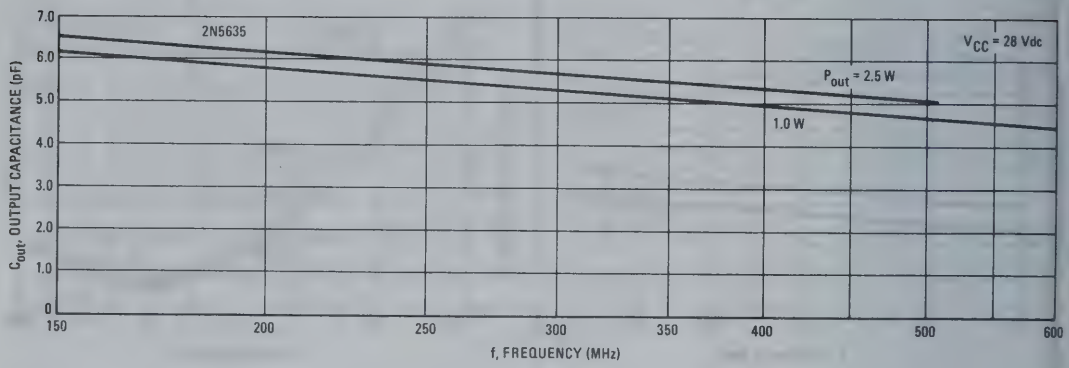


FIGURE 19

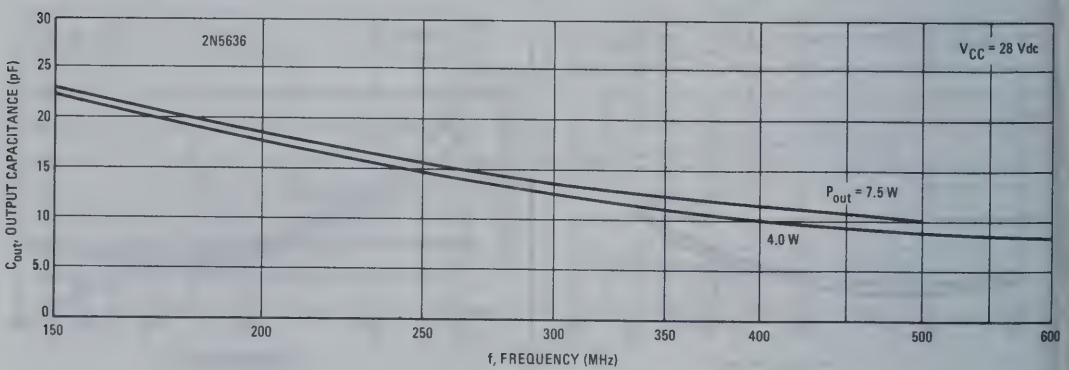
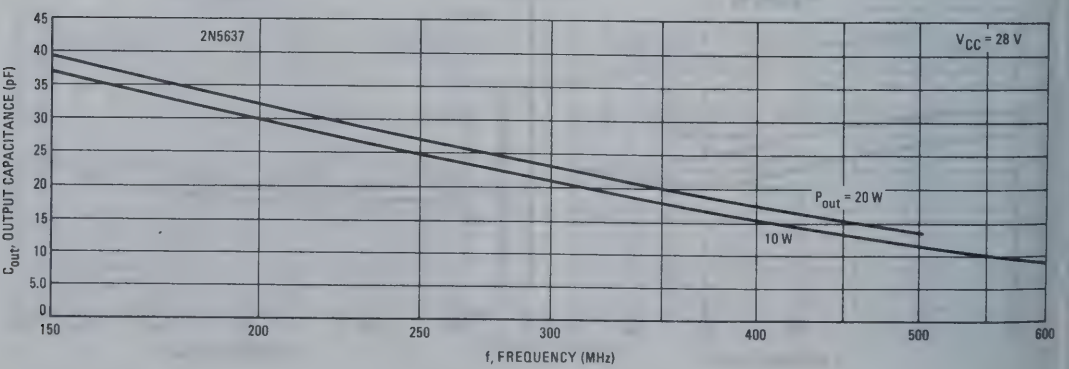
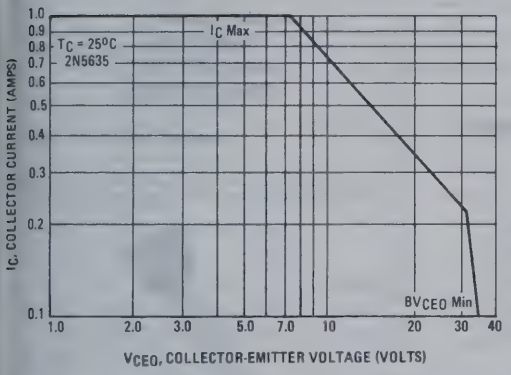


FIGURE 20



DC SAFE OPERATING AREA

FIGURE 21



POWER DISSIPATION DERATING CURVE

FIGURE 22

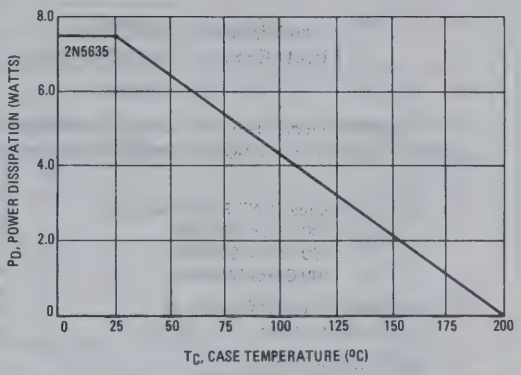


FIGURE 23

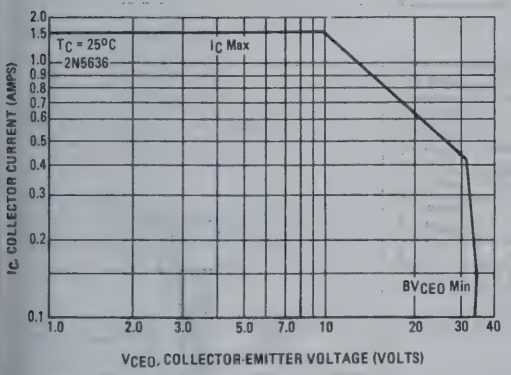


FIGURE 24

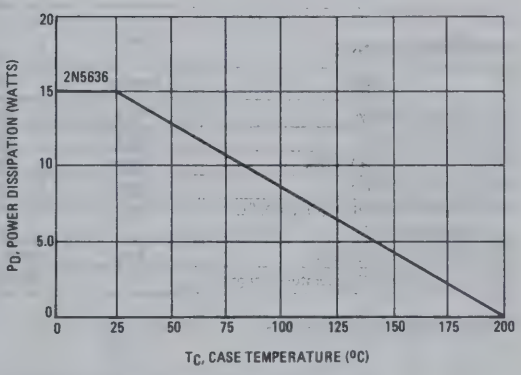


FIGURE 25

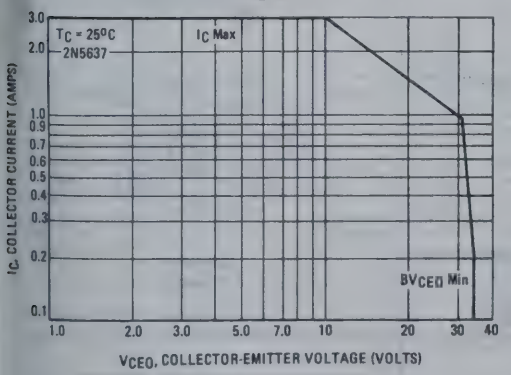
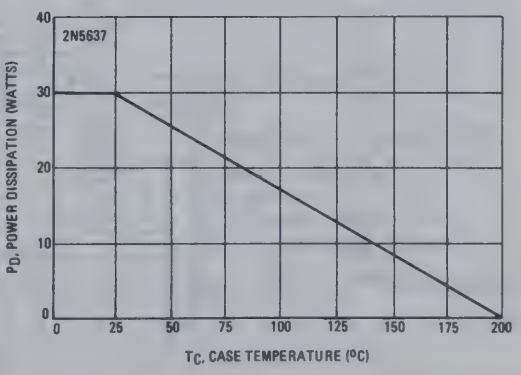


FIGURE 26



2N5638 (SILICON)
2N5639
2N5640

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

. . . depletion mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

- Low Drain-Source "ON" Resistance –
  $r_{ds(on)}$ = 30 Ohms (2N5638)
  60 Ohms (2N5639)
  100 Ohms (2N5640)
- Low Reverse Transfer Capacitance –
  C_{rss} = 4.0 pF (Max) @ f = 1.0 MHz
- Fast Switching Characteristics –
  t_r = 5.0 ns (Max) (2N5638)

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

TYPE A

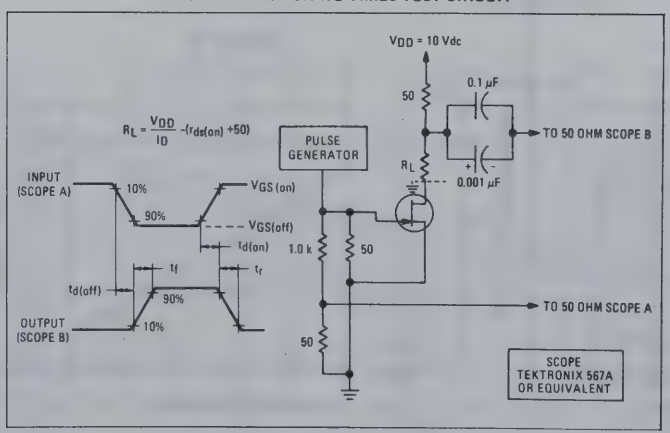


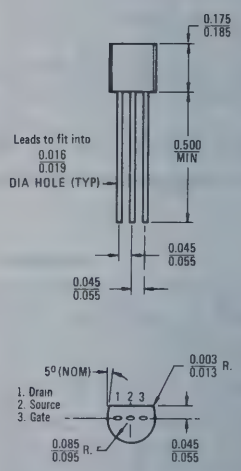
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
*Drain-Gate Voltage	V_{DG}	30	Vdc
*Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
*Forward Gate Current	I_{GF}	10	mAdc
*Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
*Storage Temperature Range	T_{stg}	-65 to +150	°C
Operating Junction Temperature Range	T_J	-65 to +135	°C

*Indicates JEDEC Registered Data.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT





Case 29 (5)
(TO-92)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	–	Vdc
Gate Reverse Current		I_{GSS}			
(V_{GS} = -15 Vdc, V_{DS} = 0)			–	1.0	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 100°C)			–	1.0	μAdc
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = 15 Vdc, V_{GS} = -12 Vdc)	2N5638		–	1.0	nAdc
(V_{DS} = 15 Vdc, V_{GS} = -8.0 Vdc)	2N5639		–	1.0	
(V_{DS} = 15 Vdc, V_{GS} = -6.0 Vdc)	2N5640		–	1.0	
(V_{DS} = 15 Vdc, V_{GS} = -12 Vdc, T_A = 100°C)	2N5638		–	1.0	μAdc
(V_{DS} = 15 Vdc, V_{GS} = -8.0 Vdc, T_A = 100°C)	2N5639		–	1.0	
(V_{DS} = 15 Vdc, V_{GS} = -6.0 Vdc, T_A = 100°C)	2N5640		–	1.0	
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1)		I_{DSS}			mAdc
(V_{DS} = 20 Vdc, V_{GS} = 0)	2N5638		50	–	
	2N5639		25	–	
	2N5640		5.0	–	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 12 mAdc, V_{GS} = 0)	2N5638		–	0.5	
(I_D = 6.0 mAdc, V_{GS} = 0)	2N5639		–	0.5	
(I_D = 3.0 mAdc, V_{GS} = 0)	2N5640		–	0.5	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$			Ohms
(I_D = 1.0 mAdc, V_{GS} = 0)	2N5638		–	30	
	2N5639		–	60	
	2N5640		–	100	
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N5638		–	30	
	2N5639		–	60	
	2N5640		–	100	
Input Capacitance (V_{DS} = 0, V_{GS} = -12 Vdc, f = 1.0 MHz)		C_{iss}	–	10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = -12 Vdc, f = 1.0 MHz)		C_{rss}	–	4.0	pF
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Delay Time	$I_{D(on)}$ = 12 mAdc 2N5638	$t_{d(on)}$	–	4.0	ns
	6.0 mAdc 2N5639		–	6.0	
	3.0 mAdc 2N5640		–	8.0	
Rise Time	$I_{D(on)}$ = 12 mAdc 2N5638	t_r	–	5.0	ns
	6.0 mAdc 2N5639		–	8.0	
	3.0 mAdc 2N5640		–	10	
Turn-Off Delay Time	$I_{D(on)}$ = 12 mAdc 2N5638	$t_{d(off)}$	–	5.0	ns
	6.0 mAdc 2N5639		–	10	
	3.0 mAdc 2N5640		–	15	
Fall Time	$I_{D(on)}$ = 12 mAdc 2N5638	t_f	–	10	ns
	6.0 mAdc 2N5639		–	20	
	3.0 mAdc 2N5640		–	30	

(V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = -10 Vdc, R_G = 50 ohms)

*Indicates JEDEC Registered Data.

Note 1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

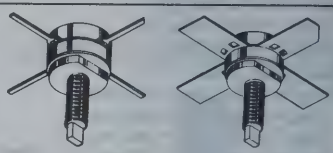
2N5641 (SILICON)
2N5642
2N5643

NPN SILICON RF POWER TRANSISTORS

. . . designed for VHF power amplifier or oscillator applications in military and industrial equipment. These devices are particularly suited for use in Class AB, B, or C amplifier applications to 400 MHz.

- Balanced Emitter Construction to provide the designer with the device technology that assures ruggedness and resists transistor damage caused by load mismatch.
- Stripline packaging for lower lead inductance and better broadband capability.
- Ceramic Packaging
- Specified 28 Volt, 175 MHz Characteristics –
  2N5641 – 7.0 Watts Output Power at 8.4 dB Gain
  2N5642 – 20 Watts Output Power at 8.2 dB Gain
  2N5643 – 40 Watts Output Power at 7.6 dB Gain

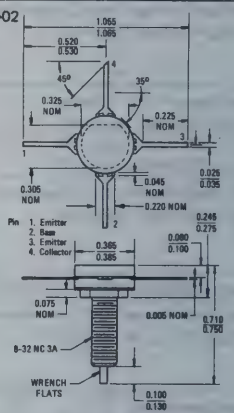
NPN SILICON RF POWER TRANSISTORS



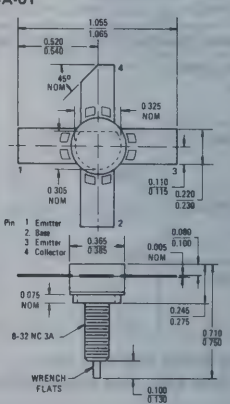
CASE 144B–02
2N5641

CASE 145A-01
2N5642
2N5643

CASE 144B-02
2N5641



CASE 145A-01
2N5642,
2N5643



***MAXIMUM RATINGS**

Rating	Symbol	2N5641	2N5642	2N5643	Unit
Collector-Emitter Voltage	V_{CEO}	← 35 →			Vdc
Collector-Base Voltage	V_{CB}	← 65 →			Vdc
Emitter-Base Voltage	V_{EB}	← 4.0 →			Vdc
Collector Current – Continuous	I_C	1.0	3.0	5.0	Adc
Total Device Dissipation @ $T_A = 25^oC$	P_D	15	30	60	Watts
Derate above 25^oC		86	171	342	mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			^oC

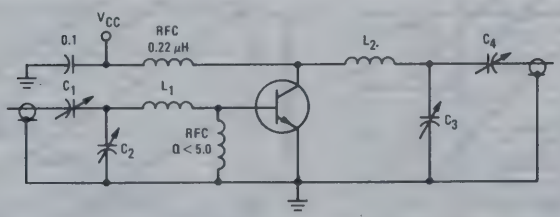
*Indicates JEDEC Registered Data.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)		BV_{CEO}	35	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)		BV_{CES}	65	–	–	Vdc
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 5.0 mAdc, I_C = 0)	2N5641		4.0	–	–	
(I_E = 10 mAdc, I_C = 0)	2N5642,2N5643		4.0	–	–	
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	2N5641		5.0	–	–	
(I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	2N5642		5.0	–	–	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	2N5643		5.0	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	2N5641		–	8.5	15	
	2N5642		–	22	35	
	2N5643		–	45	65	
FUNCTIONAL TEST						
Power Input (Figure 1)		P_{in}				Watts
(P_{out} = 7.0 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5641		–	0.4	1.0	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5642		–	1.9	3.0	
(P_{out} = 40 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5643		–	5.0	7.0	
Common-Emitter Amplifier Power Gain (Figure 1)		G_{PE}				dB
(P_{out} = 7.0 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5641		8.4	12.5	–	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5642		8.2	10.2	–	
(P_{out} = 40 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5643		7.6	8.1		
Collector Efficiency (Figure 1)		η				%
(P_{out} = 7.0 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5641		60	–	–	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5642		60	–	–	
(P_{out} = 40 Watts, V_{CE} = 28 Vdc, f = 175 MHz)	2N5643		60	–	–	

Note 1: Pulsed through 25 mH inductor.
*Indicates JEDEC Registered Data.

FIGURE 1 – 175 MHz TEST CIRCUIT



2N5641	2N5642	2N5643
C_1, C_3, C_4 – 5.0 – 80 pF	C_1 – 3.0 – 30 pF	C_1, C_2, C_3, C_4 – ARCO 464 25-280 pF
C_2 – 9.0 – 180 pF	C_2, C_3, C_4 – 9.0 – 180 pF	L_1 – 1" Straight #14 AWG
L_1 – 1¼" Straight #14 AWG	L_1 – 1" Straight #14 AWG	L_2 – 1 Turn #16 AWG, ¼" I.D.
L_2 – 3 Turns #16 AWG, 14" I.D.	L_2 – 1 Turn #16 AWG, ¼" I.D.	

TYPICAL PERFORMANCE DATA

POWER OUTPUT versus FREQUENCY

FIGURE 2

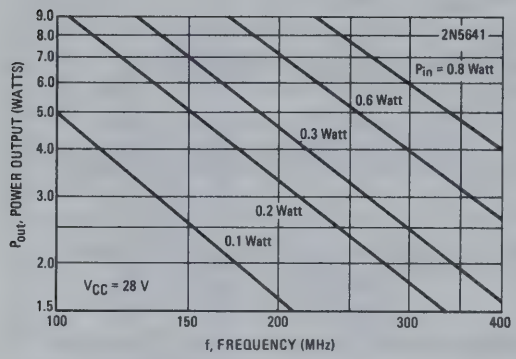


FIGURE 3

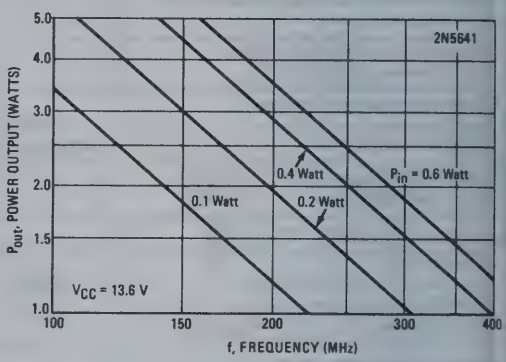


FIGURE 4

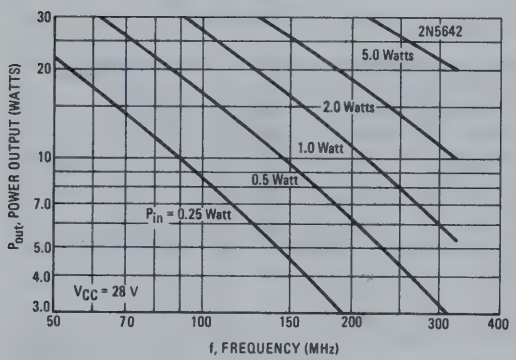


FIGURE 5

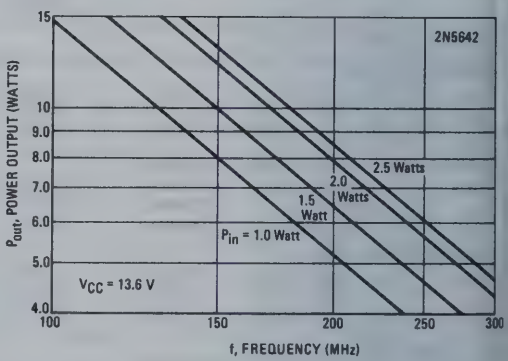


FIGURE 6

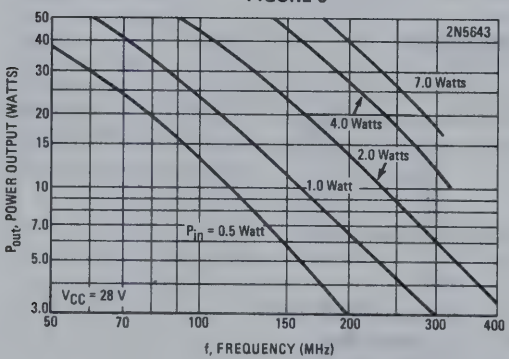
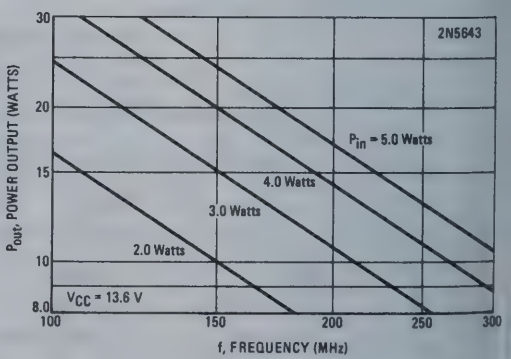


FIGURE 7



TYPICAL PERFORMANCE DATA
POWER OUTPUT versus POWER INPUT

FIGURE 8

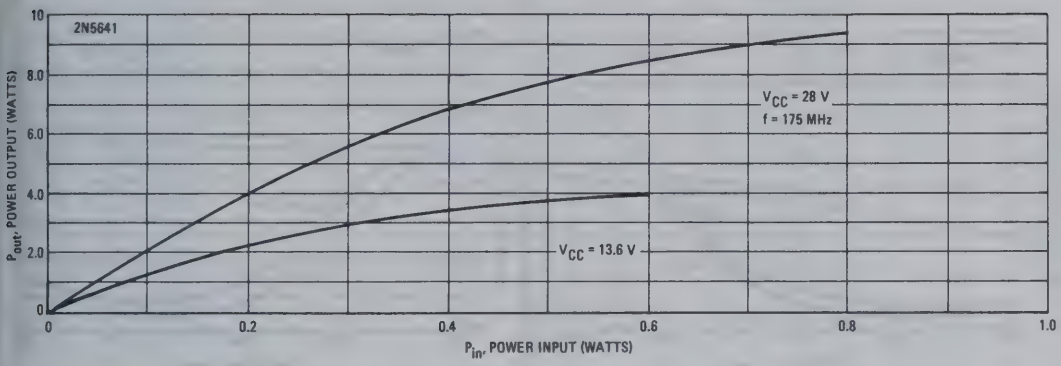


FIGURE 9

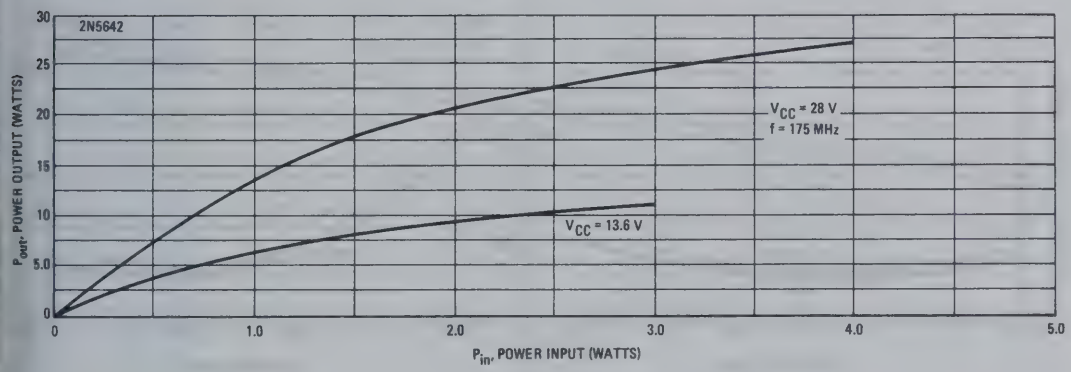
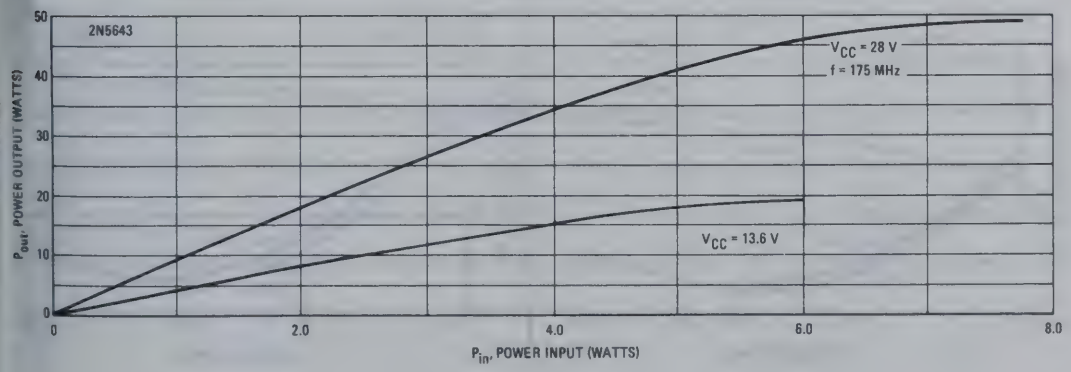


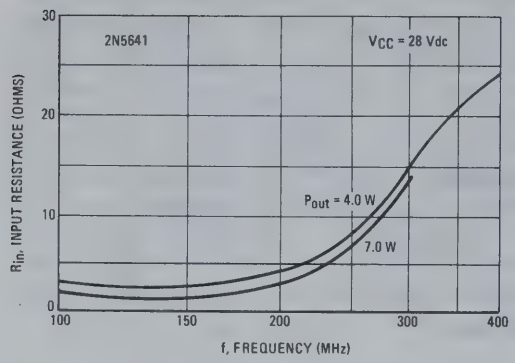
FIGURE 10



CIRCUIT DESIGN DATA

PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 11



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 12

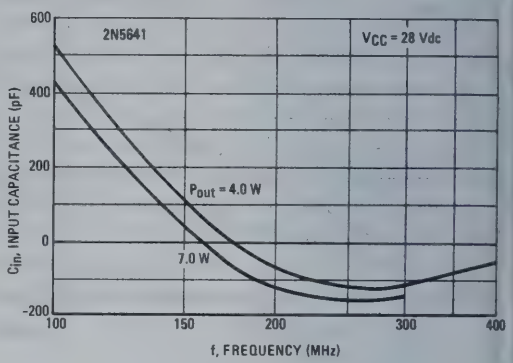


FIGURE 13

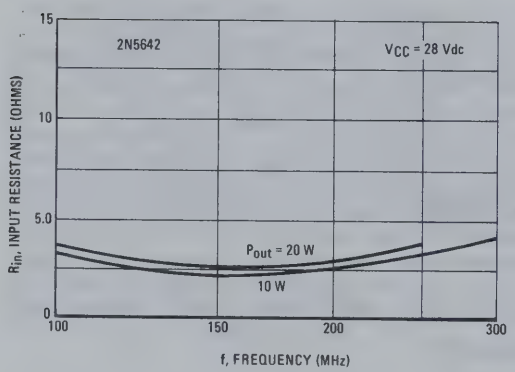


FIGURE 14

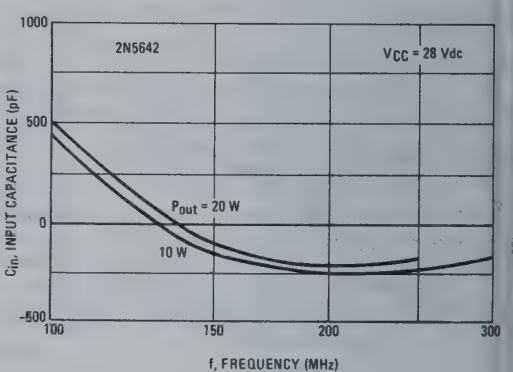


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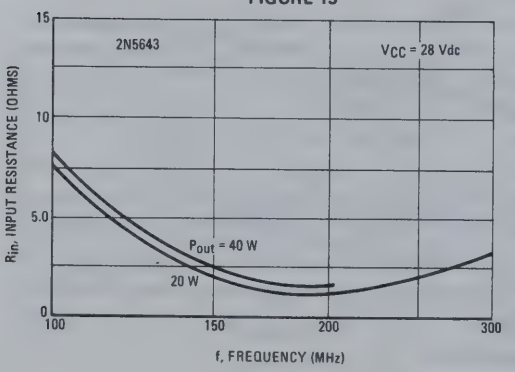
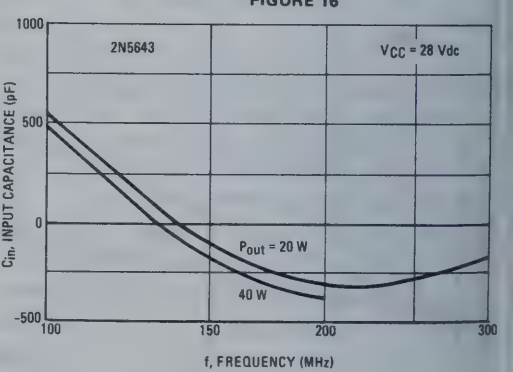


FIGURE 16



CIRCUIT DESIGN DATA

LARGE SIGNAL OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 17

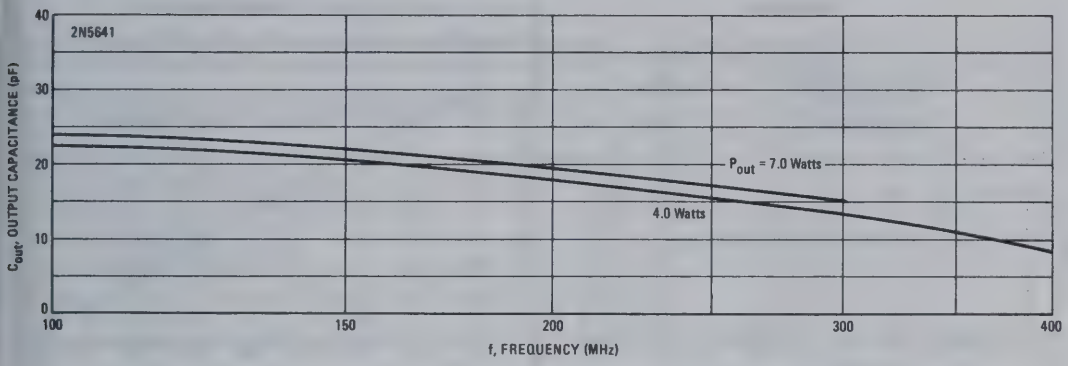


FIGURE 18

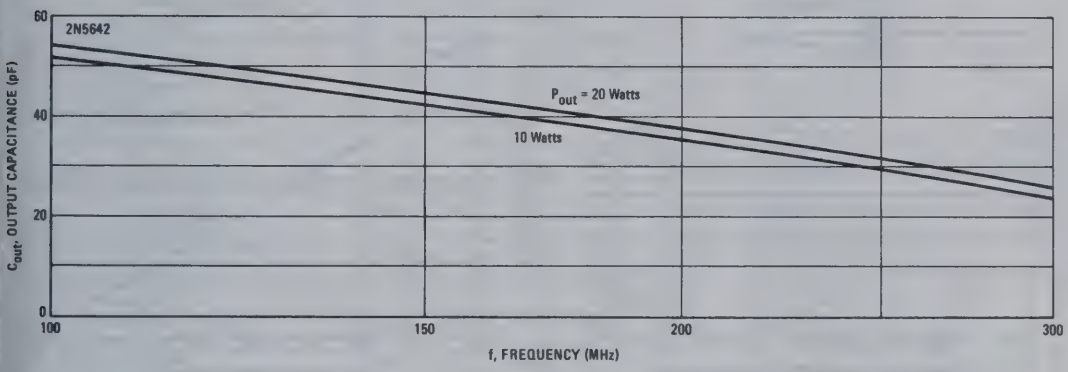
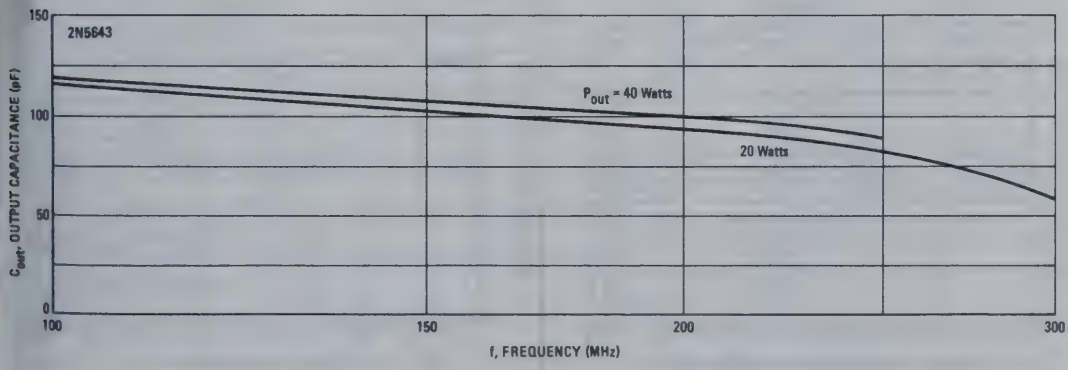


FIGURE 19



DC SAFE OPERATING AREA

FIGURE 20

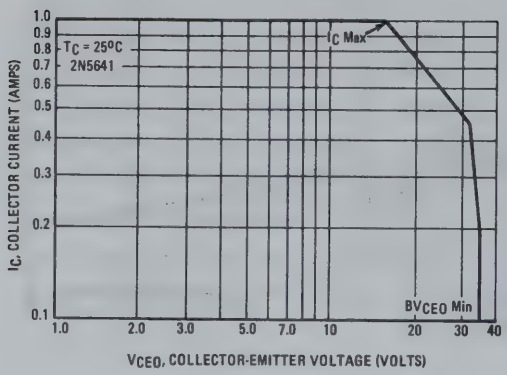


FIGURE 22

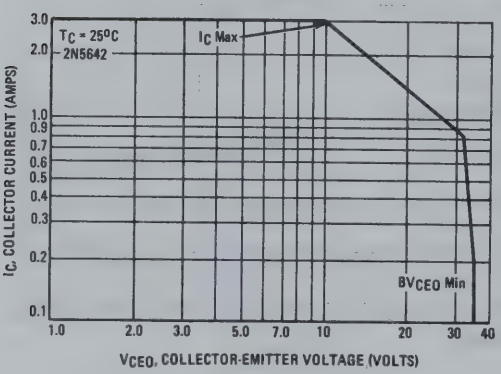
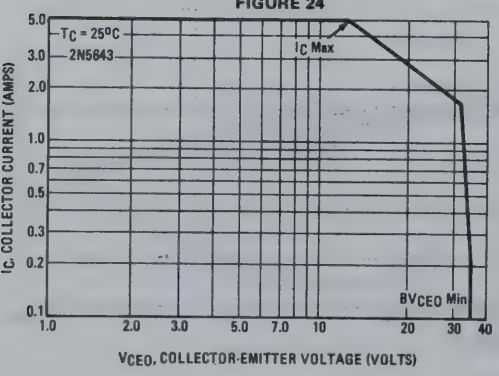


FIGURE 24



POWER DISSIPATION DERATING CURVE

FIGURE 21

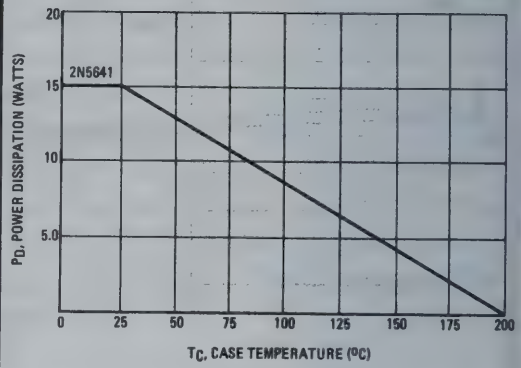


FIGURE 23

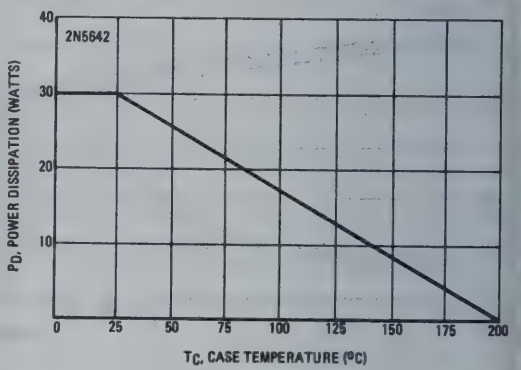
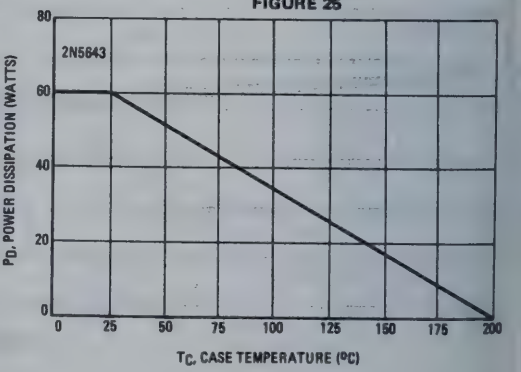


FIGURE 25



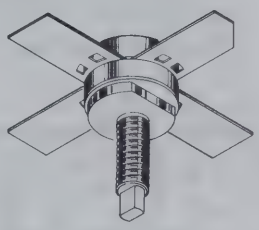
2N5644 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt, UHF large signal amplifier applications required in industrial and consumer FM equipment operating to 520 MHz.

- Low lead inductance stripline package for ease of design and increased broadband capability
- Balanced Emitter Construction to protect against device damage due to load mismatch
- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 1.0 Watt
  Minimum Gain = 7.0 dB
  Efficiency = 60%

NPN SILICON RF POWER TRANSISTOR



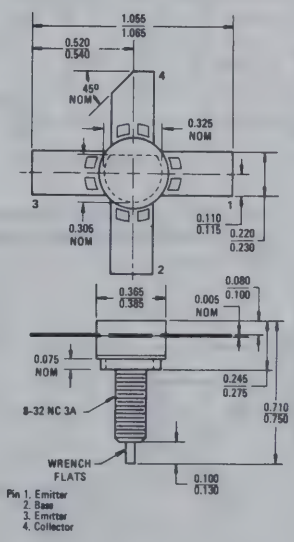
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	0.25	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	3.5 0.02	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, $T_A = 125^oC$)	I_{CES}	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.1	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (Note 2) (I_C = 50 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 1.0 W, V_{CC} = 12.5 Vdc, I_C = 0.133 Adc, f = 470 MHz)	G_{PE}	7.0	–	dB
Collector Efficiency (P_{out} = 1.0 W, V_{CC} = 12.5 Vdc, I_C = 0.133 Adc, f = 470 MHz)	η	60	–	%

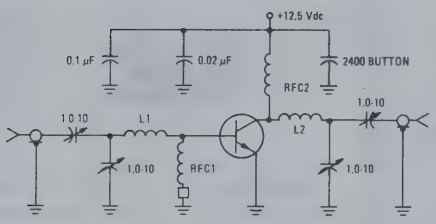
*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.
Note 2: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.



CASE 145A-01

DESIGN DATA

FIGURE 1 – 470 MHz TEST CIRCUIT



L1 = COPPER STRAP 1" Long, 5/32" Wide

L2 = 1 Turn #16 AWG WIRE, 3/32" I.D., Total Length of Coil and Leads = 13/16"

RFC 1 = 0.15 μH MOLDED CHOKE with Ferrite Bead on Ground Lead.

RFC 2 = 8 Turns #20 WIRE, 7/32" I.D., 3/8" Long

All Capacitance Values in pF Except As Noted.

FIGURE 2 – POWER OUTPUT versus POWER INPUT

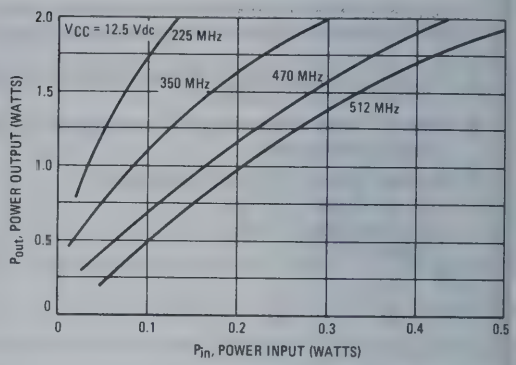


FIGURE 3 – POWER OUTPUT versus FREQUENCY

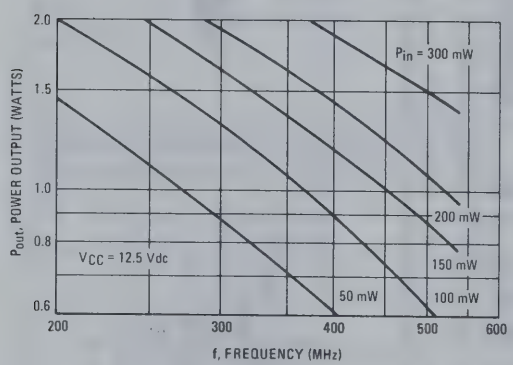


FIGURE 4 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

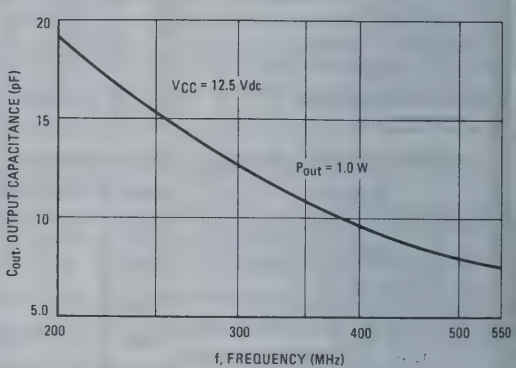


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

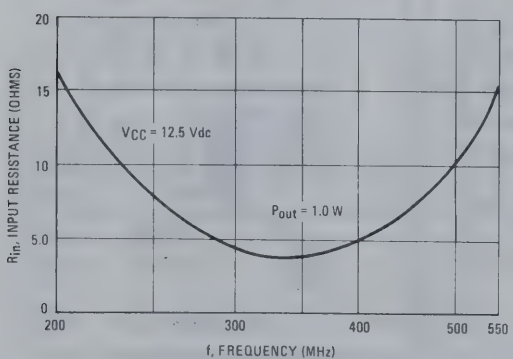
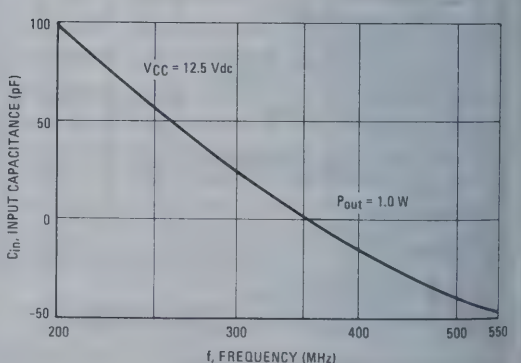


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



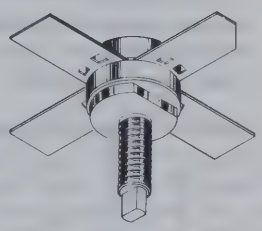
2N5645 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt, UHF large signal amplifier applications required in industrial and consumer FM equipment operating to 520 MHz.

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- Balanced Emitter Construction to protect against device damage due to load mismatch
- Specified 12.5 Volt, 470 MHz Characteristics —
  Output Power = 4.0 Watt
  Minimum Gain = 6.0 dB
  Efficiency = 60%

NPN SILICON RF POWER TRANSISTOR



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	12 0.068	Watts W/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

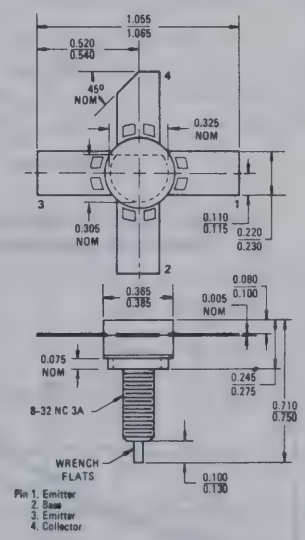
*** ELECTRICAL CHARACTERISTICS** ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, $T_A = 125^oC$)	I_{CES}	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.5	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (Note 2) (I_C = 100 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	20	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, I_C = 0.53 Adc, f = 470 MHz)	G_{PE}	6.0	–	dB
Collector Efficiency (P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, I_C = 0.53 Adc, f = 470 MHz)	η	60	–	%

*Indicates JEDEC Registered Data.

Note 1: Pulsed through 25 mH inductor.

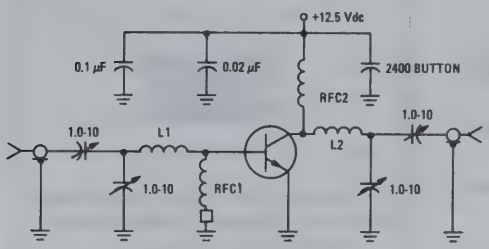
Note 2: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.



CASE 145A-01

DESIGN DATA

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L2 = 1 Turn #16 AWG WIRE, 3/32" I.D., Total Length of Coil and Leads = 13/16"

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RFC 2 = 8 Turns #20 WIRE, 7/32" I.D., 3/8" Long

All Capacitance Values in pF Except As Noted.

FIGURE 2 – POWER OUTPUT versus POWER INPUT

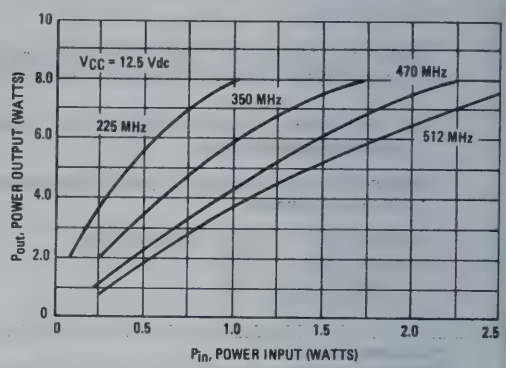


FIGURE 3 – POWER OUTPUT versus FREQUENCY

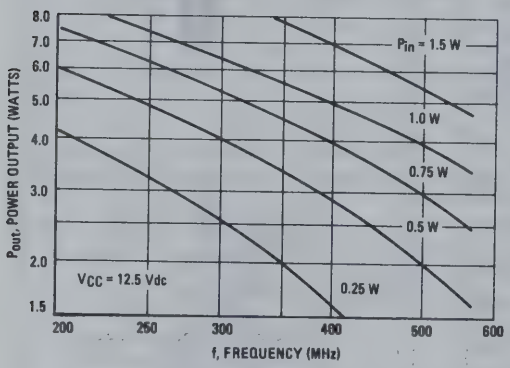


FIGURE 4 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

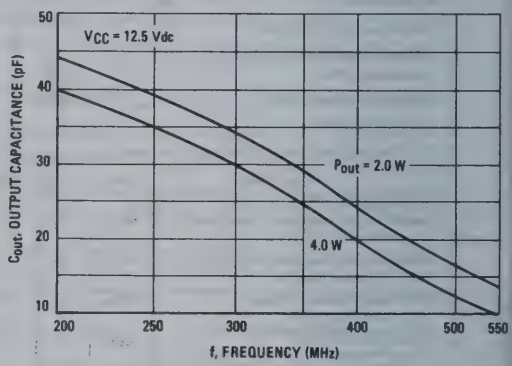


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

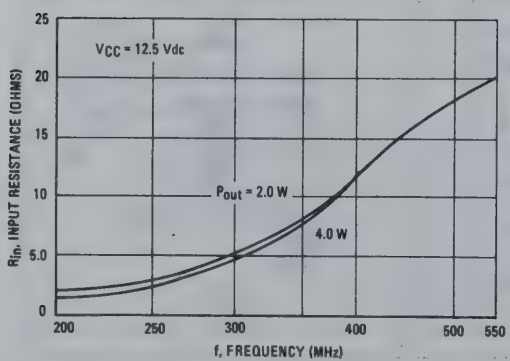
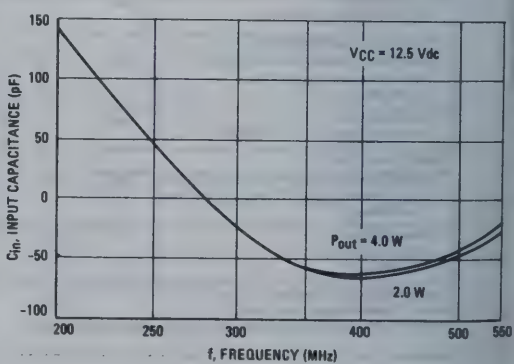


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



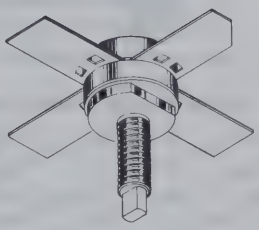
2N5646 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt, UHF large signal amplifier applications required in industrial and consumer FM equipment operating to 520 MHz.

- Low lead inductance stripline package for ease of design and increased broadband capability
- Balanced Emitter Construction to protect against device damage due to load mismatch
- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 12 Watt
  Minimum Gain = 4.7 dB
  Efficiency = 60%

NPN SILICON RF POWER TRANSISTOR

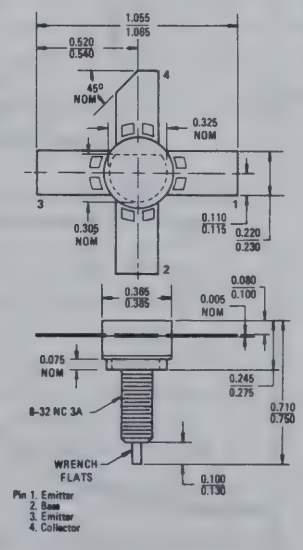


*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	2.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	30 0.171	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, $T_A = 125^oC$)	I_{CES}	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (Note 2) (I_C = 250 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	40	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 12 W, V_{CC} = 12.5 Vdc, I_C = 1.6 Adc, f = 470 MHz)	G_{PE}	4.7	–	dB
Collector Efficiency (P_{out} = 12 W, V_{CC} = 12.5 Vdc, I_C = 1.6 Adc, f = 470 MHz)	η	60	–	%



CASE 145A-01

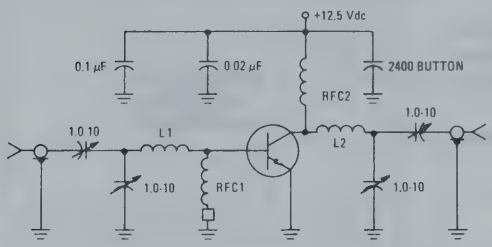
*Indicates JEDEC Registered Data.

Note 1: Pulsed through 25 mH inductor.

Note 2: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

DESIGN DATA

FIGURE 1 – 470 MHz TEST CIRCUIT



L1 = COPPER STRAP 1" Long, 5/32" Wide

L2 = 1 Turn #16 AWG WIRE, 3/32" I.D., Total Length of Coil and Leads = 13/16"

RFC 1 = 0.15 μH MOLDED CHOKE with Ferrite Bead on Ground Lead.

RFC 2 = 8 Turns #20 WIRE, 7/32" I.D., 3/8" Long

All Capacitance Values in pF Except As Noted.

FIGURE 2 – POWER OUTPUT versus POWER INPUT

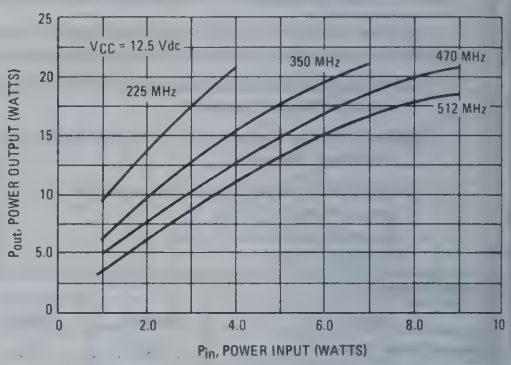


FIGURE 3 – POWER OUTPUT versus FREQUENCY

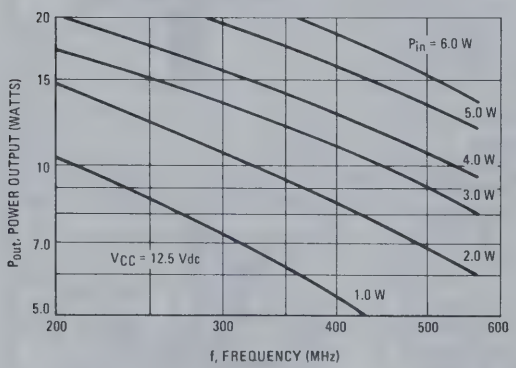


FIGURE 4 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

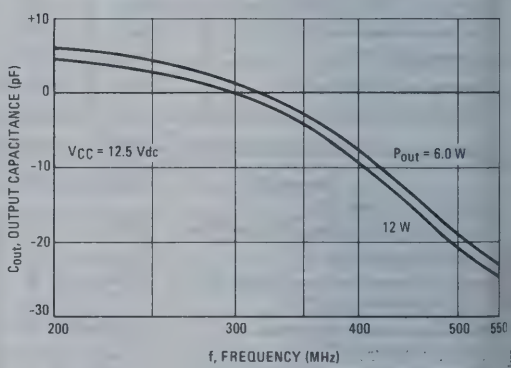


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

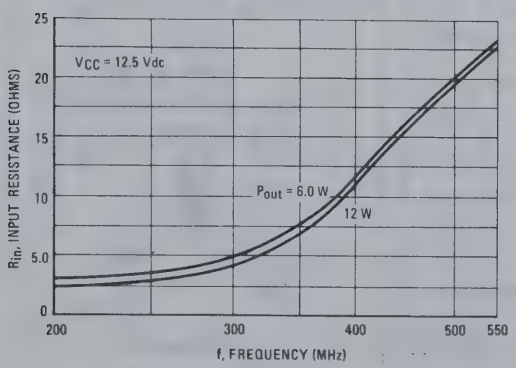
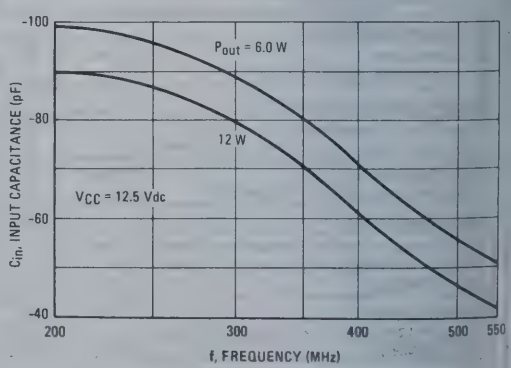


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



2N5653 (SILICON)
2N5654

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for low-power, chopper and switching applications.

- Fast Switching Times — 2N5653
  $t_{d(on)}$ = 4.0 ns (Max)
  t_r = 5.0 ns (Max)
  $t_{d(off)}$ = 5.0 ns (Max)
  t_f = 10 ns (Max)
- Low Drain-Source "ON" Resistance —
  $r_{ds(on)}$ = 50 Ohms (Max) @ I_D = 1.0 mAdc - 2N5653
- Low Reverse Transfer Capacitance —
  C_{rss} = 3.5 pF (Max) @ V_{GS} = -12 Vdc

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

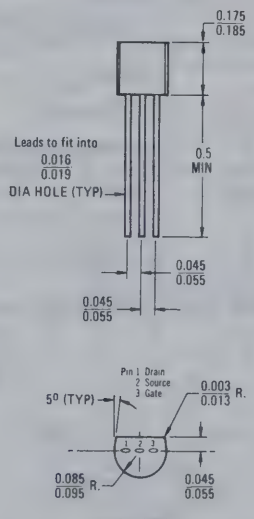
(Type A)



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*Indicates JEDEC Registered Data.



CASE 29 (5)
TO-92

Drain and Source may be interchanged.

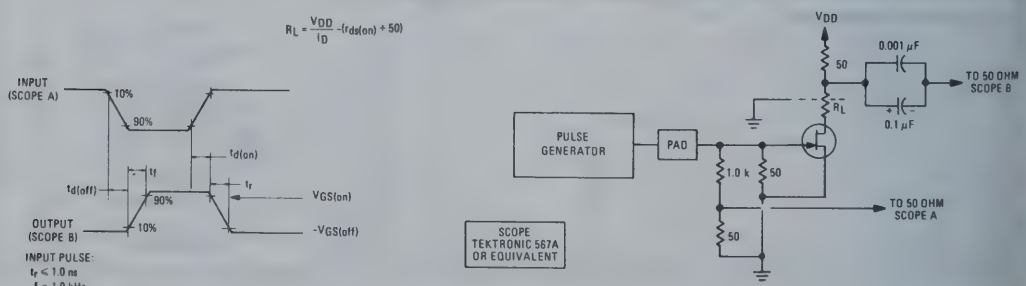
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	–	Vdc
Gate Reverse Current		I_{GSS}			
(V_{GS} = -15 Vdc, V_{DS} = 0)			–	1.0	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 100°C)			–	1.0	μAdc
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = 15 Vdc, V_{GS} = -12 Vdc)	2N5653		–	1.0	nAdc
(V_{DS} = 15 Vdc, V_{GS} = -8.0 Vdc)	2N5654		–	1.0	
(V_{DS} = 15 Vdc, V_{GS} = -12 Vdc, T_A = 100°C)	2N5653		–	1.0	μAdc
(V_{DS} = 15 Vdc, V_{GS} = -8.0 Vdc, T_A = 100°C)	2N5654		–	1.0	
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1)		I_{DSS}			mAdc
(V_{DS} = 20 Vdc, V_{GS} = 0)	2N5653		40	–	
	2N5654		15	–	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 10 mAdc, V_{GS} = 0)	2N5653		–	0.75	
(I_D = 5.0 mAdc, V_{GS} = 0)	2N5654		–	0.75	
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 1.0 mAdc)	2N5653		–	50	
	2N5654		–	100	
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N5653		–	50	
	2N5654		–	100	
Input Capacitance (V_{DS} = 0, V_{GS} = -12 Vdc, f = 1.0 MHz)		C_{iss}	–	10	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = -12 Vdc, f = 1.0 MHz)		C_{rss}	–	3.5	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay Time	Test Condition for 2N5653:				
	(V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0,	2N5653	$t_{d(on)}$	–	4.0	ns
	$V_{GS(off)}$ = -12 Vdc,	2N5654		–	6.0	
Rise Time	$I_{D(on)}$ = 10 mAdc,	2N5653	t_r	–	5.0	ns
	R_G' = 50 Ohms)	2N5654		–	8.0	
Turn-Off Delay Time	Test Condition for 2N5654:				
	(V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0,	2N5653	$t_{d(off)}$	–	5.0	ns
	$V_{GS(off)}$ = -12 Vdc,	2N5654		–	10	
Fall Time	$I_{D(on)}$ = 5.0 mAdc,	2N5653	t_f	–	10	ns
	R_G' = 50 Ohms)	2N5654		–	20	
	(Figure 1)				

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



2N5655 (SILICON)
2N5656
2N5657

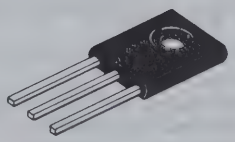
PLASTIC NPN SILICON HIGH-VOLTAGE POWER TRANSISTORS

. . . designed for use in line-operated equipment such as audio output amplifiers; low-current, high-voltage converters; and AC line relays.

- Excellent DC Current Gain — h_{FE} = 30-250 @ I_C = 50 mAdc
- Current-Gain—Bandwidth Product — f_T = 10 MHz (Min) @ I_C = 100 mAdc
- Packaged in Thermopad Case for Low Cost

0.5 AMPERE POWER TRANSISTORS
NPN SILICON

250-300-350 VOLTS
20 WATTS



*MAXIMUM RATINGS

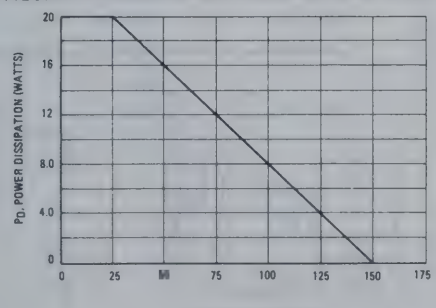
Rating	Symbol	2N5655	2N5656	2N5657	Unit
Collector-Emitter Voltage	V_{CEO}	250	300	350	Vdc
Collector-Base Voltage	V_{CB}	275	325	375	Vdc
Emitter-Base Voltage	V_{EB}	6.0			Vdc
Collector Current — Continuous Peak	I_C	0.5 1.0			Adc
Base Current	I_B	0.25			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	20 0.16			Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +150			°C

*THERMAL CHARACTERISTICS

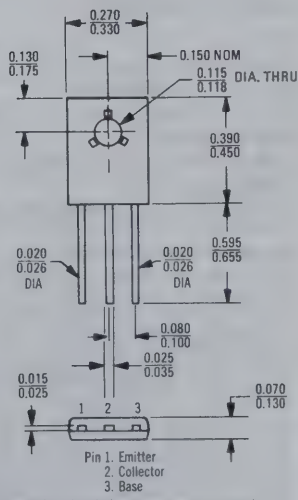
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.25	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 2. Both limits are applicable and must be observed.



Pin 1. Emitter
2. Collector
3. Base

When mounting the device, torque not to exceed 6.0 in.-lb

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

CASE 77-02

2N5655, 2N5656, 2N5657 (continued)

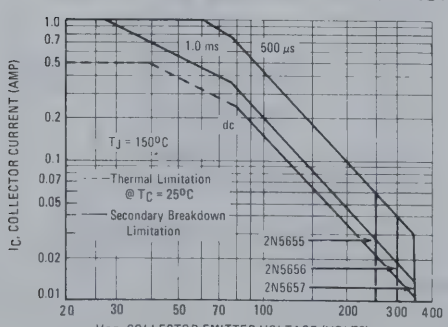
***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc (inductive), L = 50 mH)	2N5655		250	–	
	2N5656		300	–	
	2N5657		350	–	
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 1.0 mAdc, I_B = 0)	2N5655		250	–	
	2N5656		300	–	
	2N5657		350	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 150 Vdc, I_B = 0)	2N5655		–	0.1	
(V_{CE} = 200 Vdc, I_B = 0)	2N5656		–	0.1	
(V_{CE} = 250 Vdc, I_B = 0)	2N5657		–	0.1	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 250 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5655		–	0.1	
(V_{CE} = 300 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5656		–	0.1	
(V_{CE} = 350 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5657		–	0.1	
(V_{CE} = 150 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N5655		–	1.0	
(V_{CE} = 200 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N5656		–	1.0	
(V_{CE} = 250 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N5657		–	1.0	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 275 Vdc, I_E = 0)	2N5655		–	10	
(V_{CB} = 325 Vdc, I_E = 0)	2N5656		–	10	
(V_{CB} = 375 Vdc, I_E = 0)	2N5657		–	10	
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)		I_{EBO}	–	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 10 Vdc)			30	250	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)			25	–	
(I_C = 250 mAdc, V_{CE} = 10 Vdc)			15	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			–	1.0	
(I_C = 250 mAdc, I_B = 25 mAdc)			–	2.5	
Base-Emitter Voltage (Note 1) (I_C = 100 mAdc, V_{CE} = 10 Vdc)		V_{BE}	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	10	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	25	pF
Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	–	–

*Indicates JEDEC Registered Data.

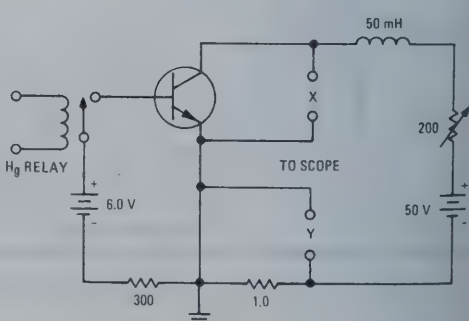
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – SUSTAINING VOLTAGE TEST CIRCUIT



LARGE SIGNAL CHARACTERISTICS

FIGURE 4 – TRANSCONDUCTANCE

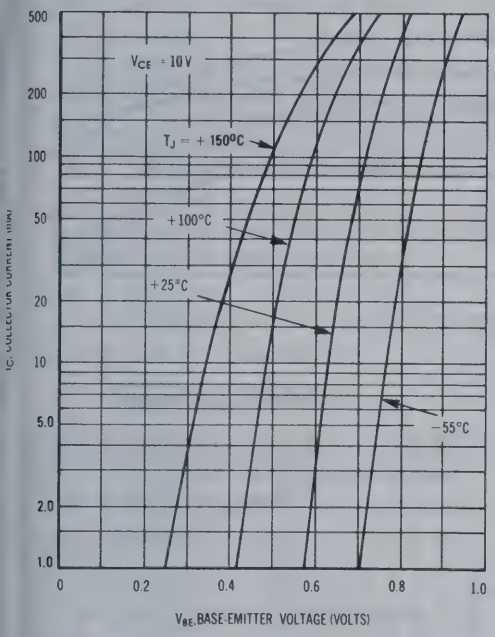
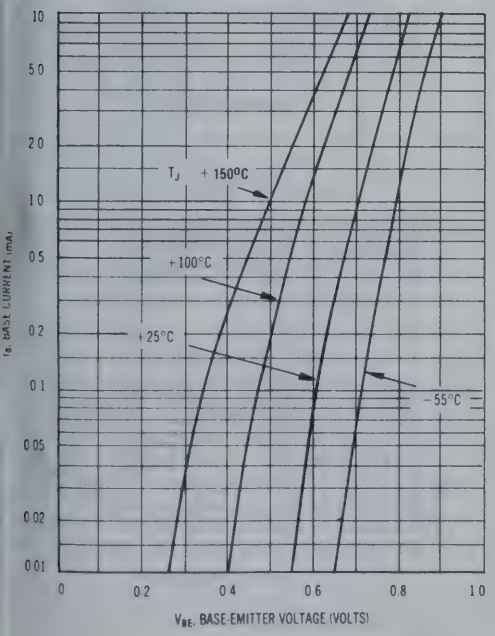


FIGURE 6 – INPUT ADMITTANCE



CUT-OFF CHARACTERISTICS

FIGURE 5 – TRANSCONDUCTANCE

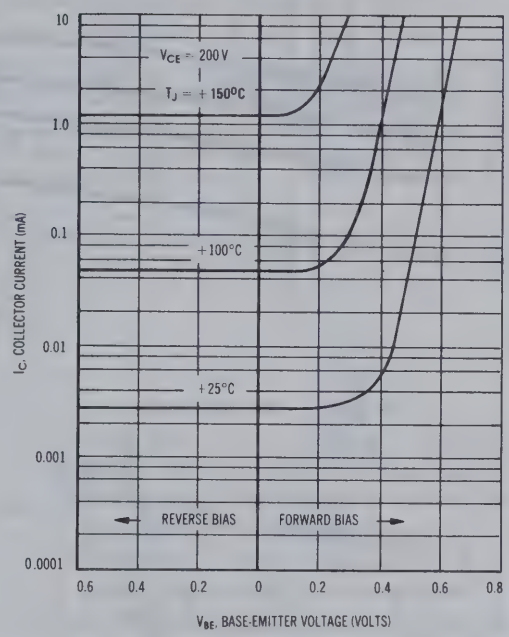


FIGURE 7 – EFFECT OF BASE-EMITTER RESISTANCE

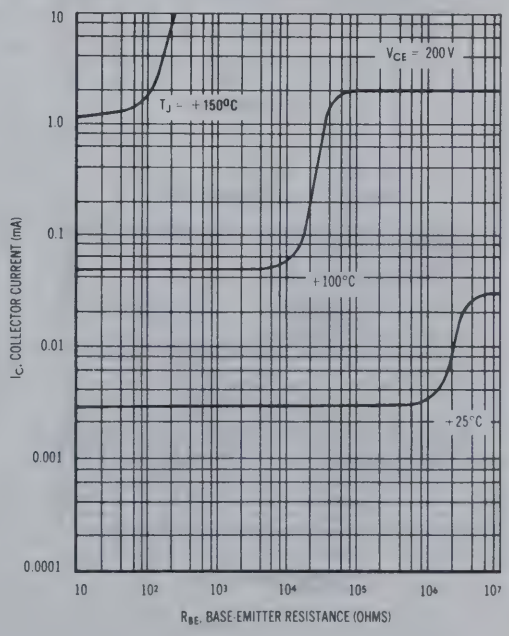


FIGURE 8 – CURRENT GAIN

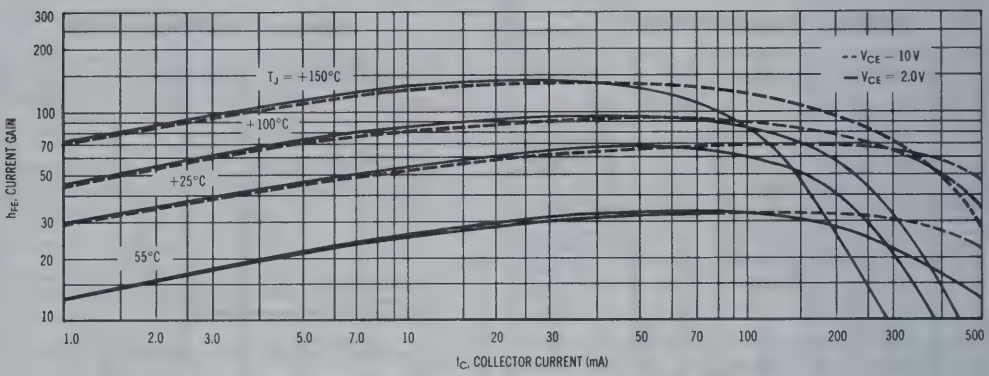


FIGURE 9 – "ON" VOLTAGES

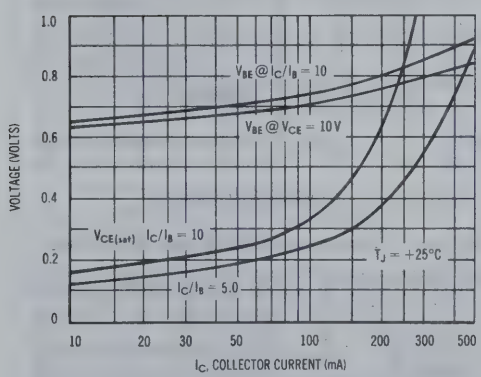


FIGURE 10 – CAPACITANCE

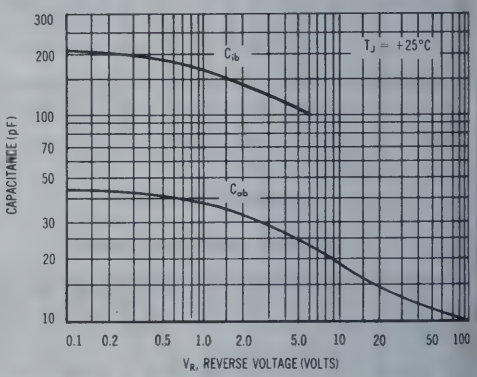


FIGURE 11 – TURN-ON TIME

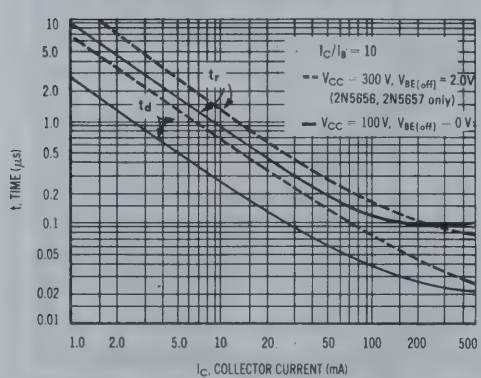
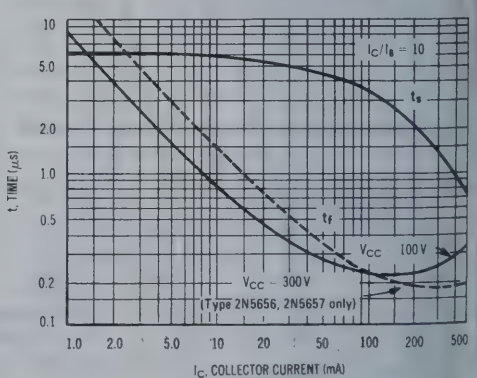


FIGURE 12 – TURN-OFF TIME



2N5668 (SILICON)
2N5669
2N5670

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed for VHF amplifier and mixer applications.

- Low Cross Modulation and Intermodulation Distortion
- Drain and Source Interchangeable
- Low 100-MHz Noise Figure – NF = 2.5 dB (Max)
- Low Reverse Transfer and Input Capcitances – C_{rss} = 1.0 pF (Typ); C_{iss} = 4.7 pF (Typ)
- High Maximum Stable Gain Due to Drain and Gate Lead Separation

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

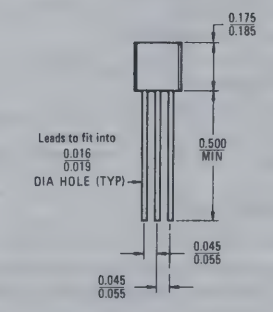
(Type A)

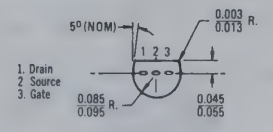


*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
*Drain-Gate Voltage	V_{DG}	25	Vdc
*Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
*Forward Gate Current	I_{GF}	10	mAdc
Drain Current	I_D	20	mAdc
*Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
*Storage Temperature Range	T_{stg}	−65 to +150	°C

*Indicates JEDEC Registered Data.





BOTTOM VIEW
CASE 29 (5)
TO-92

Drain and Source may be Interchanged.

2N5668, 2N5669, 2N5670 (continued)

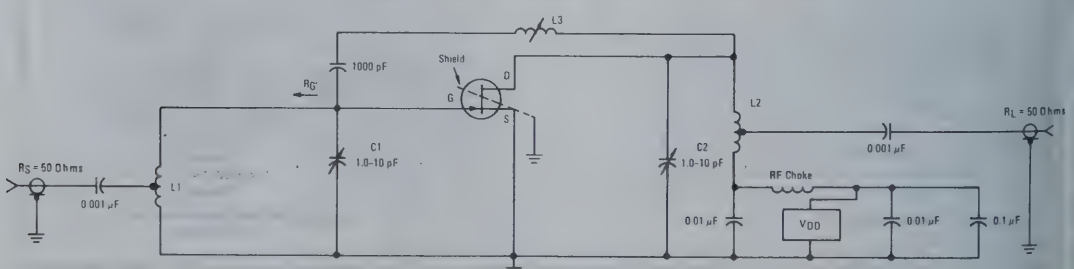
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	–	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 10 nAdc)	2N5668	$V_{GS(off)}$	0.2	–	4.0	Vdc
	2N5669		1.0	–	6.0	
	2N5670		2.0	–	8.0	
Gate Reverse Current		I_{GSS}				
(V_{GS} = –15 Vdc, V_{DS} = 0)			–	–	2.0	nAdc
(V_{GS} = –15 Vdc, V_{DS} = 0, T_A = 100°C)			–	–	2.0	μAdc
***ON CHARACTERISTICS**						
Zero-Gate Voltage Drain Current (Note 1) (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5668	I_{DSS}	1.0	–	5.0	mAdc
	2N5669		4.0	–	10	
	2N5670		8.0	–	20	
SMALL-SIGNAL CHARACTERISTICS						
*Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5668	$\lvert y_{fs} \rvert$	1500	–	6500	μmhos
	2N5669		2000	–	6500	
	2N5670		3000	–	7500	
*Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5668	$Re(y_{fs})$	1000	–	–	μmhos
	2N5669		1600	–	–	
	2N5670		2500	–	–	
*Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5668	$\lvert y_{os} \rvert$	–	–	20	μmhos
	2N5669		–	–	50	
	2N5670		–	–	75	
*Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5668	$Re(y_{os})$	–	10	50	μmhos
	2N5669		–	25	100	
	2N5670		–	35	150	
*Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		$Re(y_{is})$	–	125	800	μmhos
*Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	4.7	7.0	pF
*Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	1.0	3.0	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	–	1.4	4.0	pF
*Common Source Noise Figure (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz, at $R_{G'}$ = 1.0 k ohm)		NF	–	–	2.5	dB
Power Gain (Figure 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		G_{ps}	16	–	–	dB

*Indicates JEDEC Registered Data, excluding typical values.

Note 1: Pulse Test: Pulse With = 100 ms, Duty Cycle ≤ 10%.

FIGURE 1 – 100 MHz, POWER GAIN AND NOISE FIGURE TEST CIRCUIT



L1 ≈ 8.5 Turns of #14 AWG Tinned Copper, Dia. ≈ 3/8", ≈ 0.9" Long. Tapped at ≈ 2-1/2 Turns (adjust to give R_G = 1.0 k ohm); Parallel Resistance = 40 k ohms, tunes at ≈ 8.0 pF.

L2 ≈ 13.5 Turns #16 AWG Tinned Copper, Dia. ≈ 3/8", ≈ 1.2" Long. Tapped at ≈ 5 Turns; Parallel Resistance = 40 k ohms, tunes at ≈ 4.0 pF

L3 ≈ 17 Turns of #28 AWG Enameled Copper Wire, Close Wound on 9/32" Ceramic Form, Tuning Provided by a Powdered Iron Slug

2N5679 (SILICON)
2N5680

LOW-POWER PNP SILICON TRANSISTORS

. . . designed for use as a driver for high-power transistors in general-purpose amplifier and switching circuit applications.

- High Current-Gain—Bandwidth Product — f_T = 30 MHz (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 0.25 Adc
- DC Current Gain Bracketed at 0.25 Adc
- Complement to NPN 2N5681 and 2N5682

1 AMPERE
POWER TRANSISTORS
PNP SILICON

100-120 VOLTS
10 WATTS



*MAXIMUM RATINGS

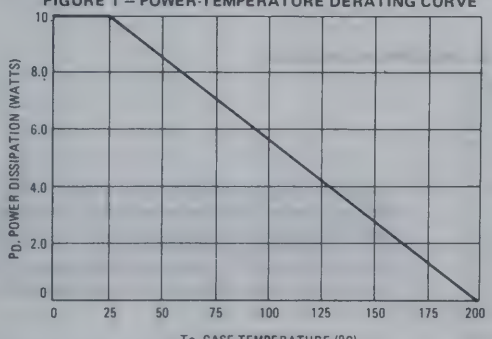
Rating	Symbol	2N5679	2N5680	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	Vdc
Collector-Base Voltage	V_{CB}	100	120	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Base Current	I_B	0.5		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 0.0057		Watt W/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 0.057		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

THERMAL CHARACTERISTICS

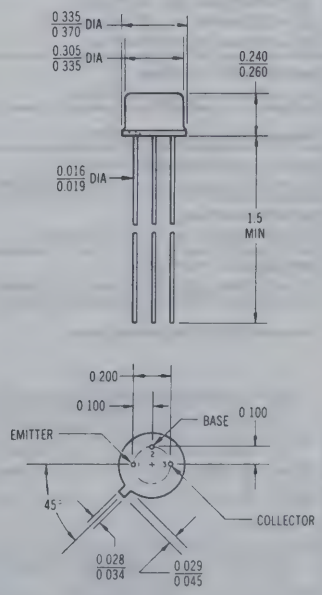
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	175	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.
All limits are applicable and must be observed.



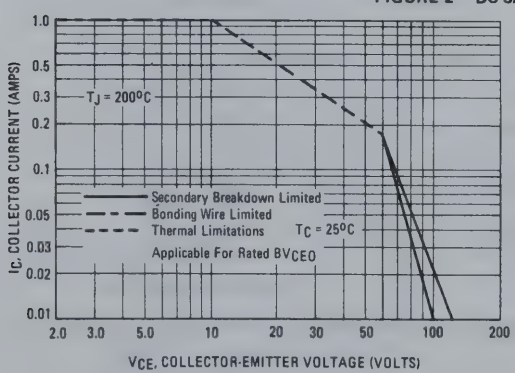
CASE 31 (1)
TO-5
Collector Connected to Case

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	2N5679	$V_{CEO(sus)}$	100	–	Vdc
	2N5680		120	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 70 Vdc, I_B = 0)			–	10	
(V_{CE} = 80 Vdc, I_B = 0)			–	10	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5679		–	1.0	μAdc
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5680		–	1.0	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5679		–	1.0	mAdc
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5680		–	1.0	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N5679		–	1.0	
(V_{CB} = 120 Vdc, I_E = 0)	2N5680		–	1.0	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 250 mAdc, V_{CE} = 2.0 Vdc)			40	150	
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 250 mAdc, I_B = 25 mAdc)			–	0.6	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	1.0	
(I_C = 1.0 Adc, I_B = 200 mAdc)			–	2.0	
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	–
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	50	pF
Small-Signal Current Gain (I_C = 0.2 Adc, V_{CE} = 1.5 Vdc, f = 1.0 kHz)		h_{fe}	40	–	–

*Indicates JEDEC Registered Data.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

2N5681 (SILICON)
2N5682

LOW-POWER NPN SILICON TRANSISTORS

. . . designed for use as a driver for high-power transistors in general-purpose amplifier and switching circuit applications.

- High Current-Gain–Bandwidth Product – f_T = 30 MHz (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 0.25 Adc
- DC Current Gain Bracketed at 0.25 Adc
- Complement to PNP 2N5679 and 2N5680

1 AMPERE POWER TRANSISTORS NPN SILICON

100-120 VOLTS
10 WATTS



*MAXIMUM RATINGS

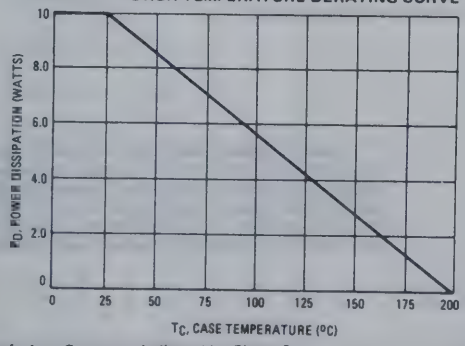
Rating	Symbol	2N5681	2N5682	Unit
Collector-Emitter Voltage	V_{CEO}	100	120	Vdc
Collector-Base Voltage	V_{CB}	100	120	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	1.0		Adc
Base Current	I_B	0.5		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 0.0057		Watt W/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 0.057		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

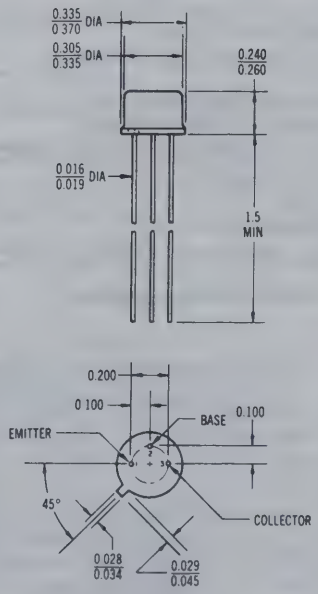
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	175	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.
All limits are applicable and must be observed.



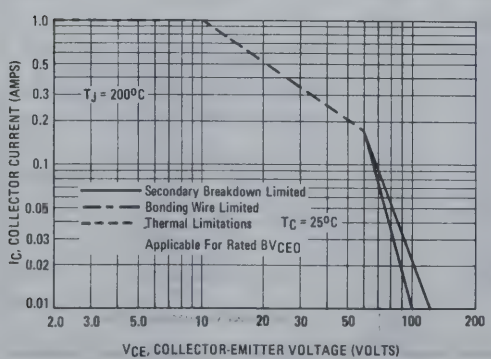
CASE 31 (1)
TO-5
Collector Connected to Case

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	2N5681 2N5682	$V_{CEO(sus)}$	100 120	– –	Vdc
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 70 Vdc, I_B = 0)			–	10	
(V_{CE} = 80 Vdc, I_B = 0)			–	10	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5681		–	1.0	μAdc
(V_{CE} = 120 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5682		–	1.0	
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5681		–	1.0	mAdc
(V_{CE} = 120 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5682		–	1.0	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N5681		–	1.0	
(V_{CB} = 120 Vdc, I_E = 0)	2N5682		–	1.0	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 250 mAdc, V_{CE} = 2.0 Vdc)			40	150	
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 250 mAdc, I_B = 25 mAdc)			–	0.6	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	1.0	
(I_C = 1.0 Adc, I_B = 200 mAdc)			–	2.0	
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	–
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	50	pF
Small-Signal Current Gain (I_C = 0.2 Adc, V_{CE} = 1.5 Vdc, f = 1.0 kHz)		h_{fe}	40	–	–

*Indicates JEDEC Registered Data.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

2N5683 (SILICON)
2N5684

HIGH CURRENT PNP SILICON TRANSISTORS

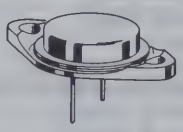
. . . designed for use in high-power amplifier and switching circuit applications.

- DC Current Gain — h_{FE} = 15 - 60 @ I_C = 25 Adc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 25 Adc
- Complements to 2N5685, 2N5686

50 AMPERE POWER TRANSISTORS

PNP SILICON

60–80 VOLTS 300 WATTS



*MAXIMUM RATINGS

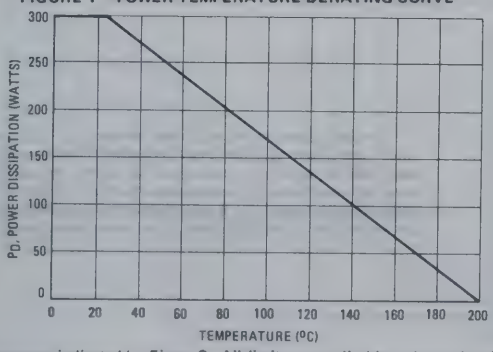
Rating	Symbol	2N5683	2N5684	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	50		Adc
Base Current	I_B	15		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.715		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*THERMAL CHARACTERISTICS

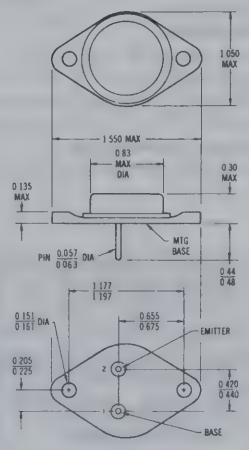
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.584	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. All limits are applicable and must be observed.



Collector Connected to Case
Case 197
TO-3 except Pin Diameter

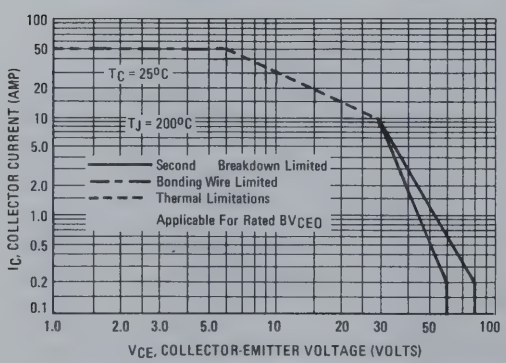
***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$			Vdc
(I_C = 0.2 Adc, I_B = 0)	2N5683		60	–	
	2N5684		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N5683		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N5684		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5683		–	2.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5684		–	2.0	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5683		–	10	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5684		–	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N5683		–	2.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N5684		–	2.0	
Emitter Cutoff Current		I_{EBO}	–	5.0	mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 25 Adc, V_{CE} = 2.0 Vdc)			15	60	
(I_C = 50 Adc, V_{CE} = 5.0 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 25 Adc, I_B = 2.5 Adc)			–	1.0	
(I_C = 50 Adc, I_B = 10 Adc)			–	5.0	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$	–	2.0	Vdc
(I_C = 25 Adc, I_B = 2.5 Adc)					
Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$	–	2.0	Vdc
(I_C = 25 Adc, V_{CE} = 2.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product		f_T	2.0	–	MHz
(I_C = 5.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)					
Output Capacitance		C_{ob}	–	2000	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)					
Small-Signal Current Gain		h_{fe}	15	–	–
(I_C = 10 Adc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)					

*Indicates JEDEC Registered Data

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

2N5685 (SILICON)
2N5686

HIGH-CURRENT NPN SILICON TRANSISTORS

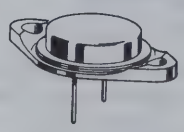
. . . designed for use in high-power amplifier and switching circuit applications.

- DC Current Gain — h_{FE} = 15 - 60 @ I_C = 25 Adc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 25 Adc
- Complements to 2N5683 and 2N5684

50 AMPERE POWER TRANSISTORS

NPN SILICON

60–80 VOLTS
300 WATTS



*MAXIMUM RATINGS

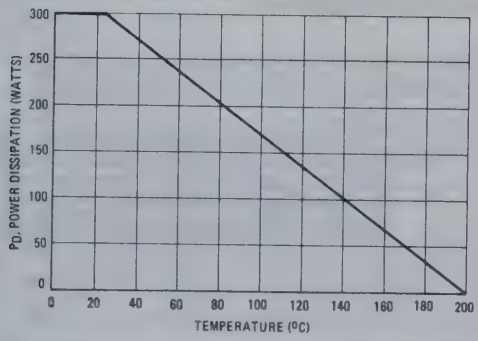
Rating	Symbol	2N5685	2N5686	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	50		Adc
Base Current	I_B	15		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.715		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*THERMAL CHARACTERISTICS

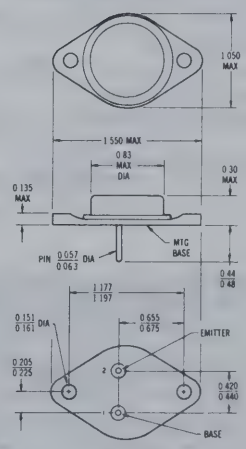
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.584	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. All limits are applicable and must be observed.



Collector Connected to Case
Case 197
TO-3 except Pin Diameter

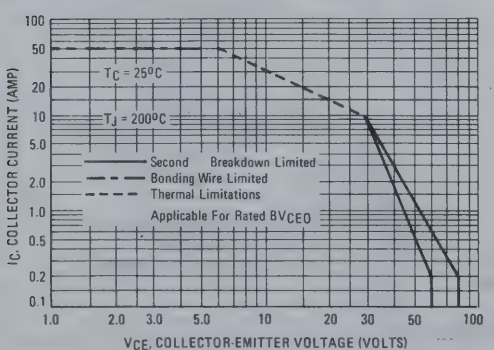
*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$			Vdc
(I_C = 0.2 Adc, I_B = 0)	2N5685		60	–	
	2N5686		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N5685		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N5686		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5685		–	2.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5686		–	2.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5685		–	10	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5686		–	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N5685		–	2.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N5686		–	2.0	
Emitter Cutoff Current		I_{EBO}	–	5.0	mAdc
(V_{BE} = 5.0 Vdc, I_C = 0)					
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 25 Adc, V_{CE} = 2.0 Vdc)			15	60	
(I_C = 50 Adc, V_{CE} = 5.0 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 25 Adc, I_B = 2.5 Adc)			–	1.0	
(I_C = 50 Adc, I_B = 10 Adc)			–	5.0	
Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$	–	2.0	Vdc
(I_C = 25 Adc, I_B = 2.5 Adc)					
Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$	–	2.0	Vdc
(I_C = 25 Adc, V_{CE} = 2.0 Vdc)					
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product		f_T	2.0	–	MHz
(I_C = 5.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)					
Output Capacitance		C_{ob}	–	1200	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)					
Small-Signal Current Gain		h_{fe}	15	–	
(I_C = 10 Adc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)					

*Indicates JEDEC Registered Data

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC SAFE OPERATING AREA



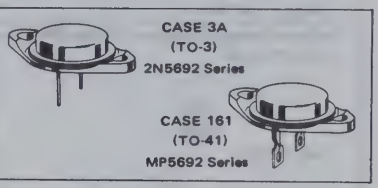
The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collecto load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

2N5692 thru 2N5696 (GERMANIUM)
MP5692 thru MP5696

PNP GERMANIUM POWER SWITCHING TRANSISTORS

. . . designed for high-current, fast-switching applications requiring low saturation voltage and excellent safe operating area.

40 AMPERE "ADE" POWER TRANSISTORS
PNP GERMANIUM
50–140 VOLTS
120 WATTS



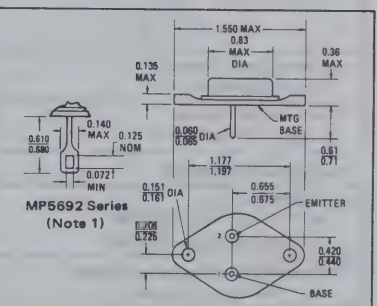
MAXIMUM RATINGS

Rating	Symbol	2N5692 MP5692	2N5693 MP5693	2N5694 MP5694	2N5695 MP5695	2N5696 MP5696	Unit
*Collector-Emitter Voltage	V_{CEO}	30	60	80	100	120	Vdc
*Collector-Base Voltage	V_{CB}	50	80	100	120	140	Vdc
*Emitter-Base Voltage	V_{EB}	2.5					Vdc
*Collector Current — Continuous — Peak	I_C	40 60					Adc
*Base Current — Continuous	I_B	12					Adc
*Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	120 1.43					Watts W/^oC
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +110					^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.7	$^oC/W$

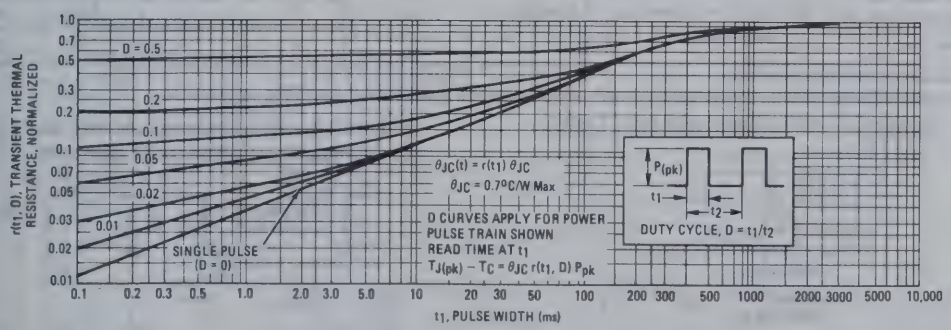
*Indicates JEDEC Registered Data.



CASE 3A
(TO-3)
Collector Connected to Case

Note 1. Case 161 (TO-41)
All dimensions identical to Case 3A (TO-3) except as noted.

FIGURE 1 — THERMAL RESPONSE



2N5692 thru 2N5696/MP5692 thru MP5696 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
* Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0)	2N5692 MP5692	BV_{CEO}	30	–	Vdc
	2N5693 MP5693		60	–	
	2N5694 MP5694		80	–	
	2N5695 MP5695		100	–	
	2N5696 MP5696		120	–	
* Collector Cutoff Current		I_{CEX1}			mAdc
(V_{CE} = 50 Vdc) $V_{BE(off)}$ = 0.2 Vdc	2N5692 MP5692		–	10	
(V_{CE} = 80 Vdc)	2N5693 MP5693		–	10	
(V_{CE} = 100 Vdc) For	2N5694 MP5694		–	10	
(V_{CE} = 120 Vdc) All Types	2N5695 MP5695		–	10	
(V_{CE} = 140 Vdc)	2N5696 MP5696		–	10	
* Collector Cutoff Current		I_{CEX2}(1)			mAdc
(V_{CE} = 50 Vdc) $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C	2N5692 MP5692		–	30	
(V_{CE} = 80 Vdc) For	2N5693 MP5693		–	30	
(V_{CE} = 100 Vdc)	2N5694 MP5694		–	30	
(V_{CE} = 120 Vdc) All Types	2N5695 MP5695		–	30	
(V_{CE} = 140 Vdc)	2N5696 MP5696		–	30	
* Collector-Emitter Sustaining Voltage (See Figure 3)		$V_{CEX(sus)}$			Vdc
(I_C = 10 Adc)	2N5692 MP5692		50	–	
	2N5693 MP5693		80	–	
	2N5694 MP5694		100	–	
	2N5695 MP5695		120	–	
	2N5696 MP5696		140	–	
(I_C = 40 Adc)	2N5692 MP5692		45	–	
	2N5693 MP5693		50	–	
	2N5694 MP5694		55	–	
	2N5695 MP5695		60	–	
	2N5696 MP5696		65	–	
* Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	–	200	μAdc
* Emitter Cutoff Current (V_{BE} = 2.5 Vdc, I_C = 0)		I_{EBO}	–	500	mAdc
ON CHARACTERISTICS					
* DC Current Gain		h_{FE}(1)			–
(I_C = 25 Adc, V_{CE} = 2.0 Vdc)			20	65	
(I_C = 40 Adc, V_{CE} = 2.0 Vdc)			10	–	
* Collector-Emitter Saturation Voltage (I_C = 60 Adc, I_B = 12 Adc)		$V_{CE(sat)}$(1)	–	0.75	Vdc
* Base-Emitter Saturation Voltage (I_C = 60 Adc, I_B = 12 Adc)		$V_{BE(sat)}$(1)	–	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
* Current-Gain—Bandwidth Product (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc, f = 100 kHz)		f_T	200	–	kHz
SWITCHING CHARACTERISTICS					
* Rise Time	(I_C = 25 Adc, I_{B1} = 2.5 Adc, I_{B2} = 2.5 Adc) (See Figure 2)	t_r	–	20	μs
* Storage Time		t_s	–	8.0	μs
* Fall Time		t_f	–	15	μs

*Indicates JEDEC Registered Data.

(1) To avoid excessive heating of the collector junction, perform test with pulse method. (PW ≤ 300 μs, DC ≤ 2.0%).

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

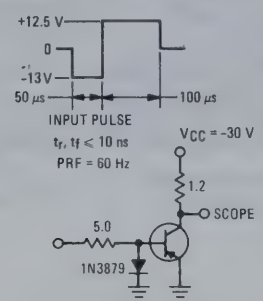
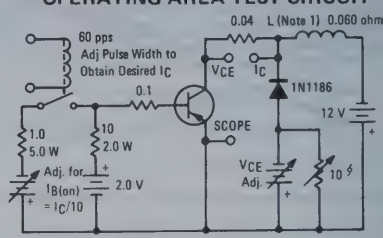


FIGURE 3 – CLAMPED INDUCTIVE SAFE OPERATING AREA TEST CIRCUIT



ϕ Set to allow reverse surge current to by pass power supply. Not needed for power supply with low reverse impedance.

NOTE 1: L = 10 mH at I_C = 10 A
L = 0.25 mH at I_C = 40 A

2N5716 (SILICON)
2N5717
2N5718

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for low-power audio amplifier applications.

- High DC Input Resistance
- Drain and Source Interchangeable
- Low Input Capacitance —
  C_{iss} = 5.0 pF (Max) @ V_{DS} = 15 Vdc
- Low Reverse Transfer Capacitance —
  C_{rss} = 1.5 pF (Max) @ V_{DS} = 15 Vdc
- Low Zero Gate Voltage Drain Current —
  I_{DSS} = 0.05 — 0.25 mAdc 2N5716
  0.2 — 1.0 mAdc 2N5717
  0.8 — 4.0 mAdc 2N5718

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

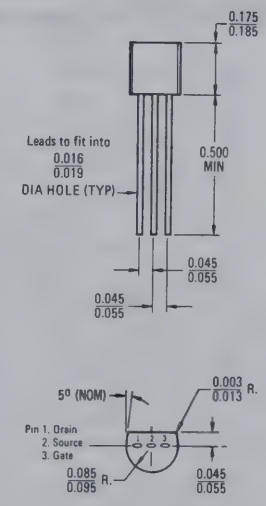
(Type A)



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
#Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	-40	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
#Operating Junction Temperature	T_J	125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*Indicates JEDEC Registered Data.
#Motorola Guarantees this Data in Addition to JEDEC Registered Data.



Case 29(5)
(TO-92)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	-40	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 nAdc)	2N5716 2N5717 2N5718	$V_{GS(off)}$	-0.2 -0.5 -1.0	-3.0 -5.0 -8.0	Vdc
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0) (V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	– –	1.0 200	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1) (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5716 2N5717 2N5718	I_{DSS}	0.05 0.2 0.8	0.25 1.0 4.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (Note 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5716 2N5717 2N5718	$\lvert y_{fs} \rvert$	200 400 500	1000 1600 2000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\lvert y_{os} \rvert$	–	25	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	1.5	pF

*Indicates JEDEC Registered Data.
Note 1: Pulse Test: Pulse Width ≤ 630 μs, Duty Cycle ≤ 10%.

2N5793 (SILICON)
2N5794

DUAL NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-speed switching circuits, dc to VHF amplifier applications and complementary circuitry to the PNP 2N5795 and 2N5796.

- DC Current Gain Specified – 0.1 mAdc to 300 mAdc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 150 mAdc
- All Leads Electrically Isolated for Design Flexibility
- Each Transistor Similar to 2N2218A or 2N2219A

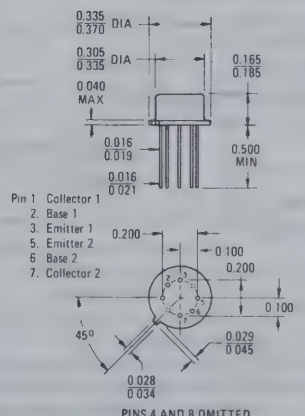
NPN SILICON DUAL TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	75		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	600		mAdc
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C
		Each Device	Total Package	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	2.0 11.43	Watts mW/°C

*Indicates JEDEC Registered Data.



PINS 4 AND 8 OMITTED
All Leads Electrically Isolated from Case

CASE 654-04
Formerly 32-02

2N5793, 2N5794 (continued)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	75	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	10	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	10	nAdc
Collector 1 to Collector 2 Leakage Current ($V_{1C\text{-}2C}$ = ±50 Vdc)		$I_{1C\text{-}2C}$	–	±1.0	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	2N5793		20	–	
	2N5794		35	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N5793		25	–	
	2N5794		50	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)	2N5793		35	–	
	2N5794		75	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N5793		20	–	
	2N5794		50	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N5793		40	120	
	2N5794		100	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)(1)	2N5793		25	–	
	2N5794		40	--	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.3	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	0.9	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			0.6	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	1.8	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	250	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	–	8.0	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{eb}	–	25	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (See Figure 1)	t_d	–	15	ns
Rise Time		t_r	–	30	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (See Figure 2)	t_s	–	250	ns
Fall Time		t_f	–	60	ns

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – TURN-ON TIME TEST

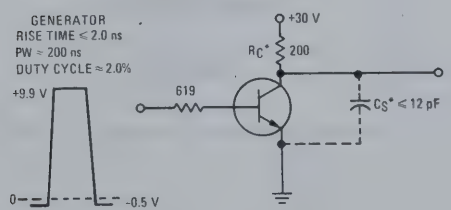
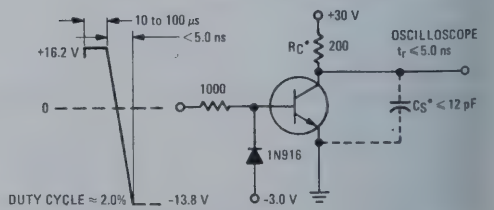


FIGURE 2 – TURN-OFF TIME TEST CIRCUIT



*C_S is total shunt capacitance of oscilloscope and test fixture.
R_C includes oscilloscope resistance.

2N5829 (SILICON)

PNP SILICON SMALL-SIGNAL RF TRANSISTOR

. . . designed for high-gain, low-noise amplifier, oscillator, and mixer applications.

- Low Noise Figure – NF = 2.5 dB (Max) @ f = 450 MHz
- High Power Gain – G_{pe} = 17 dB (Min) @ f = 450 MHz
- High Gain-Bandwidth Product – f_T = 1600 MHz (Typ)
- Low Collector-Base Capacitance – C_{cb} = 0.4 pF (Typ)

PNP SILICON RF AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

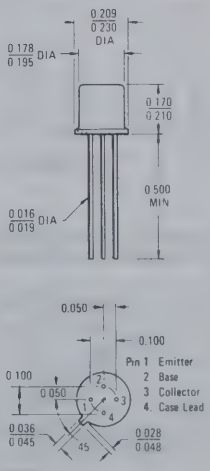
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30			Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30			Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0			Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}			0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	40	150	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product(1) (I_E = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	1200	1600		MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}		0.4	0.8	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20		200	
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	$r_b C_C$	1.0		8.0	ps
Noise Figure (Figure 1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	NF		2.3	2.5	dB
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz)	G_{pe}	17			dB

*Indicates JEDEC Registered Data.

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity



CASE 20 (10)
TO-72 PACKAGE

ACTIVE ELEMENTS ISOLATED FROM CASE

RF PERFORMANCE DATA

FIGURE 1 – NOISE FIGURE AND POWER GAIN TEST CIRCUIT

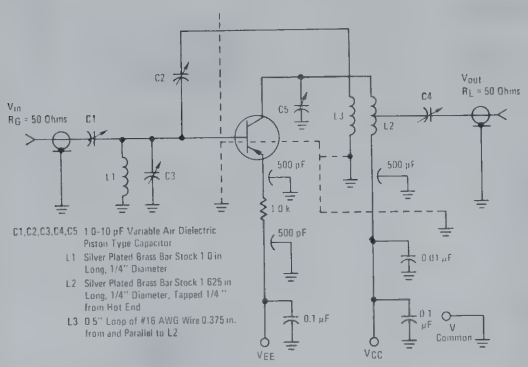


FIGURE 2 – UNILATERALIZED POWER GAIN versus FREQUENCY

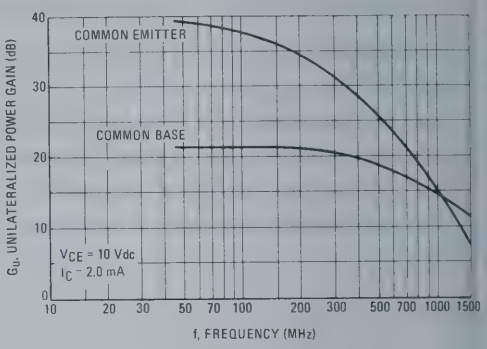


FIGURE 3 – NOISE FIGURE versus FREQUENCY

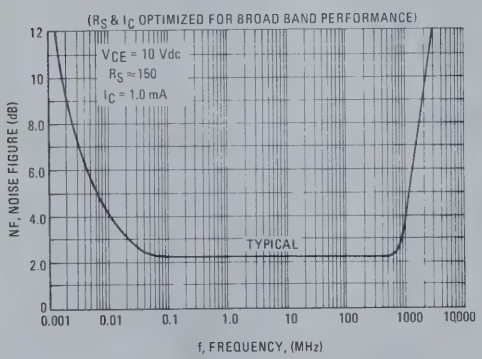


FIGURE 4 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

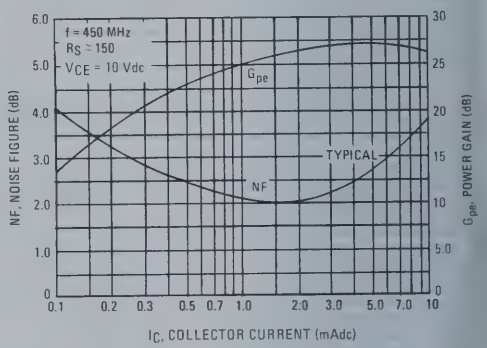


FIGURE 5 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

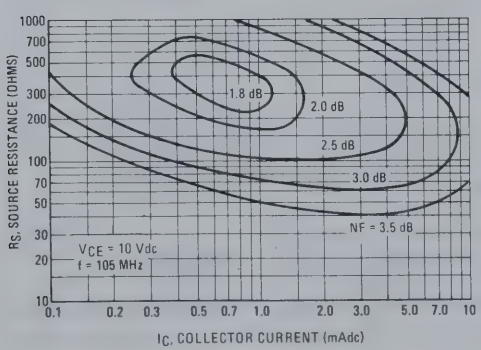
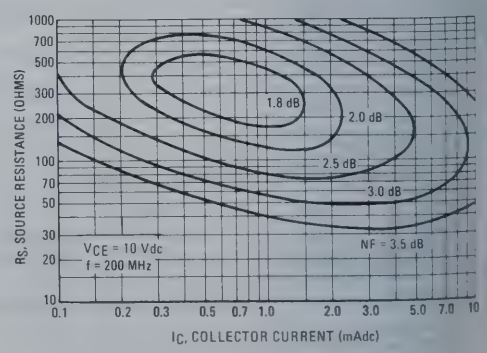


FIGURE 6 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT



COMMON EMITTER CIRCUIT DESIGN DATA

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 7 – TRANSDUCER GAIN versus FREQUENCY

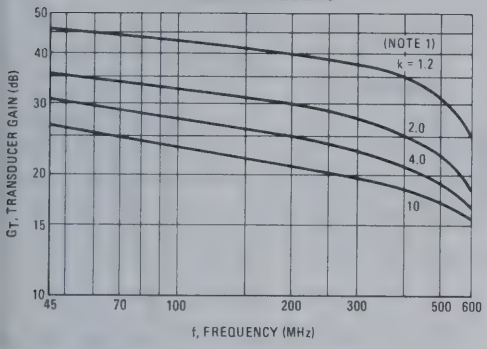


FIGURE 8 – LINVILL STABILITY FACTOR versus FREQUENCY

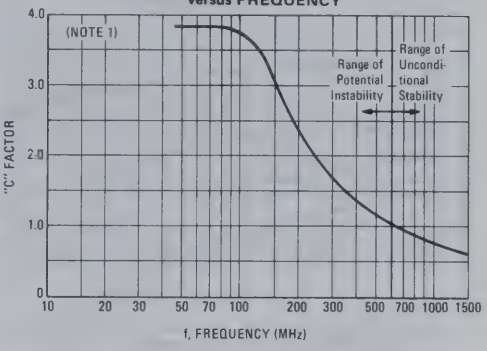


FIGURE 9 – LOAD ADMITTANCE versus FREQUENCY (REAL)

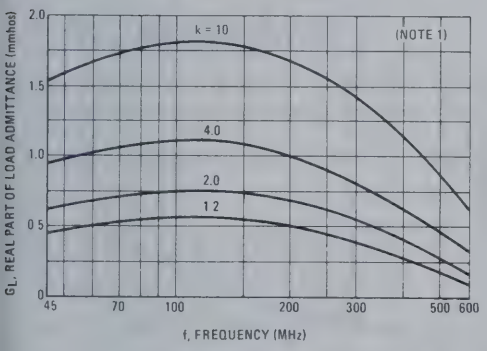


FIGURE 10 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

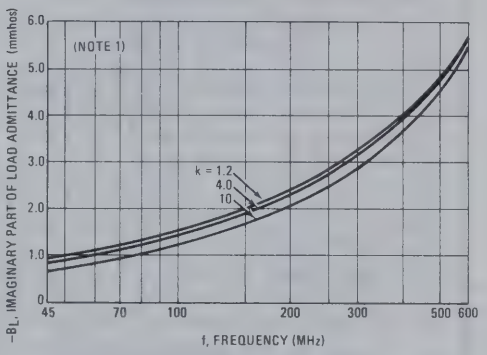


FIGURE 11 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

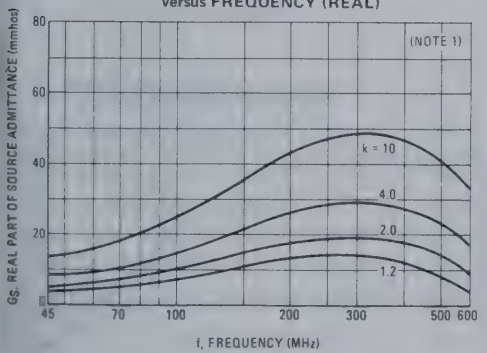
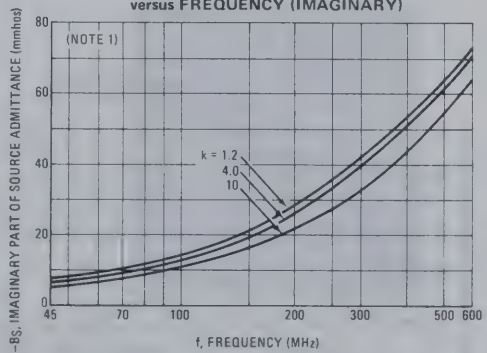


FIGURE 12 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)



NOTE 1

Figures 7 through 18 are included to assist the circuit designer in determining the stability of his particular circuit. Two stability criteria are given in these figures.

The Linvill "C" factor* is a measure of transistor stability when the input and output are terminated in the worst-case (open circuit) condition. When "C" is less than 1.0, the circuit is unconditionally stable. When "C" is greater than 1.0, the circuit is potentially unstable.

The Stern "K" factor† has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN-215.

* "Transistors and Active Circuits," Linvill and Gibbons, McGraw-Hill, 1961.

† "Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc I.R.E., March 1967

COMMON BASE CIRCUIT DESIGN DATA

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 13 – TRANSDUCER GAIN versus FREQUENCY

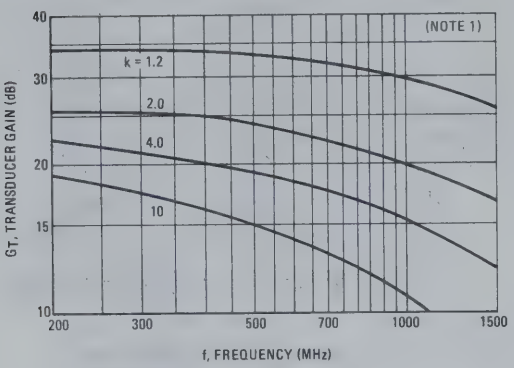


FIGURE 14 – LINVILL STABILITY FACTOR versus FREQUENCY

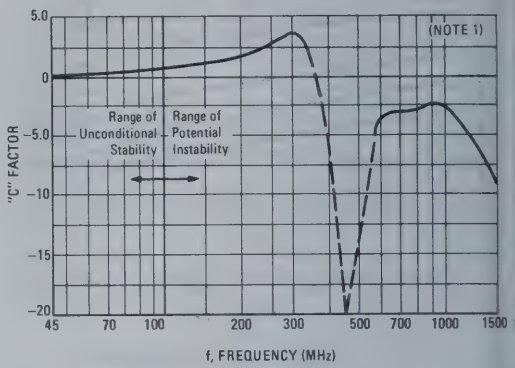


FIGURE 15 – LOAD ADMITTANCE versus FREQUENCY (REAL)

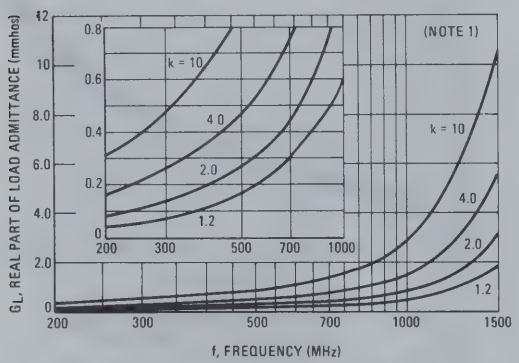


FIGURE 16 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

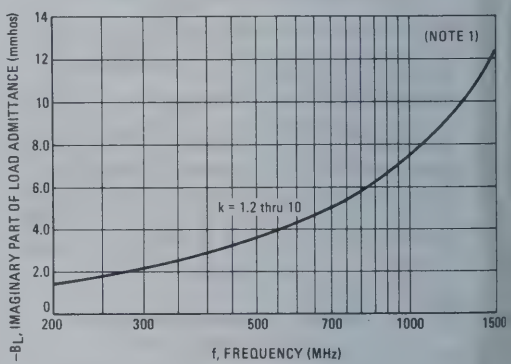


FIGURE 17 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

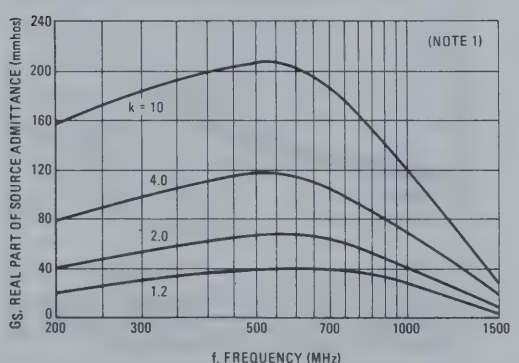


FIGURE 18 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)

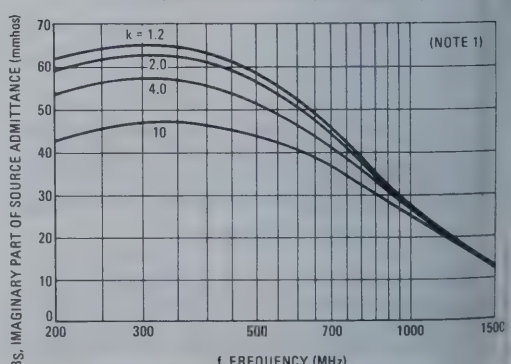


FIGURE 19 – SMALL-SIGNAL CURRENT GAIN versus FREQUENCY

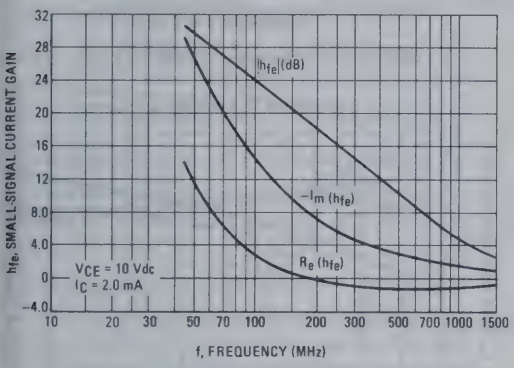


FIGURE 20 – POLAR h_{fe}

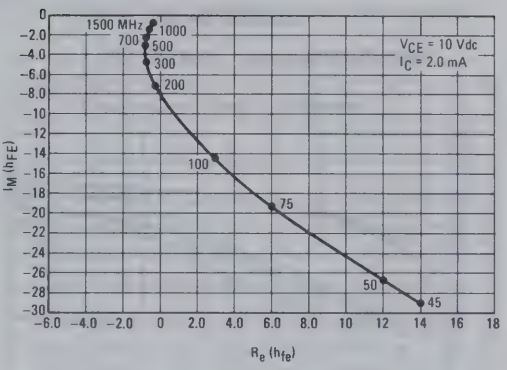


FIGURE 21 – f_T versus COLLECTOR CURRENT

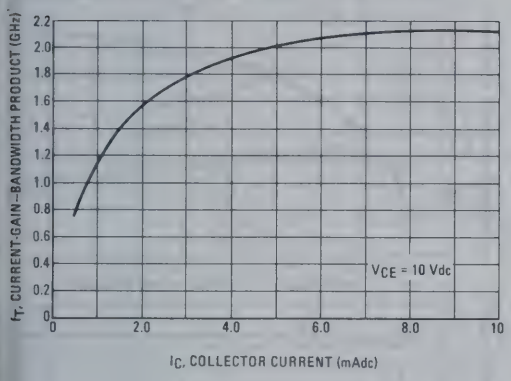


FIGURE 22 – DC CURRENT GAIN

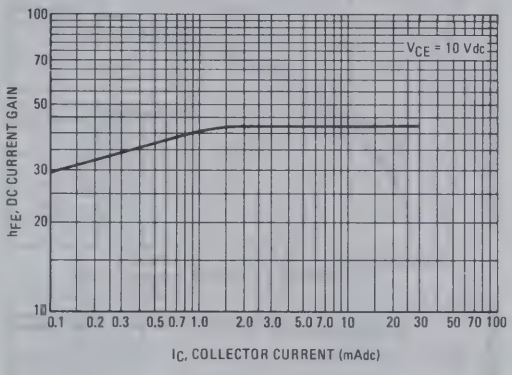


FIGURE 23 – CAPACITANCE

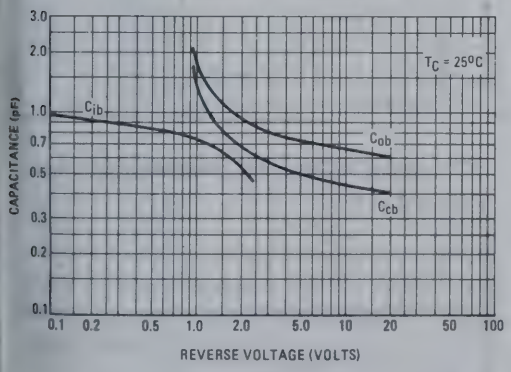
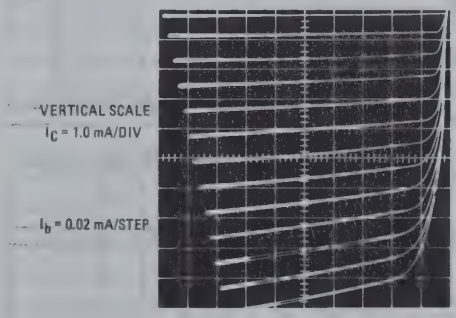


FIGURE 24 – COLLECTOR CHARACTERISTICS

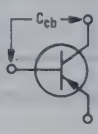




Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is open.



Apply reverse bias between emitter and base and measure capacitance between these terminals. Collector is open.



Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is guarded.

Y PARAMETERS versus CURRENT

(f = 450 MHz)

COMMON BASE

V_{CB} = 10 Vdc ——— V_{CB} = 15 Vdc — — —

FIGURE 25 – INPUT ADMITTANCE

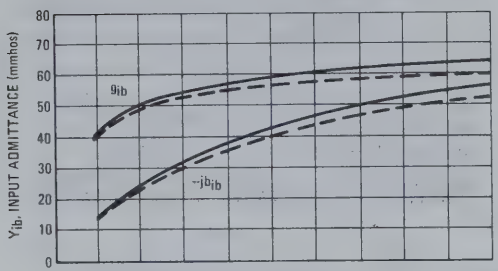


FIGURE 27 – FORWARD TRANSFER ADMITTANCE

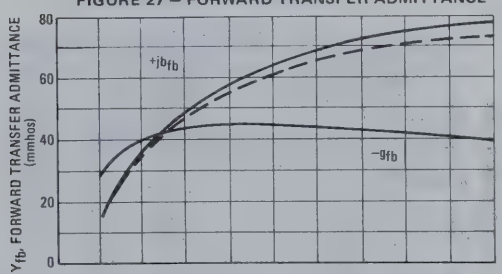


FIGURE 29 – OUTPUT ADMITTANCE

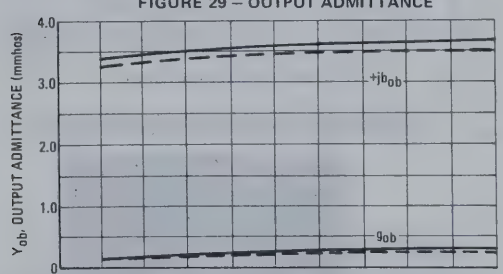
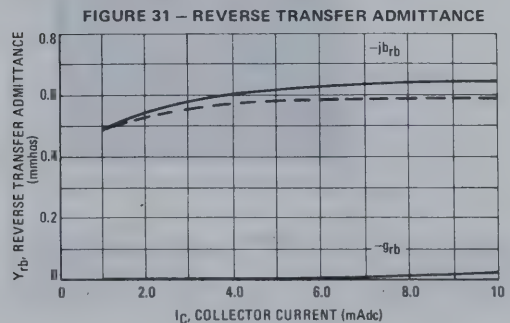


FIGURE 31 – REVERSE TRANSFER ADMITTANCE



COMMON EMITTER

V_{CE} = 10 Vdc ——— V_{CE} = 15 Vdc — — —

FIGURE 26 – INPUT ADMITTANCE

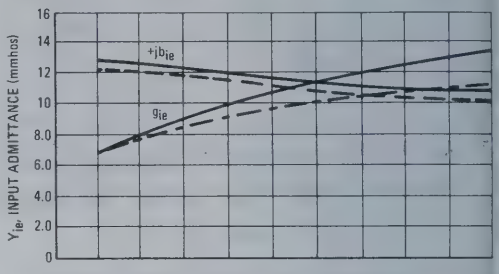


FIGURE 28 – FORWARD TRANSFER ADMITTANCE

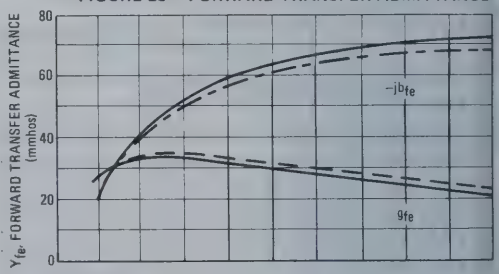


FIGURE 30 – OUTPUT ADMITTANCE

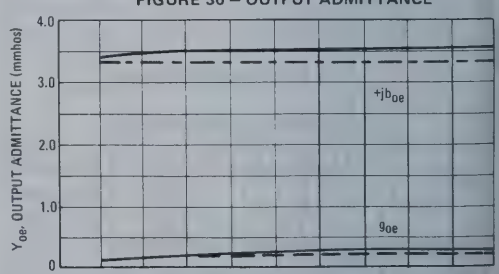
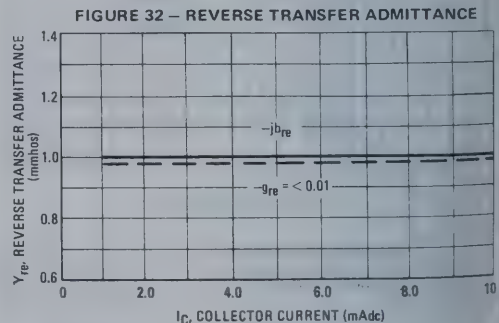


FIGURE 32 – REVERSE TRANSFER ADMITTANCE



COMMON BASE Y PARAMETER VARIATIONS

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

Y PARAMETERS versus FREQUENCY

FIGURE 33 – y_{ib} INPUT ADMITTANCE

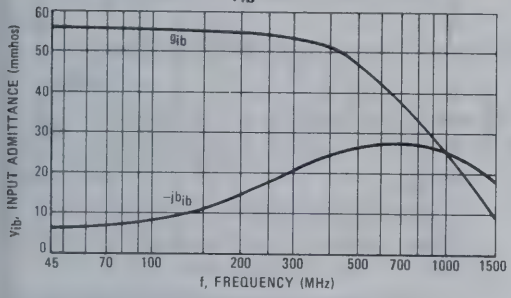


FIGURE 35 – y_{fb} FORWARD TRANSFER ADMITTANCE

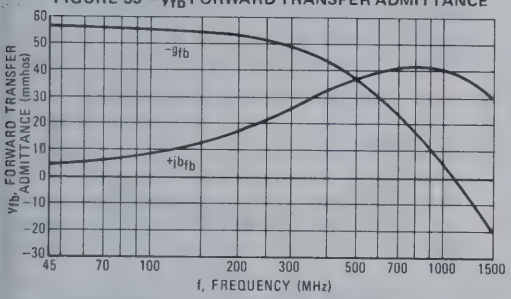


FIGURE 37 – y_{ob} OUTPUT ADMITTANCE

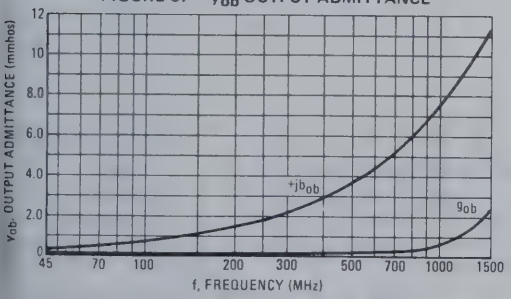
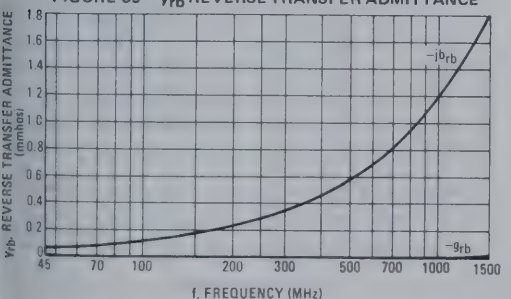


FIGURE 39 – y_{rb} REVERSE TRANSFER ADMITTANCE



POLAR Y PARAMETERS versus FREQUENCY

FIGURE 34 – y_{ib} INPUT ADMITTANCE

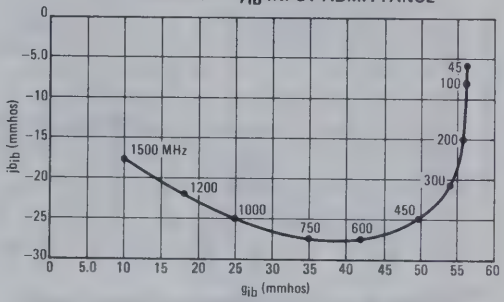


FIGURE 36 – y_{fb} FORWARD TRANSFER ADMITTANCE

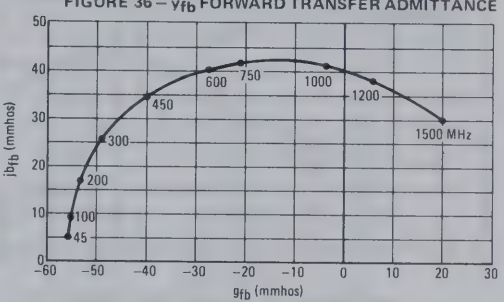


FIGURE 38 – y_{ob} OUTPUT ADMITTANCE

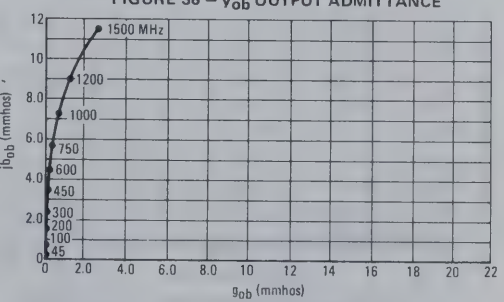
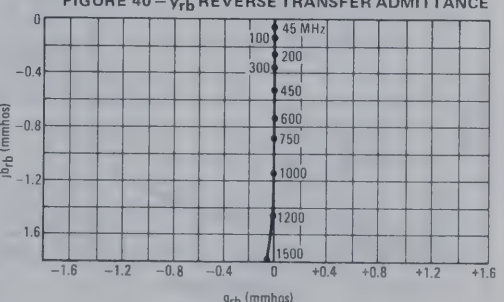


FIGURE 40 – y_{rb} REVERSE TRANSFER ADMITTANCE



COMMON EMITTER Y PARAMETER VARIATIONS

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

Y PARAMETERS versus FREQUENCY

FIGURE 41 – y_{ie} INPUT ADMITTANCE

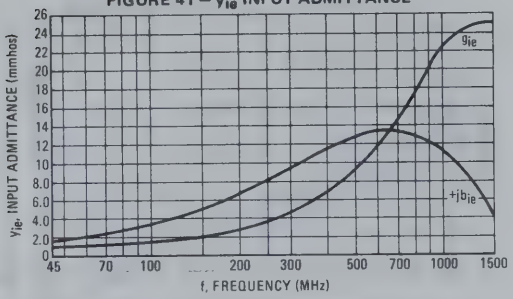


FIGURE 43 – y_{fe} FORWARD TRANSFER ADMITTANCE

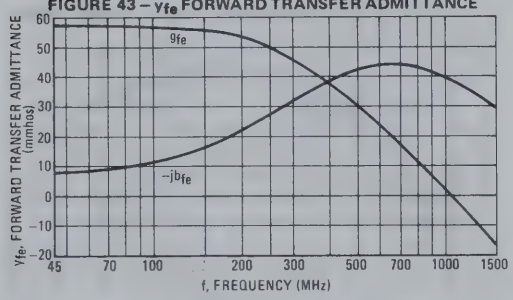


FIGURE 45 – y_{oe} OUTPUT ADMITTANCE

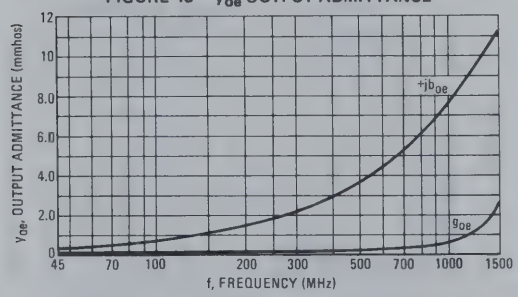
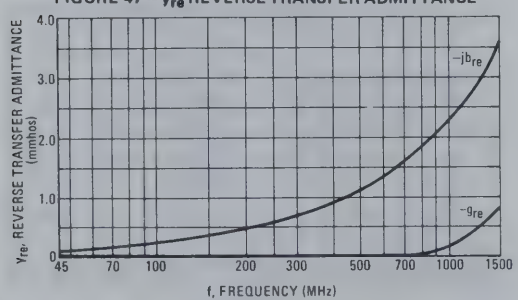


FIGURE 47 – y_{re} REVERSE TRANSFER ADMITTANCE



POLAR Y PARAMETERS versus FREQUENCY

FIGURE 42 – y_{ie} INPUT ADMITTANCE

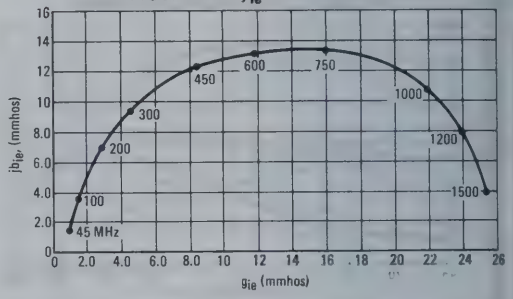


FIGURE 44 – y_{fe} FORWARD TRANSFER ADMITTANCE

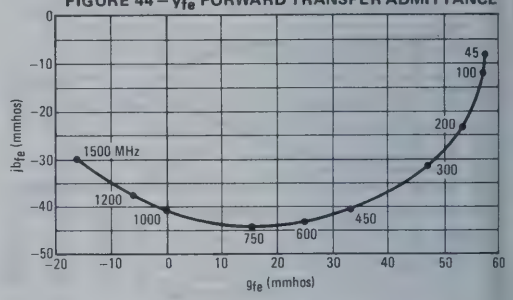


FIGURE 46 – y_{oe} OUTPUT ADMITTANCE

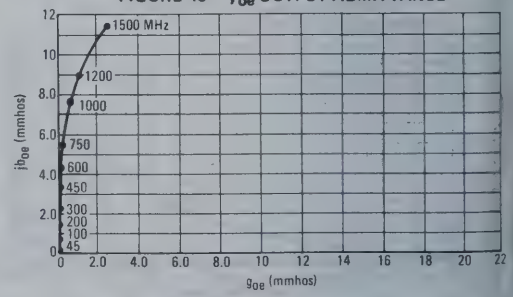
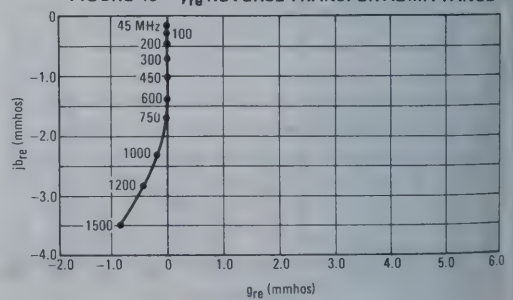


FIGURE 48 – y_{re} REVERSE TRANSFER ADMITTANCE



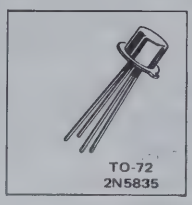
2N5835 (SILICON)
2N5836
2N5837

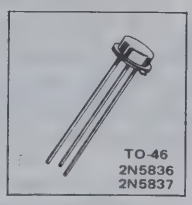
NPN SILICON HIGH-FREQUENCY TRANSISTORS

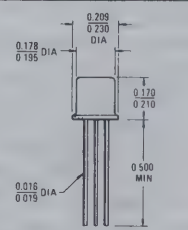
. . . designed primarily for use in fast current-mode switching circuits in military and industrial equipment. Suitable for use in general high-frequency amplifier applications to 1.5 GHz.

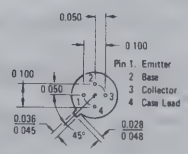
- High Current-Gain—Bandwidth Product —
  f_T = 2.5 GHz (Min) @ I_C = 10 mAdc — 2N5835
  2.0 GHz (Min) @ I_C = 50 mAdc — 2N5836
  1.7 GHz (Min) @ I_C = 100 mAdc — 2N5837
- Fast Non-Saturated Switching Times —
  t_r = 250 ps (Typ) @ I_C = 10 mAdc — 2N5835
  320 ps (Typ) @ I_C = 50 mAdc — 2N5836
  650 ps (Typ) @ I_C = 100 mAdc — 2N5837
- Characterized with Scattering Parameters

NPN SILICON HIGH-FREQUENCY TRANSISTORS


TO-72
2N5835


TO-46
2N5836
2N5837



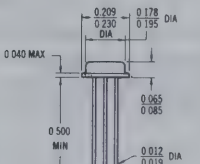


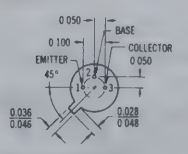
CASE 20 (10)
TO-72

*MAXIMUM RATINGS

Rating	Symbol	2N5835	2N5836	2N5837	Unit
Collector-Emitter Voltage	V_{CEO}	10	10	5.0	Vdc
Collector-Base Voltage	V_{CB}	15	15	10	Vdc
Emitter-Base Voltage	V_{EB}	3.5	3.5	3.5	Vdc
Collector Current — Continuous	I_C	15	200	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	— —	— —	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	— —	2.0 6.67	2.0 6.67	Watts mW/°C
Storage Junction Temperature Range	T_{stg}	← -65 to +200 →			°C

*Indicates JEDEC Registered Data.





CASE 26
TO-46 PACKAGE

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 10 μAdc, I_E = 0)	2N5835		15	–	–	
(I_C = 100 μAdc, I_E = 0)	2N5836		15	–	–	
	2N5837		10	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}	3.5	–	–	Vdc
(I_E = 100 μAdc, I_C = 0)						
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 7.5 Vdc, I_E = 0)	2N5835		–	–	0.01	
(V_{CB} = 10 Vdc, I_E = 0)	2N5836		–	–	10	
(V_{CB} = 5.0 Vdc, I_E = 0)	2N5837		–	–	10	
Emitter Cutoff Current		I_{EBO}	–	–	100	μAdc
(V_{EB} = 3.0 Vdc, I_C = 0)						
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 6.0 Vdc)	2N5835		25	–	–	
(I_C = 50 mAdc, V_{CE} = 6.0 Vdc)	2N5836		25	–	–	
(I_C = 100 mAdc, V_{CE} = 3.0 Vdc)	2N5837		25	–	–	
Base-Emitter On Voltage		$V_{BE(on)}$				Vdc
(I_C = 10 mAdc, V_{CE} = 6.0 Vdc)	2N5835		–	–	0.9	
(I_C = 50 mAdc, V_{CE} = 6.0 Vdc)	2N5836		–	–	0.9	
(I_C = 100 mAdc, V_{CE} = 3.0 Vdc)	2N5837		–	–	0.9	
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product ①		f_T				GHz
(I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz)	2N5835		2.5	–	–	
(I_C = 50 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz)	2N5836		2.0	–	–	
(I_C = 100 mAdc, V_{CE} = 3.0 Vdc, f = 200 MHz)	2N5837		1.7	–	–	
Collector-Base Capacitance		C_{cb}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	2N5835		–	–	0.8	
	2N5836		–	–	3.5	
(V_{CB} = 5.0 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	2N5837		–	–	5.0	
Collector-Base Time Constant ②		$r_b'C_c$				ps
(I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 63.6 MHz)	2N5835		–	5.0	–	
(I_C = 50 mAdc, V_{CE} = 6.0 Vdc, f = 63.6 MHz)	2N5836		–	6.0	–	
(I_C = 100 mAdc, V_{CE} = 3.0 Vdc, f = 63.6 MHz)	2N5837		–	6.0	–	
SWITCHING CHARACTERISTICS ②						
Rise Time (See Figure 1) (I_C = 10 mAdc)	2N5835	t_r	–	250	–	ps
(I_C = 40 mAdc)	2N5836		–	320	–	
(I_C = 100 mAdc)	2N5837		–	650	–	

*Indicates JEDEC Registered Data

① f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

② Typical values shown in addition to JEDEC Registered Data.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

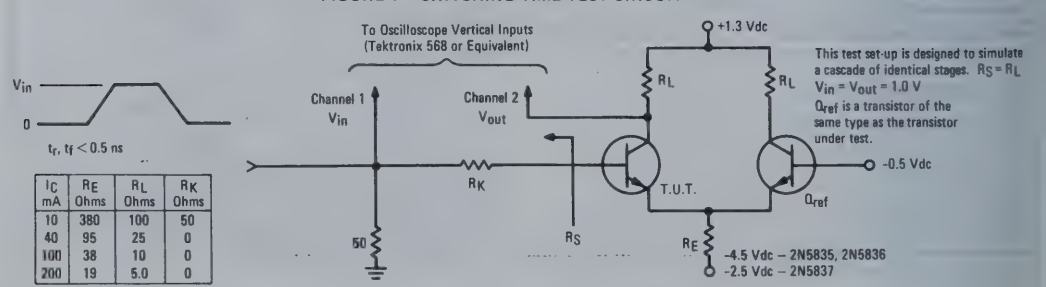


FIGURE 2 – SWITCHING TIME

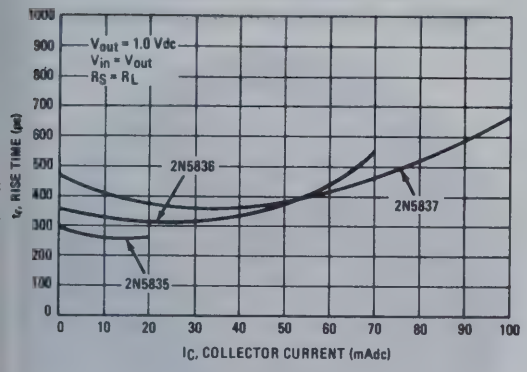


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

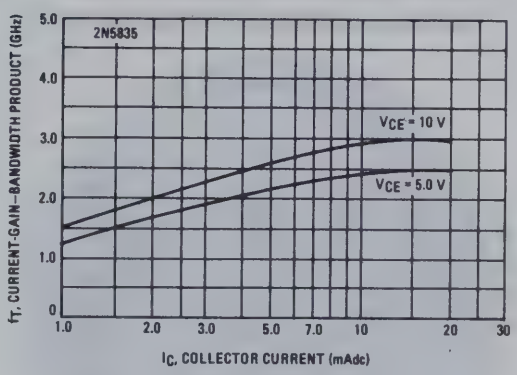


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

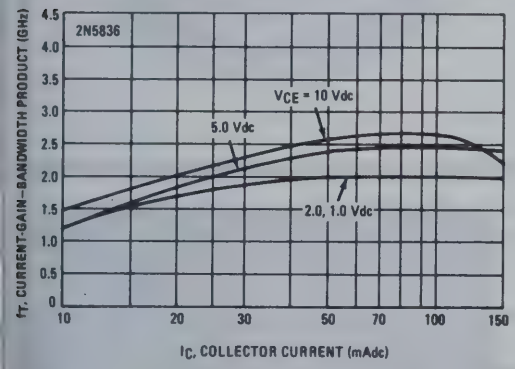


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

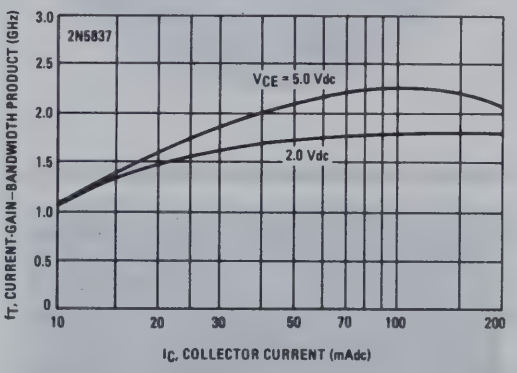


FIGURE 6 – COLLECTOR-BASE TIME CONSTANT

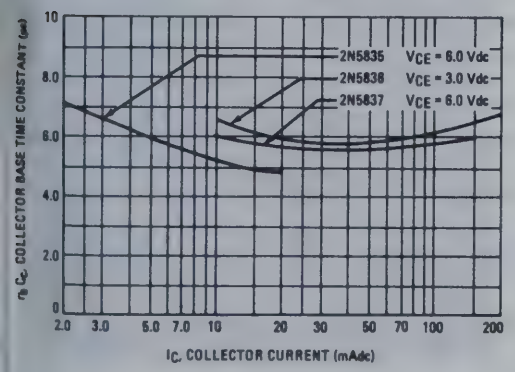
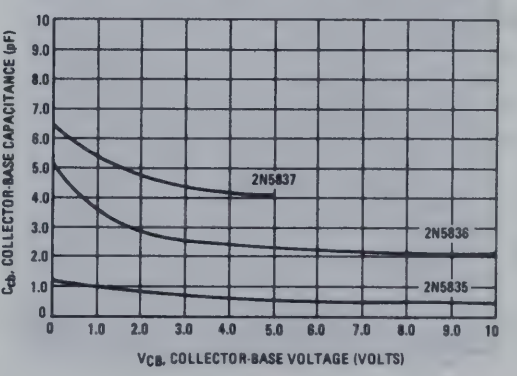


FIGURE 7 – COLLECTOR-BASE CAPACITANCE



2N5835 SCATTERING PARAMETERS
(I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, Z_G = Z_L = 50 Ohms)

FIGURE 8 – S_{11}, INPUT REFLECTION COEFFICIENT

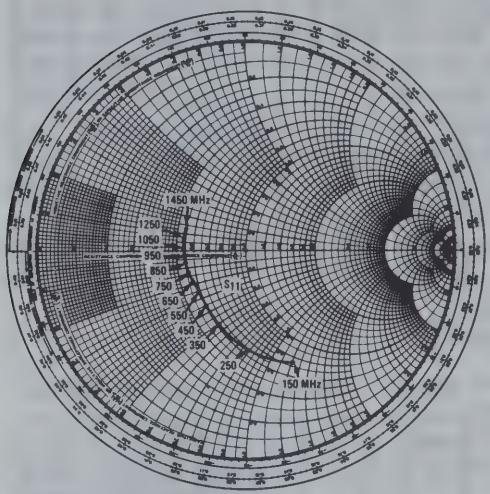


FIGURE 9 – S_{22}, OUTPUT REFLECTION COEFFICIENT

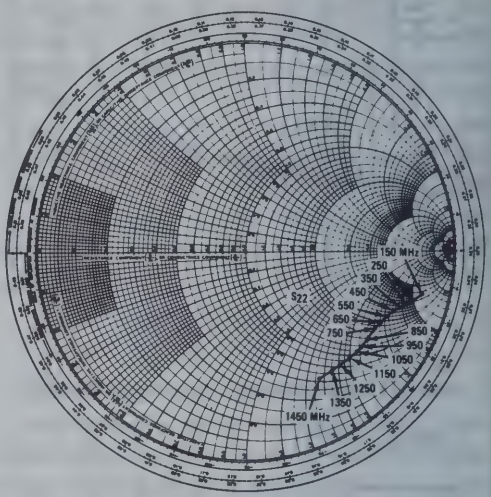


FIGURE 10 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

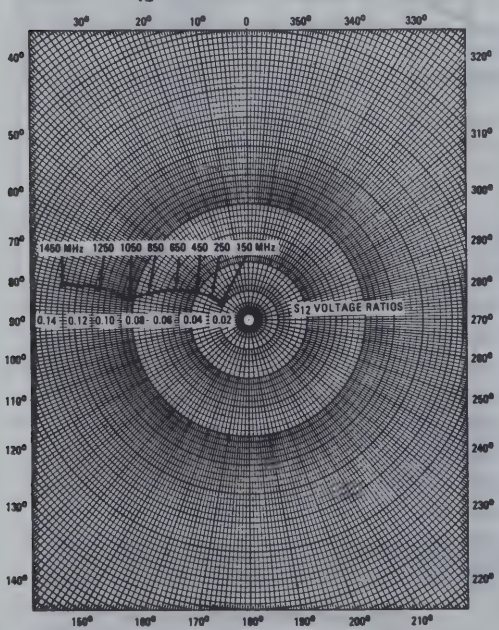
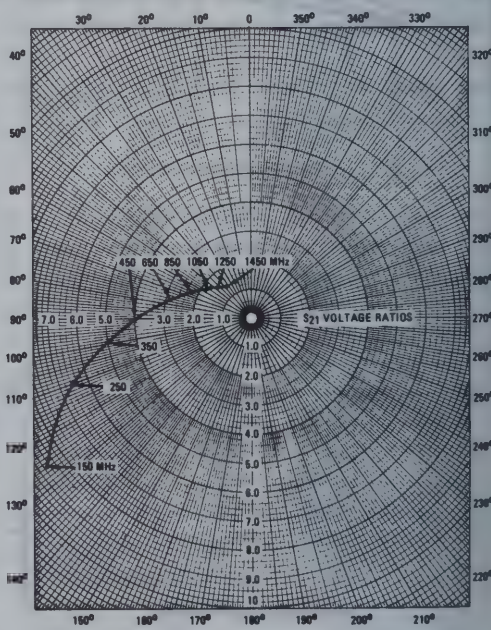


FIGURE 11 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



2N5836 SCATTERING PARAMETERS
(I_C = 100 mAdc, V_{CE} = 10 Vdc, Z_G = Z_L = 50 Ohms)

FIGURE 12 – S_{11}, INPUT REFLECTION COEFFICIENT

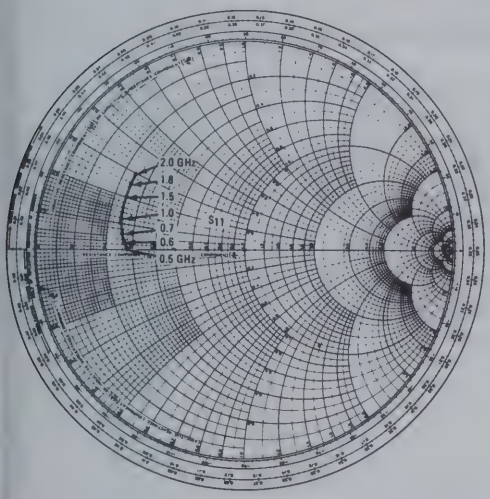


FIGURE 13 – S_{22}, OUTPUT REFLECTION COEFFICIENT

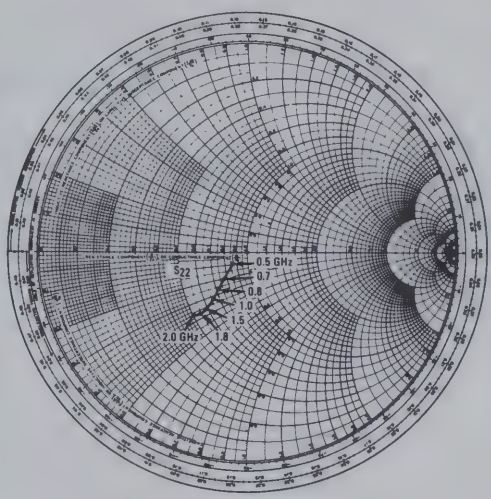


FIGURE 14 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

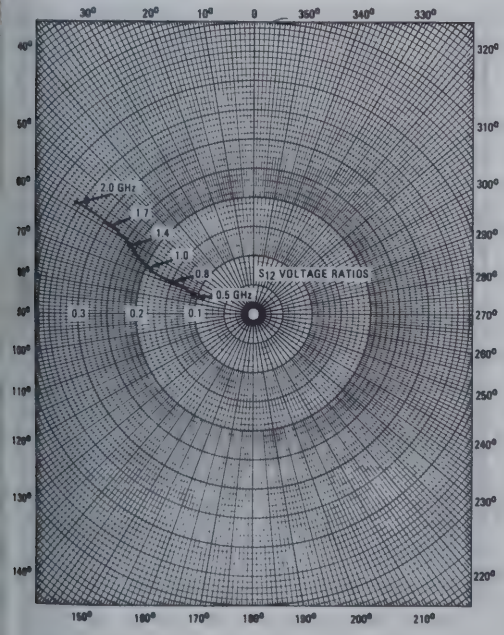
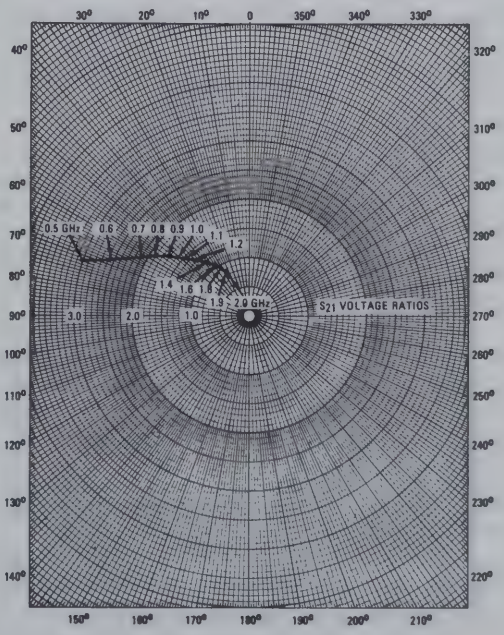


FIGURE 15 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



2N5837 SCATTERING PARAMETERS
(I_C = 100 mAdc, V_{CE} = 3.0 Vdc, $Z_G = Z_L$ = 50 Ohms)

FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT

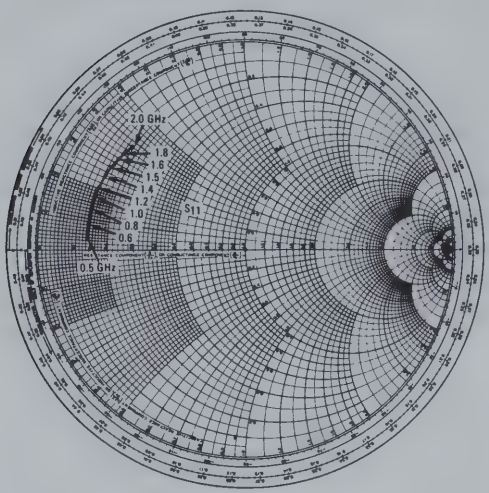


FIGURE 17 – S_{22}, OUTPUT REFLECTION COEFFICIENT

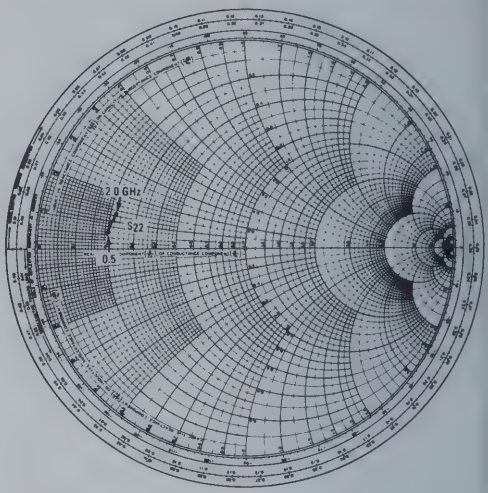


FIGURE 18 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

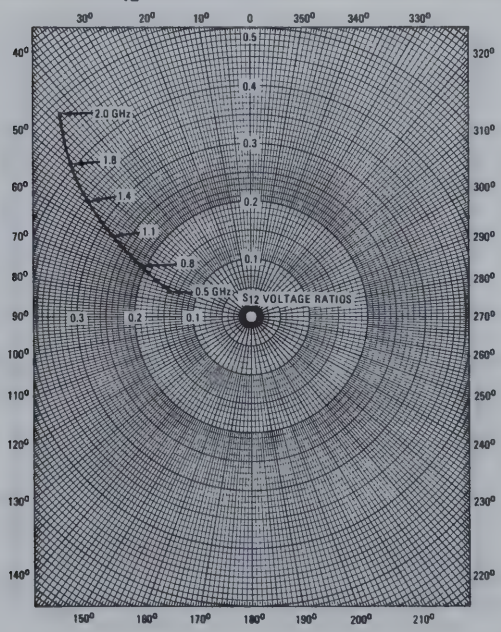
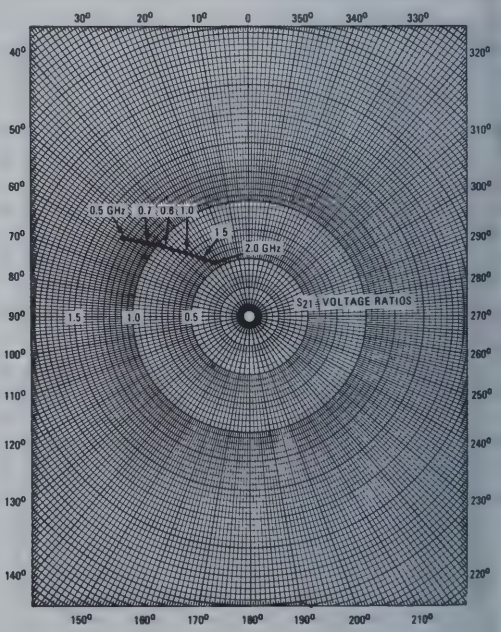


FIGURE 19 – S_{21}, FORWARD TRANSMISSION COEFFICIENT



2N5841 (SILICON)
2N5842

NPN SILICON RF TRANSISTORS

. . . designed to provide ultra-fast switching times in current-mode circuits at collector currents to 80 mAdc.

- High Current-Gain—Bandwidth Product — @ I_C = 25 mAdc
  f_T = 2.2 GHz (Min) 2N5841
  1.7 GHz (Min) 2N5842
- Low Collector-Base Capacitance —
  C_{cb} = 1.5 pF (Max) @ V_{CB} = 4.0 Vdc
- Fast Non-Saturated Switching Times — @ I_C = 30 mAdc
  Typical Values
  $t_{d(on)}$ = 0.4 ns
  t_r = 0.18 ns
  $t_{d(off)}$ = 0.3 ns
  t_f = 0.20 ns

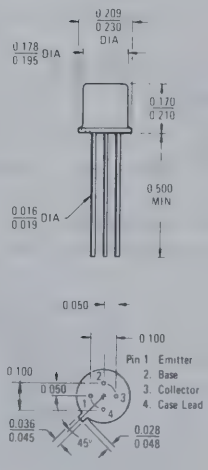
NPN SILICON RF TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	350 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



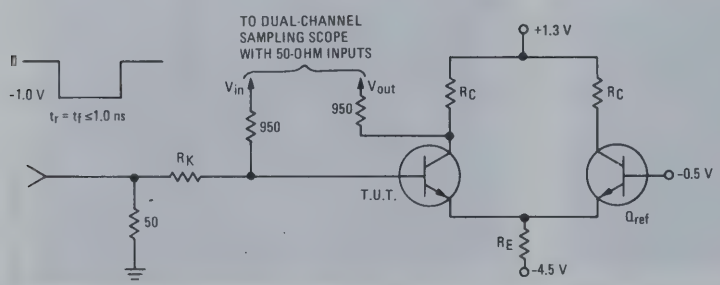
CASE 20 (10)
TO-72 PACKAGE
ACTIVE ELEMENTS ISOLATED FROM CASE

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)		$V_{CEO(sus)}$	10	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	20	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	–	–	20	nAdc
Emitter Cutoff Current (V_{BE} = 2.5 Vdc, I_C = 0)		I_{EBO}	–	–	100	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 25 mAdc, V_{CE} = 4.0 Vdc)	2N5841 2N5842	h_{FE}	25 25	– –	200 250	–
Base-Emitter On Voltage (I_C = 25 mAdc, V_{CE} = 4.0 Vdc)		$V_{BE(on)}$	–	–	1.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				GHz
(I_C = 10 mAdc, V_{CE} = 4.0 Vdc, f = 200 MHz)	2N5841		2.0	2.6	–	
	2N5842		–	2.0	–	
(I_C = 25 mAdc, V_{CE} = 4.0 Vdc, f = 200 MHz)	2N5841		2.2	2.7	–	
	2N5842		1.7	2.0	–	
(I_C = 50 mAdc, V_{CE} = 4.0 Vdc, f = 200 MHz)	2N5841		–	2.2	–	
	2N5842		–	1.5	–	
Collector-Base Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, f = 100 MHz)		C_{cb}	–	0.9	1.5	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 MHz)		C_{eb}	–	0.7	1.1	pF
Collector-Base Time Constant		$r_b'C_c$				ps
(I_C = 25 mAdc, V_{CE} = 4.0 Vdc, f = 31.8 MHz)	2N5841		–	18	25	
	2N5842		–	25	40	
SWITCHING CHARACTERISTICS						
Turn-On Delay Time	(I_C = 30 mAdc)	$t_{d(on)}$	–	0.40	–	ns
Rise Time		t_r	–	0.18	–	ns
Turn-Off Delay Time	(I_C = 30 mAdc)	$t_{d(off)}$	–	0.30	–	ns
Fall Time		t_f	–	0.20	–	ns

*Indicates JEDEC Registered Data

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



V_{in} and V_{out} are attenuated 20:1 at scope inputs. Before attenuation, $V_{in} = V_{out} = 1.0$ V.
Q_{ref} is a transistor of the same type as the transistor under test.

I_C mA	R_E Ohms	R_C Ohms	R_K Ohms
1.0	3.8 k	1.0 k	950
2.0	1.9 k	500	450
4.0	950	250	200
6.0	635	167	117
8.0	475	125	75
10	380	100	50
20	190	50	0
40	95	25	0
60	64	16-17	0
80	48	12-13	0
100	38	10	0

FIGURE 2 – CURRENT GAIN BANDWIDTH PRODUCT

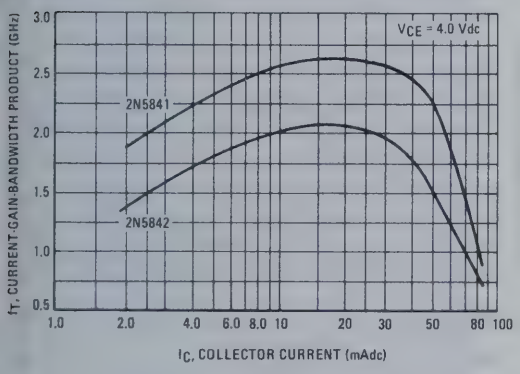


FIGURE 3 – COLLECTOR-BASE TIME CONSTANT

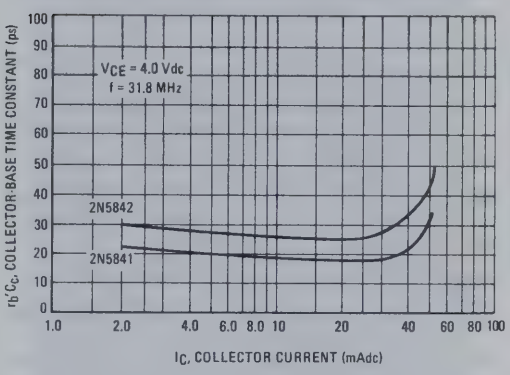


FIGURE 4 – SWITCHING TIMES

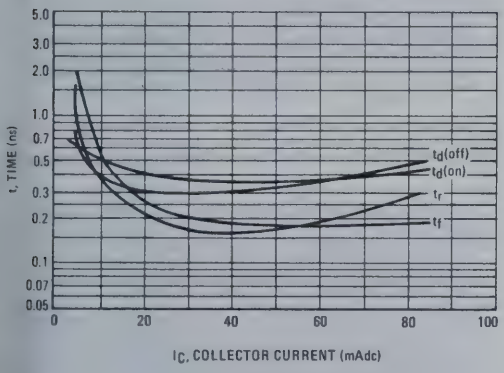


FIGURE 5 – CAPACITANCES

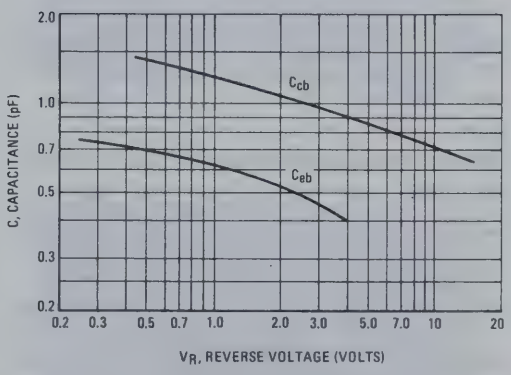


FIGURE 6 – BASE-EMITTER VOLTAGE versus CURRENT

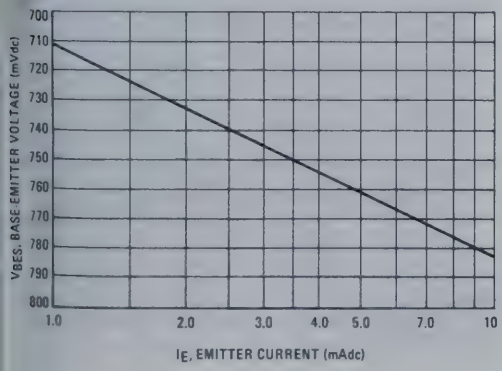
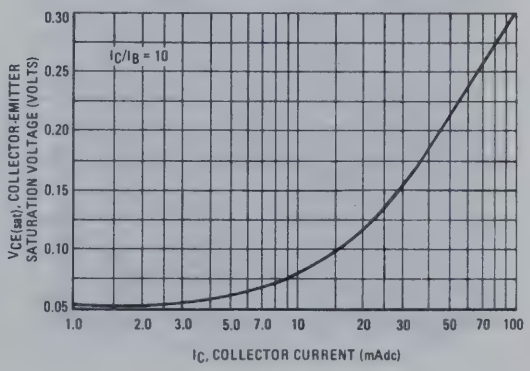


FIGURE 7 – COLLECTOR-EMITTER SATURATION VOLTAGE



V_{CE} = 4.0 Vdc, I_C = 10 mAdc

FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

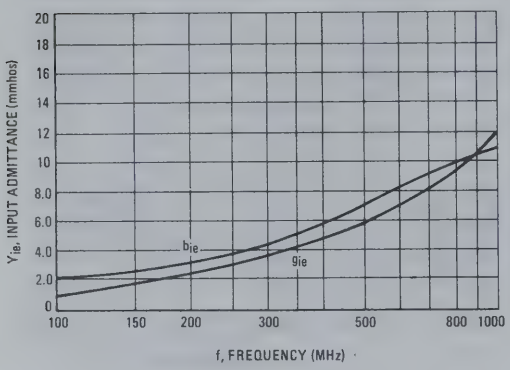


FIGURE 9 – OUTPUT ADMITTANCE versus FREQUENCY

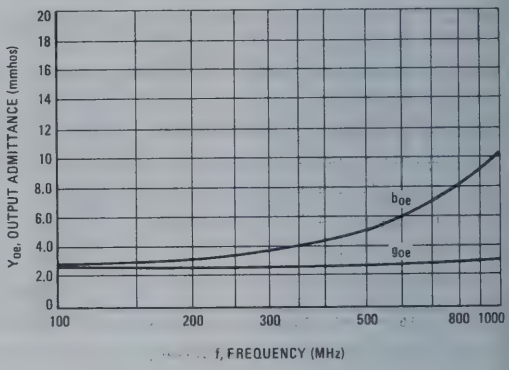


FIGURE 10 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

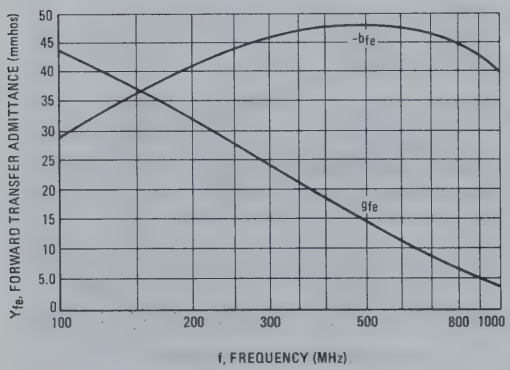
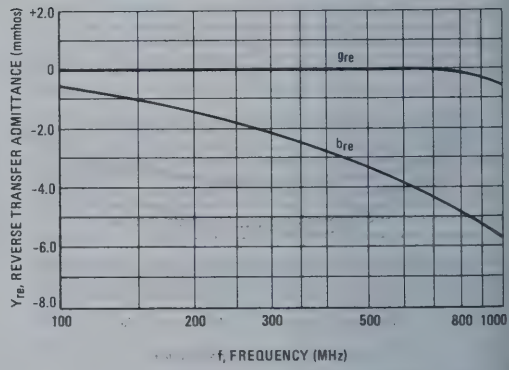
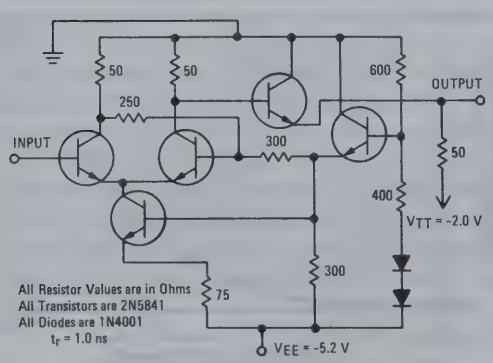


FIGURE 11 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



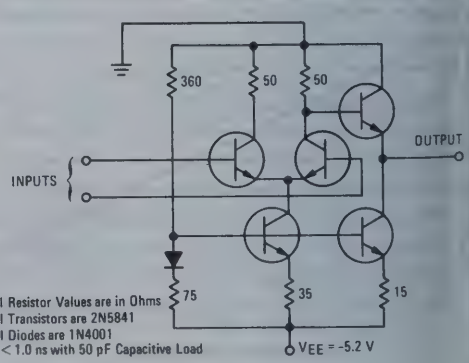
NON-SATURATED SWITCHING APPLICATIONS

SCHMITT TRIGGER



All Resistor Values are in Ohms
All Transistors are 2N5841
All Diodes are 1N4001
t_r = 1.0 ns

HIGH-SPEED CLOCK DRIVER



All Resistor Values are in Ohms
All Transistors are 2N5841
All Diodes are 1N4001
t_r < 1.0 ns with 50 pF Capacitive Load

V_{CE} = 4.0 Vdc, I_C = 10 mAdc

FIGURE 12 – S_{11}, INPUT REFLECTION COEFFICIENT

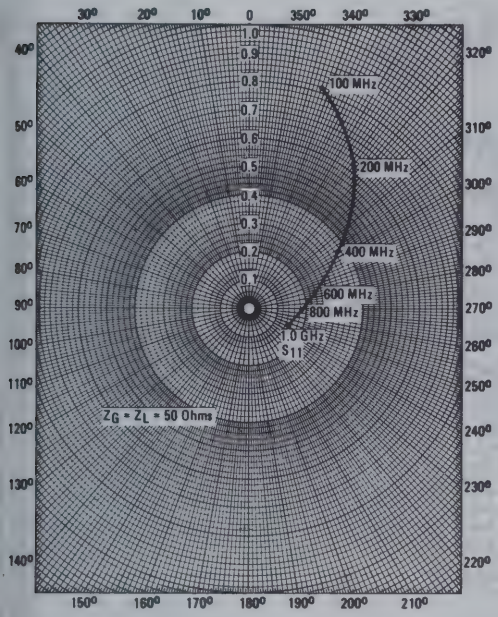


FIGURE 13 – S_{22}, OUTPUT REFLECTION COEFFICIENT

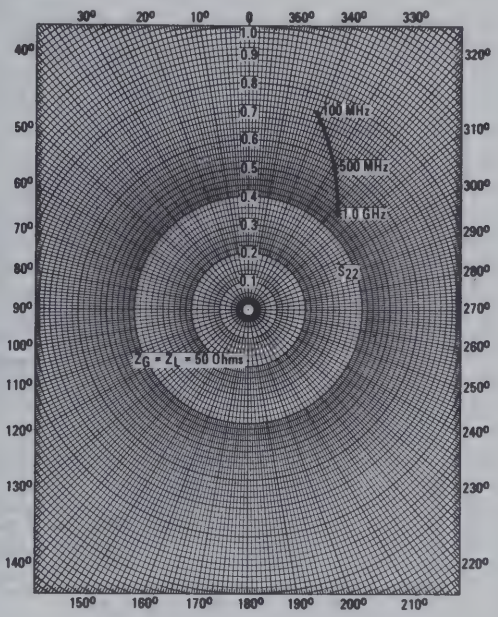


FIGURE 14 – S_{21}, FORWARD TRANSMISSION COEFFICIENT

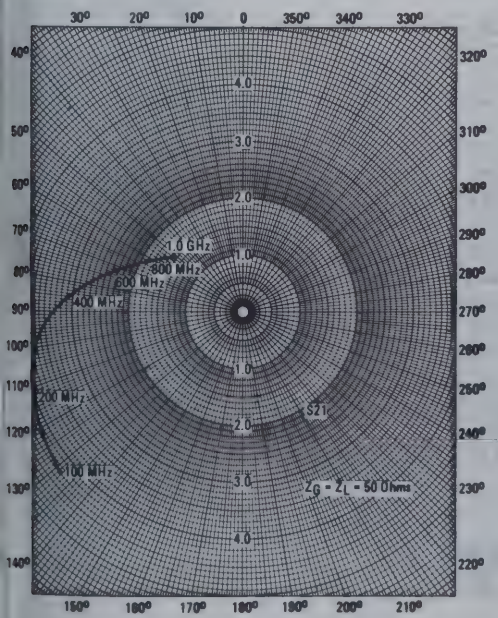
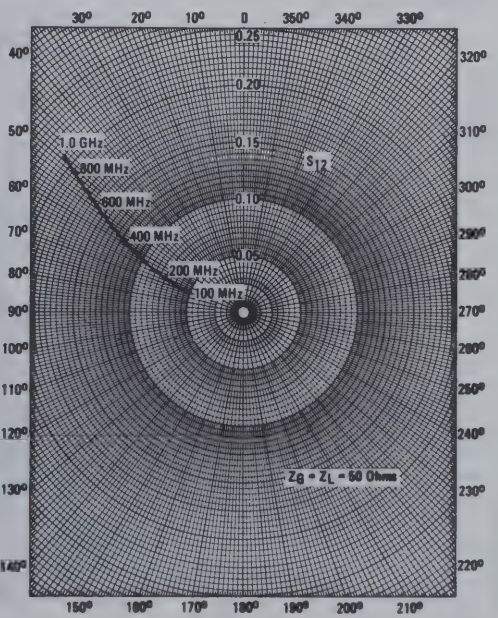


FIGURE 15 – S_{12}, REVERSE TRANSMISSION COEFFICIENT



V_{CE} = 4.0 Vdc, I_C = 10 mAdc

FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT

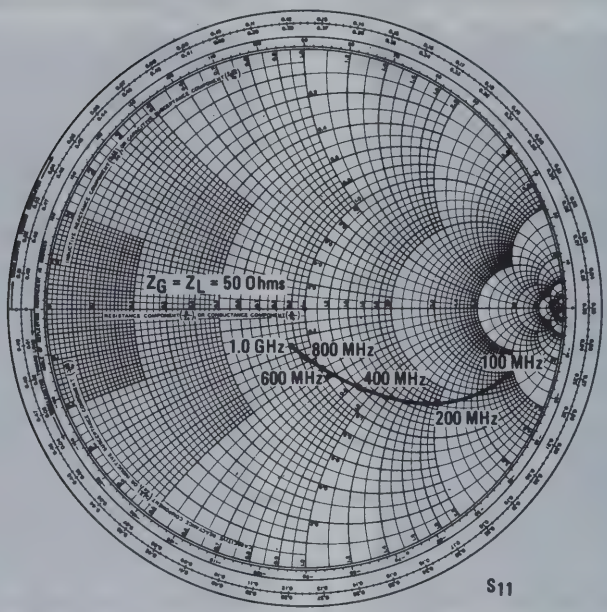
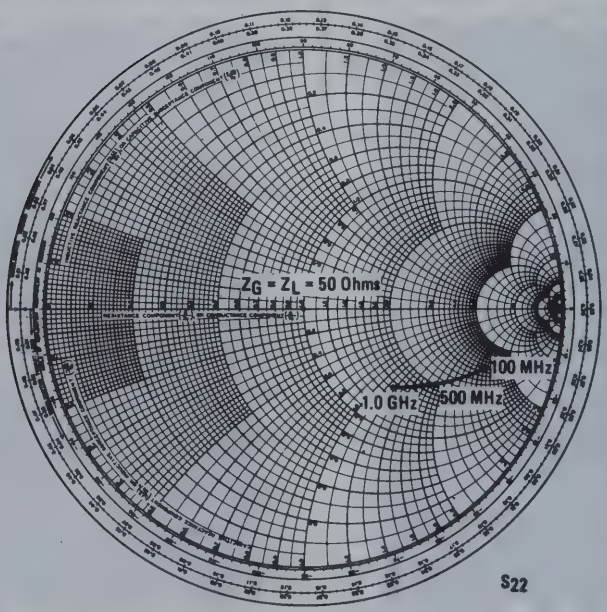


FIGURE 17 – S_{22}, OUTPUT REFLECTION COEFFICIENT



2N5845 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for medium-current saturated switching and core driver applications.

- Fast Switching Times –
  t_{on} – 40 ns (Max) @ V_{CC} = 40 Vdc
  t_{off} – 60 ns (Max) @ V_{CC} = 40 Vdc
- Current-Gain–Bandwidth Product –
  f_T = 200 MHz (Min) @ I_C = 50 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 500 mAdc

NPN SILICON SWITCHING TRANSISTOR



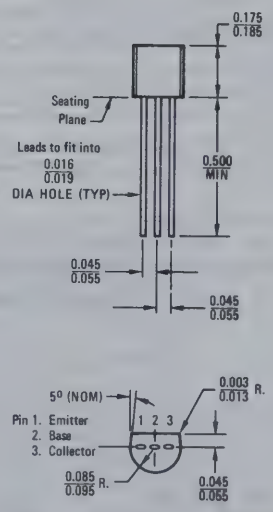
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current – Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.54	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 10.9	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	92	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	220	°C/W

*Indicates JEDEC Registered Data.



CASE 29 (1)
TO-92

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

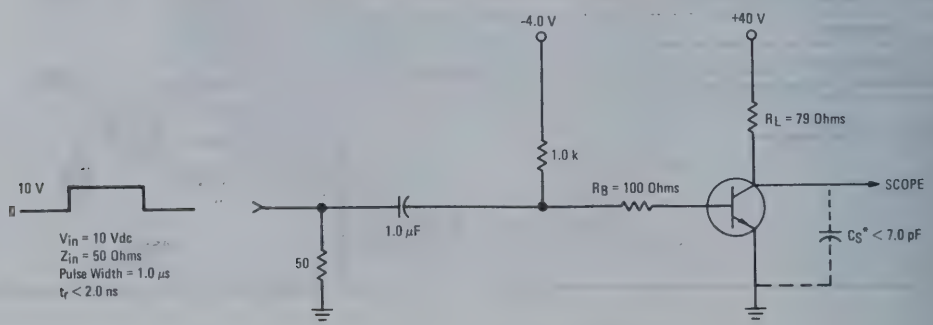
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ① (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	50	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.0	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	500	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	50	nAdc
ON CHARACTERISTICS				
DC Current Gain ① (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	150	–
Collector-Emitter Saturation Voltage ① (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	0.6	Vdc
Base-Emitter Saturation Voltage ① (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	1.1	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product ② (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	9.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	70	pF
SWITCHING CHARACTERISTICS (Figure 1)				
Turn-On Time	(V_{CC} = 40 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	–	40 ns
Delay Time		t_d	–	17 ns
Rise Time		t_r	–	28 ns
Turn-Off Time	(V_{CC} = 40 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	–	60 ns
Storage Time		t_s	–	40 ns
Fall Time		t_f	–	30 ns

*Indicates JEDEC Registered Data.

① Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

② f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



*Total Shunt Capacitance of Test Jig, Connectors, and Oscilloscope.

TRANSIENT CHARACTERISTICS

——— $T_J = 25^oC$ — — — — $T_J = 125^oC$

FIGURE 2 – TURN-ON TIME

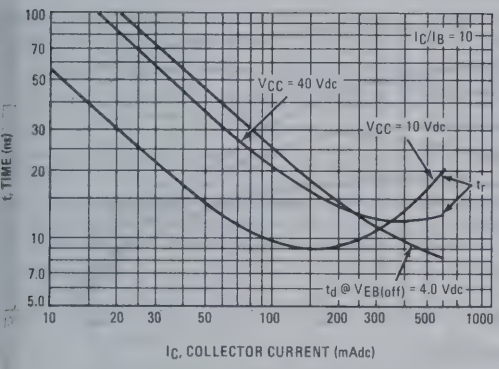


FIGURE 3 – RISE AND FALL TIMES

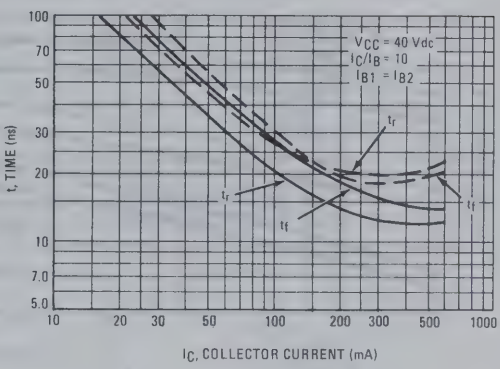


FIGURE 4 – STORAGE TIME

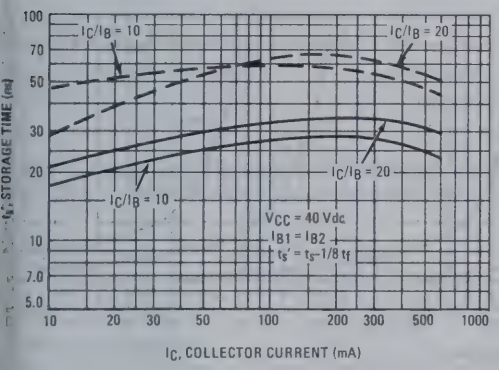


FIGURE 5 – STORAGE TIME versus FORWARD AND REVERSE DRIVE CURRENT

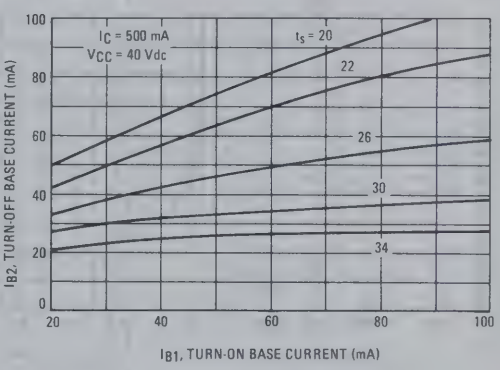


FIGURE 6 – FALL TIME

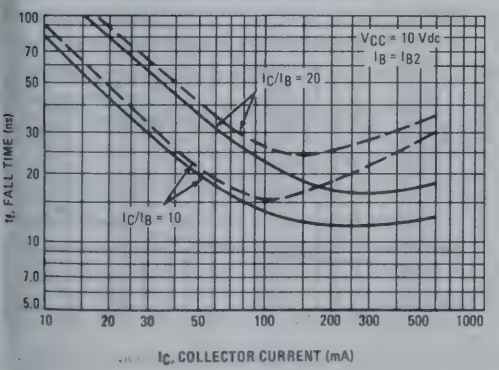
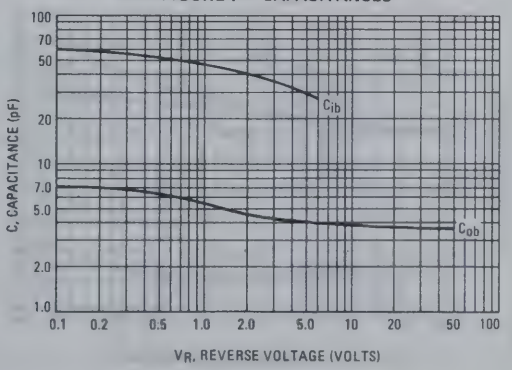


FIGURE 7 – CAPACITANCES



STATIC CHARACTERISTICS

FIGURE 8 – DC CURRENT GAIN

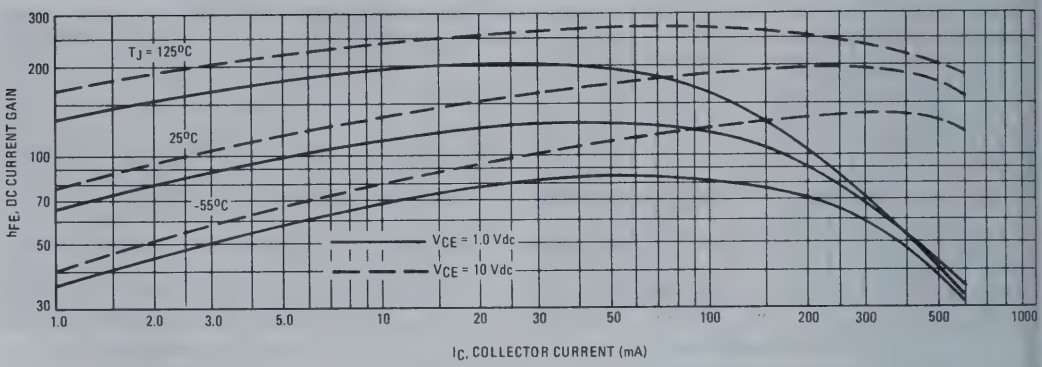


FIGURE 9 – SATURATION REGION

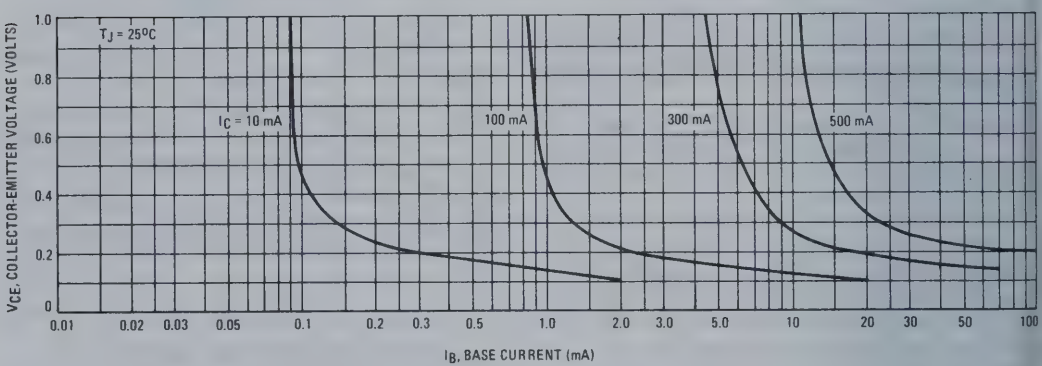


FIGURE 10 – "ON" VOLTAGES

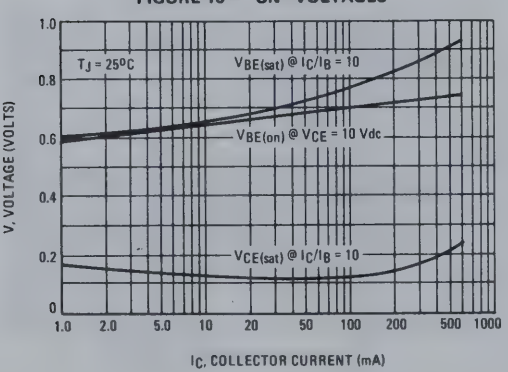
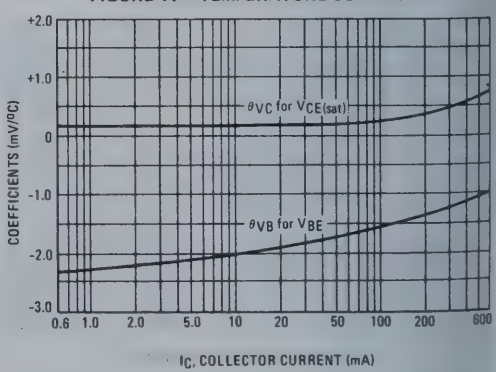


FIGURE 11 – TEMPERATURE COEFFICIENTS



2N5849 (SILICON)

NPN SILICON RF POWER TRANSISTOR

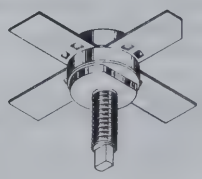
. . . designed primarily for use in large-signal amplifier output stages, the 2N5849 is intended for use in industrial communications equipment operating at frequencies to 80 MHz.

- Optimized for Operation from a 12.5 Volt Supply
- 40 Watts (Min) RF Power Output at 50 MHz
- Balanced Emitter Construction for Burn Out Protection

40 W–50 MHz

RF POWER TRANSISTOR

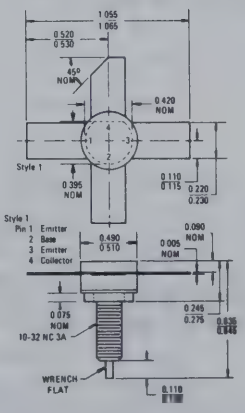
NPN SILICON



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	24	Vdc
Collector-Base Voltage	V_{CB}	48	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	7.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	100 571	Watts mW/^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.



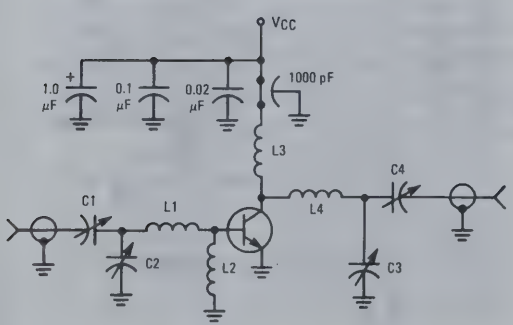
CASE 145A-02

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	24	–	–	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, V_{BE} = 0)	BV_{CES}	48	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, T_A = +125°C)	I_{CES}	–	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.4 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	3.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	180	230	pF
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 50 MHz)	G_{PE}	7.5	–	–	dB
Collector Efficiency (P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 50 MHz)	η	50	–	–	%

*Indicates JEDEC Registered Data.
(1)Pulsed thru a 25 mH Inductor.

FIGURE 1 – 50 MHz POWER GAIN TEST CIRCUIT



C1 25-280 pF, Arco 464 or Equivalent
C2 80-480 pF, Arco 466 or Equivalent
C3 0-75 pF, Hammarlund MAPC 75 or Equivalent
C4 0-50 pF, Hammarlund MAPC 50 or Equivalent
L1 1 Turn #14 AWG 5/16" I.D.
L2 2-1/2 Turns #22 AWG on 3/8" Ferrite Bead
L3 18 Turns #18 AWG 3/8" I.D. 2 Layers, 9 Turns Each
L4 4 Turns #14 AWG 7/16" I.D. 7/16" Long

FIGURE 2 – POWER OUTPUT versus POWER INPUT

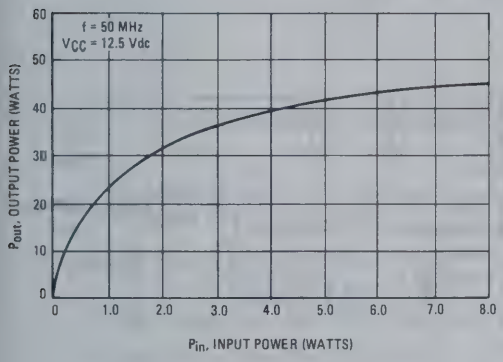


FIGURE 3 – POWER OUTPUT versus FREQUENCY

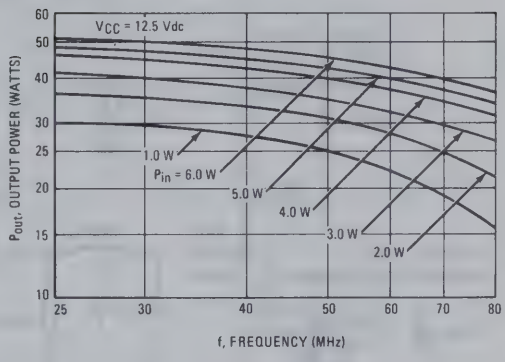


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

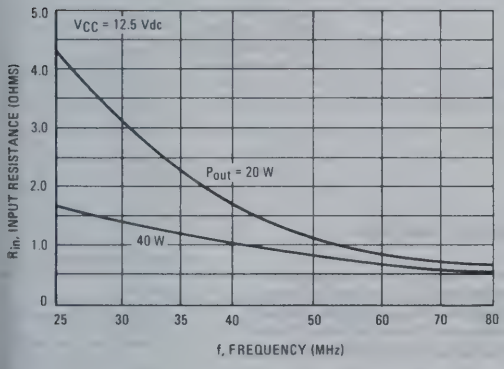


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

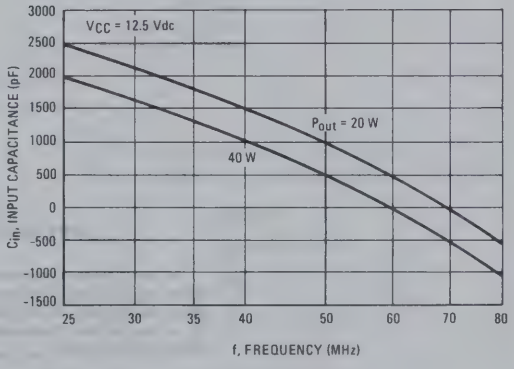


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

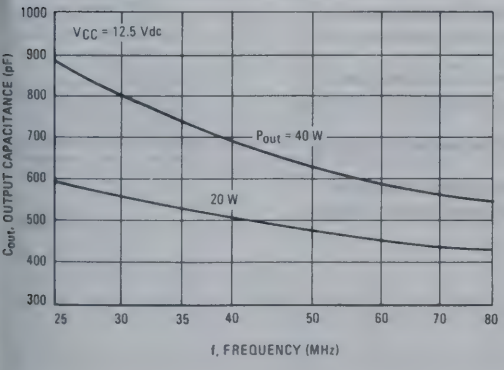
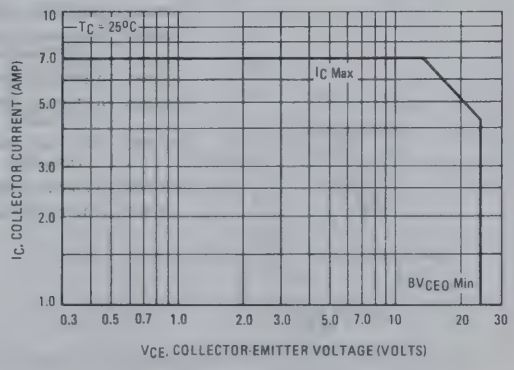
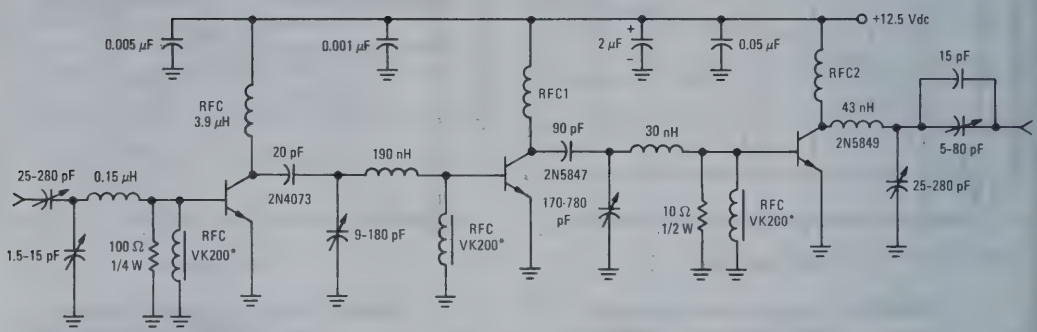


FIGURE 7 – DC SAFE OPERATING AREA



40 WATT, 50 MHz TRANSMITTER SCHEMATIC
(Information obtained from AN-502)



P_o = 40 W
P_{in} = 20 mW
Overall Gain = 33 dB
Overall Efficiency = 59.2%

*Ferroxcube Part Number
RFC1 – 20 Turns #18 AWG, 3/16" I.D., 2 Layers, 10 Turns Each, Close Wound.
RFC2 – 18 Turns, #18 AWG, 3/16" I.D., 2 Layers, 9 Turns Each, Close Wound.

APPLICATION INFORMATION

In addition to a fine selection of quality RF Semiconductors, Motorola provides applications information in the form of Application Notes. Any of the notes listed on this page may be obtained by writing to the Technical Information Center, Motorola Semiconductor Products Inc., P.O. Box 20924, Phoenix, Arizona 85036.

AN-246	A 50-Watt, 50-MHz Solid-State Transmitter
AN-267	Matching Network Designs with Computer Solutions
AN-282	Systemizing RF Power Amplifier Design
AN-477	A 30-Watt, 175-MHz Power Amplifier Using PNP Transistors
AN-481	A Broadband 4-Watt Aircraft Transmitter
AN-495	A 25-Watt, 175-MHz Transmitter for 12.5-Volt Operation
AN-502	A 40-Watt, 50-MHz Transmitter for 12.5-Volt Operation
AN-503	A 25-Watt Broadband Aircraft Transmitter
AN-507	A 13-Watt Broadband AM Aircraft Transmitter

2N5864 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for use in general-purpose amplifier and medium-speed switching applications.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 70 Vdc (Min) @ I_C = 10 mAdc
- DC Current Gain Specified — 50 mA to 500 mA
- High Collector Current — I_C = 1.5 Adc

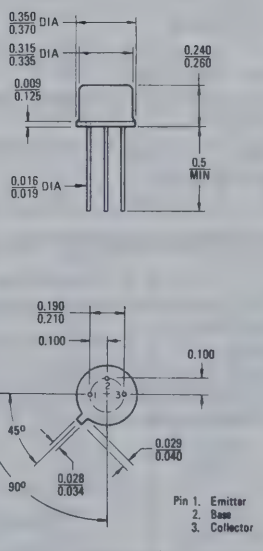
PNP SILICON GENERAL-PURPOSE TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	70	Vdc
Collector-Base Voltage	V_{CB}	90	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	1.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation@T_C = 25°C Derate above 25°C	P_D**	8.75 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data
**Motorola Guarantees this data in addition to JEDEC Registered Data.



CASE 79(1)
TO-39
Collector Connected to Case

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

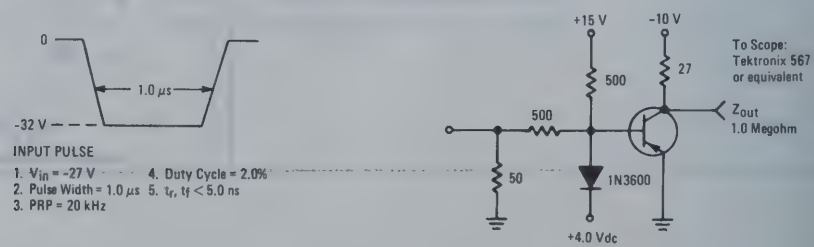
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	70	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	90	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	I_{CBO}	–	0.5	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		50	–	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		50	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		50	500	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)		35	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		25	–	
Collector-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{CE(sat)}$		0.9	Vdc
Base-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc)	$V_{BE(sat)}$**	–	1.25	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	–	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain – Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	f_T	50	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	25	pF
Emitter-Base Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)	C_{eb}**	–	150	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	200	1500	Ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	–	5.0	$X10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	500	–
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	10	200	μmhos

SWITCHING CHARACTERISTICS (See Figure 1)**

Delay Time	(V_{CC} = 10 Vdc, I_C = 300 mAdc, I_{B1} = 30 mAdc)	t_d	–	30	ns
Rise Time		t_r	–	100	ns
Storage Time	(V_{CC} = 10 Vdc, I_C = 300 mAdc, I_{B1} = I_{B2} = 30 mAdc)	t_s	–	500	ns
Fall Time		t_f	–	250	ns

*Indicates JEDEC Registered Data. **Motorola guarantees this data in addition to JEDEC Registered Data.

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.



3N124 (SILICON)
3N125
3N126



CASE 20(4)
TO-72

N-channel silicon annular tetrode-connected field-effect transistors, designed for low-power switching and amplifier applications in the audio through VHF frequency range, features high breakdown voltage, low transfer capacitance, and tetrode configuration for a broad range of applications.

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Gate-Source Voltage			Vdc
Gate 1	V_{G1S}	50	
Gate 2	V_{G2S}	50	
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage			Vdc
Gate 1	V_{DG1}	50	
Gate 2	V_{DG2}	50	
Gate 1-Gate 2 Current	I_{G1G2}	1.0	mAdc
Gate 2-Gate 1 Current	I_{G2G1}	1.0	mAdc
Gate Current			mAdc
Gate 1	I_{G1}	20	
Gate 2	I_{G2}	20	
Drain Current	I_D	20	mAdc
Junction Operating Temperature	T_J	175	^oC
Storage Temperature Range	Tstg	-65 to +175	^oC
Total Device Dissipation @ $T_A = 25^oC$	P_D	300	mW
Derate Above 25^oC		1.71	$mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$	P_D	800	mW
Derate Above 25^oC		4.57	$mW/^oC$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified.)

Characteristic		Symbol	Min	Max	Unit
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0, V_{G1G2} = 0)		$V_{(BR)GSS}$	50	-	Vdc
Gate Reverse Current (V_{GS} = 25 Vdc, V_{DS} = 0, V_{G1G2} = 0)		I_{GSS}	-	0.250	nAdc
(V_{GS} = 25 Vdc, V_{DS} = 0, V_{G1G2} = 0, T_A = +150°C)			-	250	
Zero-Gate-Voltage Drain Current (V_{DS} = 15 Vdc, V_{G1G2} = 0, V_{GS} = 0)	3N124	I_{DSS}	0.2	2.0	mAdc
	3N125		1.5	4.5	
	3N126		3.0	9.0	
Gate-Source Voltage (I_D = 20 μAdc, V_{DS} = 15 Vdc, V_{G1G2} = 0)	3N124	V_{GS}	0.2	2.0	Vdc
(I_D = 150 μAdc, V_{DS} = 15 Vdc, V_{G1G2} = 0)	3N125		1.0	3.0	
(I_D = 300 μAdc, V_{DS} = 15 Vdc, V_{G1G2} = 0)	3N126		1.5	5.5	
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc, V_{G1G2} = 0)	3N124	$V_{GS(off)}$	-	-2.5	Vdc
	3N125		-	-4.0	
	3N126		-	-6.5	
Gate 1-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc, V_{G2S} = 0)	3N124	$V_{G1S(off)}$	-	-5.0	Vdc
	3N125		-	-8.0	
	3N126		-	-18	
Gate 2-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc, V_{G1S} = 0)	3N124	$V_{G2S(off)}$	-	-8.0	Vdc
	3N125		-	-14	
	3N126		-	-26	
Gate 1-Gate 2 Reach Through Voltage (I_{G1G2} = 10 μAdc, I_S = 0, I_D = 0)	3N124	V_{G1G2}	1.0	-	Vdc
	3N125		3.0	-	
	3N126		5.0	-	
Gate 2-Gate 1 Reach Through Voltage (I_{G2G1} = 10 μAdc, I_S = 0, I_D = 0)	3N124	V_{G2G1}	2.0	-	Vdc
	3N125		6.0	-	
	3N126		10	-	
Gate 1-Gate 2 Reach Through Drain Current (V_{DS} = 15 Vdc, I_{G1} = 10 μAdc, V_{G2S} = 0)		I_D	-	1.0	μAdc
Gate 2-Gate 1 Reach Through Drain Current (V_{DS} = 15 Vdc, I_{G2} = 10 μAdc, V_{G1S} = 0)		I_D	-	1.0	μAdc

SMALL-SIGNAL COMMON-SOURCE CHARACTERISTICS

Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, f = 1.0 kHz)					μmhos
Gate 1-Gate 2	3N124	$\lvert y_{fs} \rvert$	500	2000	
	3N125		800	2400	
	3N126		1200	3600	
Gate 1 Only	3N124	$\lvert y_{fs1} \rvert$	250	1000	
	3N125		400	1600	
	3N126		600	2700	
Gate 2 Only	3N124	$\lvert y_{fs2} \rvert$	200	800	
	3N125		250	1000	
	3N126		400	1200	
(V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, f = 100 MHz)					
Gate 1 Only	3N124	$\lvert y_{fs1} \rvert$	250	-	
	3N125		400	-	
	3N126		600	-	
Output Admittance (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, f = 1.0 kHz)	3N124	y_{os}	-	2.0	μmhos
	3N125		-	10	
	3N126		-	20	
Input Capacitance (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, f = 1.0 kHz)					pF
Gate 1-Gate 2		C_{iss}	-	14	
Gate 1 Only		C_{iss1}	-	5.0	
Gate 2 Only		C_{iss2}	-	9.0	
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, f = 1.0 kHz)					pF
Gate 1-Gate 2		C_{rss}	-	2.0	
Gate 1 Only		C_{rss1}	-	0.5	
Gate 2 Only		C_{rss2}	-	1.5	
Spot Noise Figure (V_{DS} = 15 Vdc, V_{G1S} = V_{G2S} = 0, R_S = 1.0 megohm, f = 1.0 kHz, BW = 100 Hz)		NF	-	4.0	dB
			Typ		
Static Drain-Source "ON" Resistance (V_{GS} = 0, V_{DS} = 0)	3N124	$r_{DS(on)}$	1000		ohms
	3N125		750		
	3N126		500		

FIGURE 1 — DRAIN CURRENT versus GATE SOURCE VOLTAGE

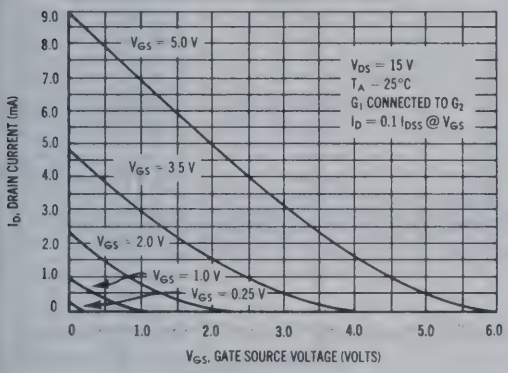


FIGURE 2 — PARAMETER INTER-RELATIONSHIPS

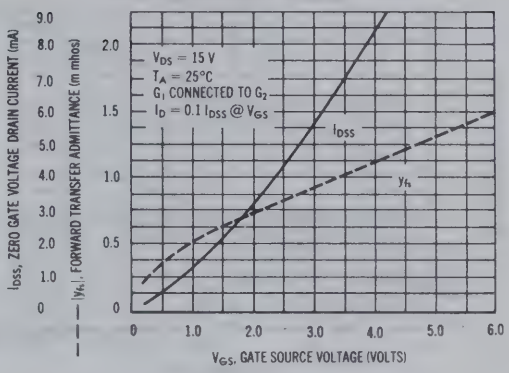


FIGURE 3 — FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

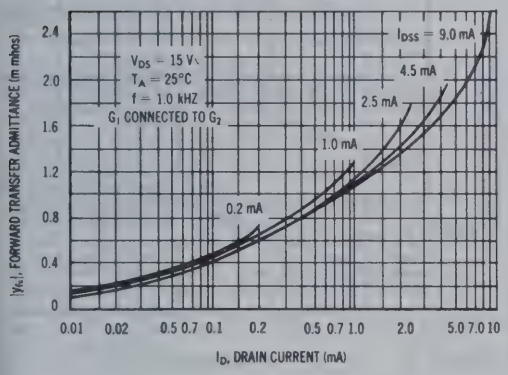
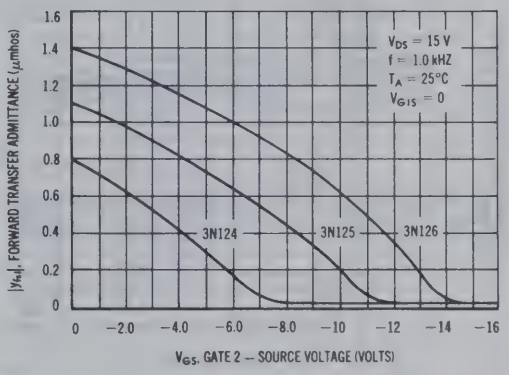


FIGURE 4 GATE 1 — FORWARD TRANSFER ADMITTANCE versus GATE 2 — SOURCE VOLTAGE



NOISE CHARACTERISTICS

V_{DS} = 15 Vdc, I_D = I_{DSS}, T_A = 25°C
GATE 1 CONNECTED TO GATE 2

FIGURE 5A — FREQUENCY VARIATIONS

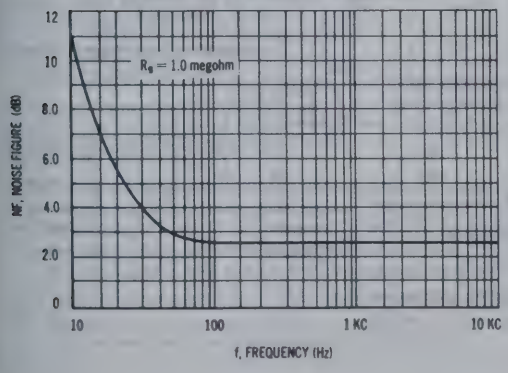
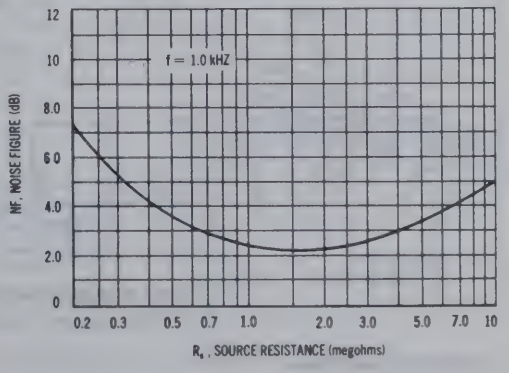


FIGURE 5B — SOURCE RESISTANCE VARIATIONS



HIGH FREQUENCY y PARAMETER CHARACTERISTICS

V_{DS} = 15 Vdc, V_{GS} = 0, T_A = 25°C — GATE 2 CONNECTED TO SOURCE

FIGURE 6 — INPUT ADMITTANCE

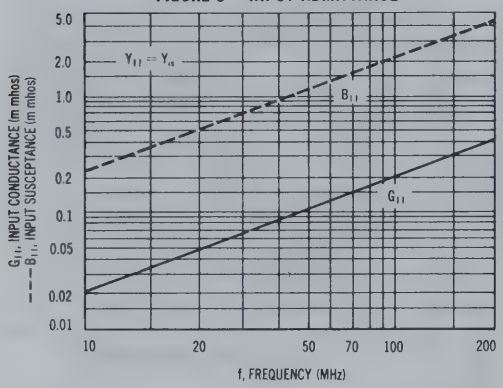


FIGURE 7 — REVERSE TRANSFER ADMITTANCE

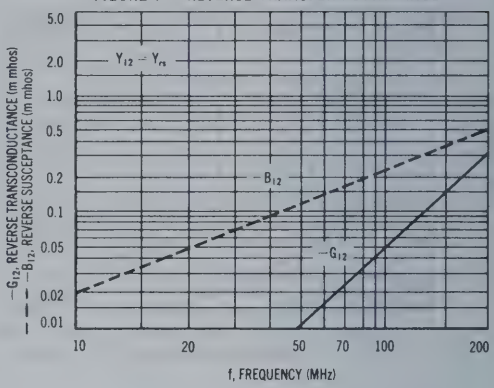


FIGURE 8 — FORWARD TRANSFER ADMITTANCE

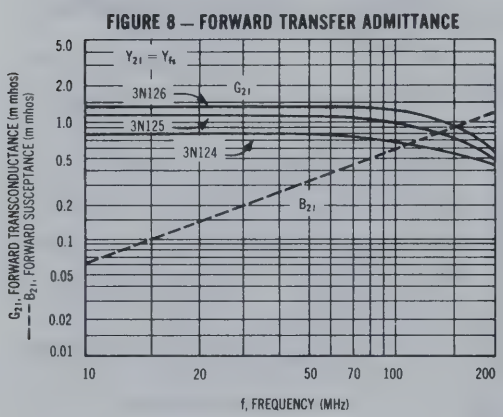
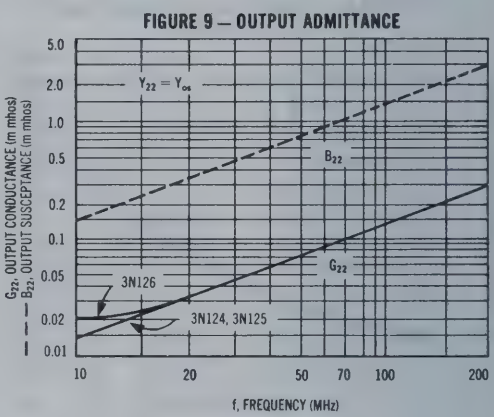
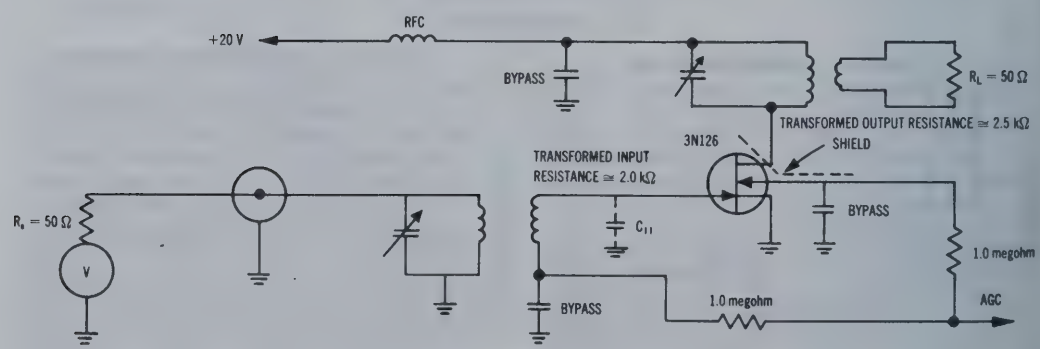


FIGURE 9 — OUTPUT ADMITTANCE



TYPICAL PERFORMANCE USING THE 3N126



CIRCUIT POWER GAIN = 8.0 dB* TYPICAL AT 105 MHz (AGC = 0V)

*Includes circuit losses.

3N140 (SILICON)

N-CHANNEL DUAL-GATE SILICON-NITRIDE PASSIVATED MOS FIELD-EFFECT TRANSISTOR

Depletion mode (Type B) dual-gate transistor designed for VHF amplifier and mixer applications.

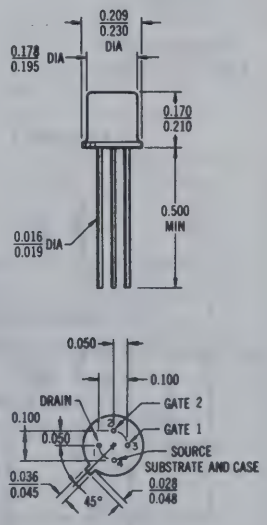
- Silicon-Nitride Passivation for Excellent Long Term Stability
- High Common-Source Power Gain — G_{ps} = 16 dB (Min) @ f = 200 MHz
- Low Reverse Transfer Capacitance — C_{rss} = 0.02 pF (Typ) @ V_{DS} = 13 Vdc

N-CHANNEL
DUAL-GATE MOS FIELD-EFFECT TRANSISTOR
Type B



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	0 to +20	Vdc
Drain-Gate 1 Voltage	V_{DG1}	20	Vdc
Drain-Gate 2 Voltage	V_{DG2}	20	Vdc
Reverse Gate 1-Source Voltage	$V_{GS1(r)}$	-8.0	Vdc
Reverse Gate 2-Source Voltage	$V_{GS2(r)}$	-8.0 to 0.4 V_{DS}	Vdc
Forward Gate 1-Source Voltage	$V_{GS1(f)}$	+1.0	Vdc
Forward Gate 2-Source Voltage	$V_{GS2(f)}$	0.4 V_{DS}	Vdc
Drain Current	I_D	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C



TO-72
CASE 20 (9)

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

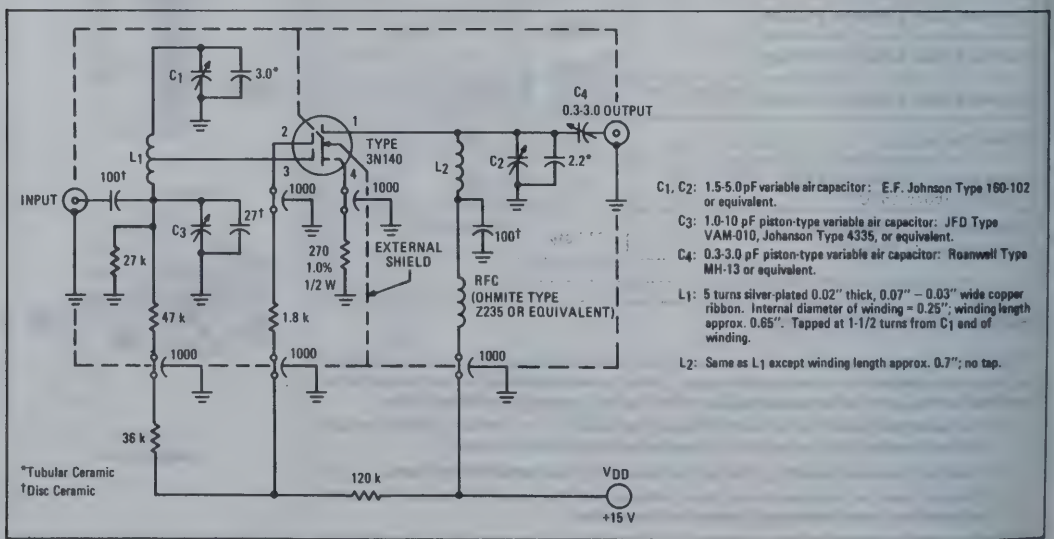
1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate 1-Source Cutoff Voltage (V_{DS} = +16 Vdc, I_D = 200 μAdc, V_{G2S} = +4.0 Vdc)	$V_{G1S(off)}$	-0.5	-4.0	Vdc
Gate 2-Source Cutoff Voltage (V_{DS} = +16 Vdc, I_D = 200 μAdc, V_{G1S} = 0)	$V_{G2S(off)}$	-0.5	-4.0	Vdc
Gate 1-Reverse Current (V_{G1S} = 20 Vdc, V_{G2S} = 0, V_{DS} = 0)	I_{G1SS}	-	1.0	nAdc
(V_{G1S} = 20 Vdc, V_{DS} = 0, V_{G2S} = 0, T_A = 125°C)		-	0.2	μAdc
Gate 2-Reverse Current (V_{G2S} = 20 Vdc, V_{G1S} = 0, V_{DS} = 0)	I_{G2SS}	-	1.0	nAdc
(V_{G2S} = 20 Vdc, V_{DS} = 0, V_{G1S} = 0, T_A = 125°C)		-	0.2	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DD} = +14 Vdc, V_{G1S} = 0, V_{G2S} = +14 Vdc)	I_{DSS}	5.0	30	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transconductance (V_{DD} = +14 Vdc, I_D = 10 mAdc, V_{G2S} = +4.0 Vdc, f = 1.0 kHz)	$Re(y_{fs})$**	6000	18,000	μmhos
Input Capacitance (V_{DS} = +13 Vdc, I_D = 10 mAdc, V_{G2S} = +4.0 Vdc, f = 1.0 MHz)	C_{iss}	3.0	7.0	pF
Reverse Transfer Capacitance (V_{DS} = +13 Vdc, I_D = 10 mAdc, V_{G2S} = +4.0 Vdc, f = 1.0 MHz)	C_{rss}*	0.01	0.03	pF
Common-Source Noise Figure (See Figure 1) (V_{DD} = +15 Vdc, R_S = 275 Ohms, R_G = 50 Ohms, f = 200 MHz)	NF	-	4.5	dB
Power Gain (See Figure 1) (f = 200 MHz)	G_{ps}	16	22	dB
Bandwidth (See Figure 1) (f = 200 MHz)	BW	9.5	14.5	MHz

*Drain-to-Gate 1
**Gate 1-to-Drain

FIGURE 1 – 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



3N155,A (SILICON)
3N156,A



CASE 20 (2)
(TO-72)

P-channel silicon nitride passivated MOS field-effect enhancement mode (Type C) transistors designed for chopper and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	35	Vdc
Drain-Gate Voltage	V_{DG}	35	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = -10 μAdc, V_G = V_S = 0)		$V_{(BR)DSS}$	35	-	-	Vdc
Gate Reverse Current (V_{GS} = +50 Vdc, V_{DS} = 0)		I_{GSS}	-	-	1000	pAdc
(V_{GS} = +25 Vdc, V_{DS} = 0)			-	-	10	
Zero-Gate Voltage Drain Current (V_{DS} = -10 Vdc, V_{GS} = 0)	3N155, 3N156	I_{DSS}	-	-	1.0	nAdc
	3N155A, 3N156A		-	-	0.25	
(V_{DS} = -10 Vdc, V_{GS} = 0, T_A = 125°C)	3N155, 3N156		-	-	1000	
	3N155A, 3N156A		-	-	250	
Resistance Drain Source (I_D = 0, V_{GS} = 0)		$R_{DS(off)}$	$1 \times 10^{+10}$	-	-	Ohms
Resistance Gate Source Input (V_{GS} = -25 Vdc)		R_{GS}	-	$1 \times 10^{+16}$	-	Ohms
ON CHARACTERISTICS						
Gate Source Threshold Voltage (V_{DS} = -10 Vdc, I_D = -10 μAdc)	3N155, 3N155A	$V_{GS(TH)}$	1.5	-	3.2	Vdc
	3N156, 3N156A		3.0	-	5.0	
Drain Source "ON" Voltage (I_D = -2.0 mAdc, V_{GS} = -10 Vdc)		$V_{DS(on)}$	-	-	-1.0	Vdc
Gate Forward Leakage Current (V_{GS} = -50 Vdc, V_{DS} = 0)		$I_{G(f)}$	-	-	1000	pAdc
(V_{GS} = -25 Vdc, V_{DS} = 0)			-	-	10	
"ON" Drain Current (V_{DS} = -15 Vdc, V_{GS} = -10 Vdc)		$I_{D(on)}$	5.0	-	-	mAdc
Static Drain-Source "ON" Resistance (I_D = 0 mAdc, V_{GS} = -10 Vdc)	3N155, 3N156	$r_{DS(on)}$	-	-	600	Ohms
	3N155A, 3N156A		-	-	300	
SMALL-SIGNAL CHARACTERISTICS						
Drain-Source Resistance (V_{GS} = -10 Vdc, I_D = 0, f = 1.0 kHz)	3N155, 3N156	$r_{ds(on)}$	-	-	600	Ohms
	3N155A, 3N156A		-	-	300	
(V_{GS} = -15 Vdc, I_D = 0, f = 1.0 kHz)	3N155, 3N156		-	-	500	
	3N155A, 3N156A		-	-	250	
Forward Transfer Admittance (V_{DS} = -15 Vdc, I_D = -2.0 mAdc, f = 1.0 kHz)		$\lvert y_{fs} \rvert$	1000	-	4000	μmhos
Input Capacitance (V_{DS} = -15 Vdc, V_{GS} = -10 Vdc, f = 140 kHz)		C_{iss}	-	-	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 140 kHz)		C_{rss}	-	-	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = -10 Vdc, f = 140 kHz)		$C_{d(sub)}$	4.0	-	-	pF
SWITCHING CHARACTERISTICS						
Turn-On Delay	(V_{DD} = -10 Vdc, $I_{D(on)}$ = -2.0 mAdc, $V_{GS(on)}$ = -10 Vdc, $V_{GS(off)}$ = 0) Test Circuit given in Figure 1	t_d	-	-	45	μs
Rise Time		t_r	-	-	65	ns
Turn-Off Delay		t_s	-	-	60	ns
Fall Time		t_f	-	-	100	ns

FIGURE 1 – GATE VOLTAGE EFFECTS

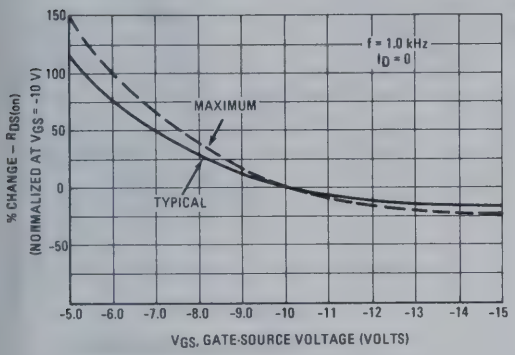


FIGURE 2 – TEMPERATURE EFFECTS

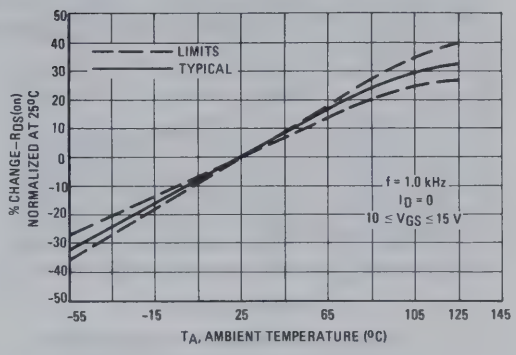


FIGURE 3 – DRAIN CURRENT versus TEMPERATURE

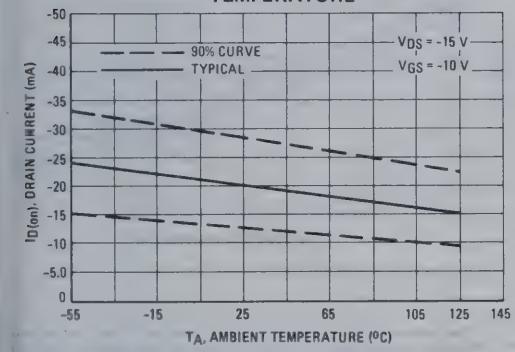


FIGURE 4 – "ON" DRAIN-SOURCE VOLTAGE

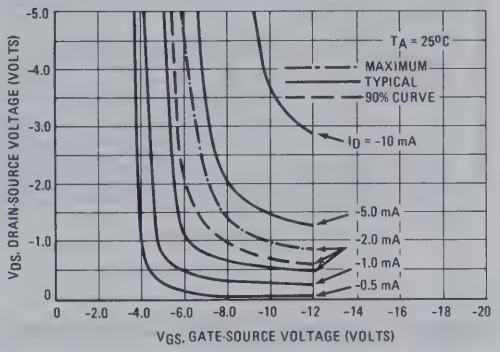


FIGURE 5 – LEAKAGE CURRENTS

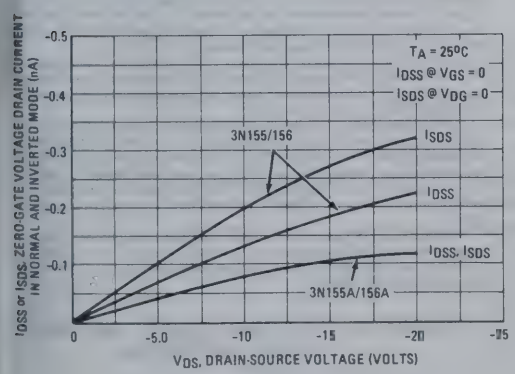
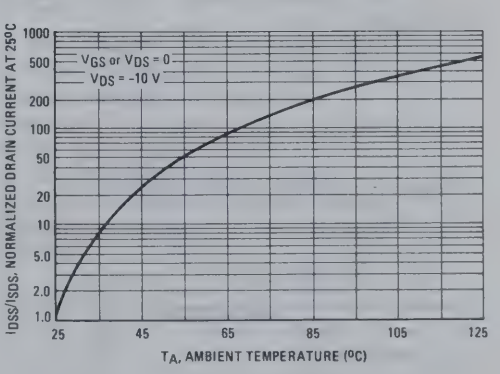


FIGURE 6 – LEAKAGE CURRENT versus TEMPERATURE



SWITCHING CHARACTERISTICS

$T_A = 25^oC$

FIGURE 7 – TURN-ON DELAY TIME

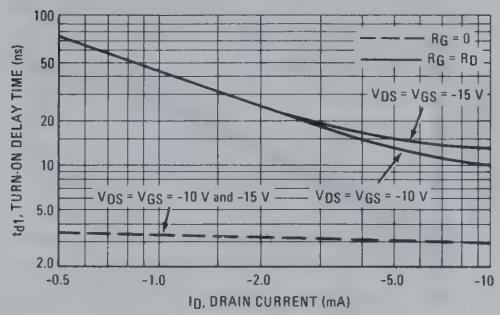


FIGURE 8 – RISE TIME

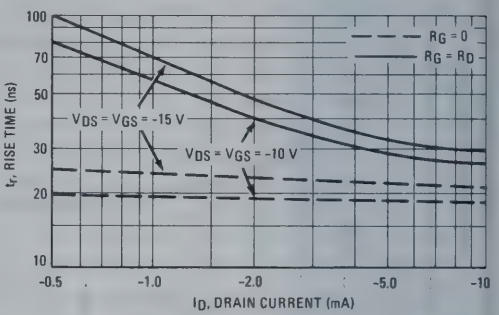


FIGURE 9 – TURN-OFF DELAY TIME

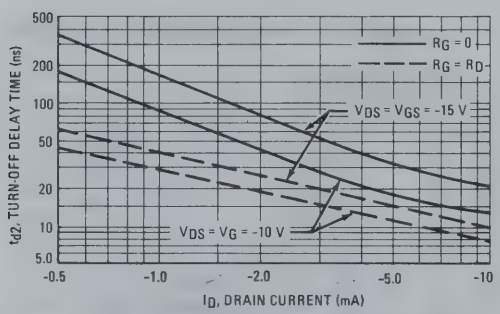


FIGURE 10 – FALL TIME

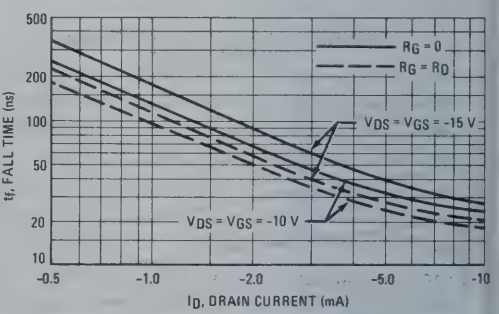
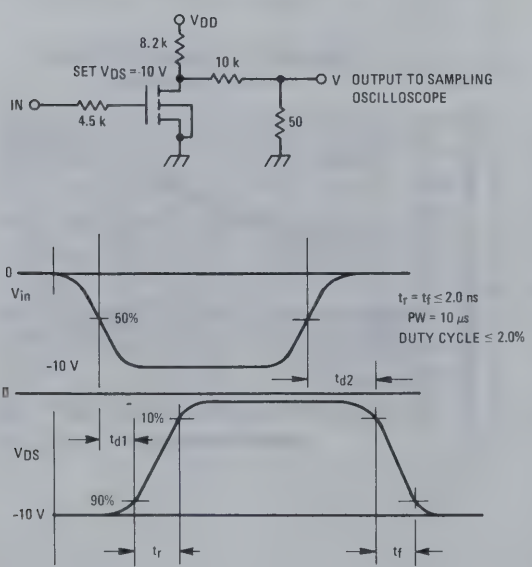


FIGURE 11 – SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 11. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

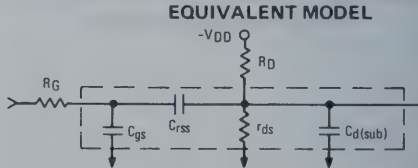
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_G (generator impedance) (Figure 12). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_G and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with d_s. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_G = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_G = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_G = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 12 – SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



3N157,A (SILICON)
3N158,A



CASE 20 (2)
(TO-72)

P-channel silicon nitride passivated MOS field-effect enhancement mode (Type C) transistors designed for amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	3N157 3N158	3N157A 3N158A	Unit
Drain-Source Voltage	V_{DS}	35	50	Vdc
Drain-Gate Voltage	V_{DG}	35	50	Vdc
Gate-Source Voltage	V_{GS}	50		Vdc
Drain Current	I_D	30		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7		mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = -10 μAdc, V_G = V_S = 0)	3N157, 3N158 3N157A, 3N158A	$V_{(BR)DSS}$	35 50	- -	- -	Vdc
Gate Reverse Current (V_{GS} = +25 Vdc, V_{DS} = 0)		I_{GSS}	-	-	10	pAdc
Zero-Gate Voltage Drain Current (V_{DS} = -15 Vdc, V_{GS} = 0)	3N157, 3N158 3N157A, 3N158A	I_{DSS}	- -	- -	1.0 0.25	nAdc
(V_{DS} = -35 Vdc, V_{GS} = 0)	3N157, 3N158		-	-	10	μAdc
(V_{DS} = -50 Vdc, V_{GS} = 0)	3N157A, 3N158A		-	-	10	
Input Resistance (V_{GS} = -25 Vdc)		R_{GS}	-	$1 \times 10^{+12}$	-	Ohms
ON CHARACTERISTICS						
Gate-Source Threshold Voltage (V_{DS} = -15 Vdc, I_D = -10 μAdc)	3N157, 3N157A 3N158, 3N158A	$V_{GS(TH)}$	1.5 3.0	- -	3.2 5.0	Vdc
Gate-Source Voltage (V_{DS} = -15 Vdc, I_D = -0.5 mAdc)	3N157, 3N157A 3N158, 3N158A	V_{GS}	1.5 3.0	- -	5.5 7.0	Vdc
Gate Forward Current (V_{GS} = -25 Vdc, V_{DS} = 0)		$I_{G(f)}$	-	-	10	pAdc
(V_{GS} = -25 Vdc, V_{DS} = 0, T_A = +55°C)			-	-	10	nAdc
"ON" Drain Current (V_{DS} = -15 Vdc, V_{GS} = -10 Vdc)		$I_{D(on)}$	5.0	-	-	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = -15 Vdc, I_D = -2.0 mAdc, f = 1.0 kHz)		$\lvert y_{fs} \rvert$	1000	-	4000	μmhos
(V_{DS} = -15 Vdc, V_{GS} = -15 Vdc, f = 1.0 kHz)			1800	-	-	
Output Admittance (V_{DS} = -15 Vdc, I_D = -2.0 mAdc, f = 1.0 kHz)		$\lvert y_{os} \rvert$	-	-	60	μmhos
Input Capacitance (V_{DS} = -15 Vdc, V_{GS} = 0, f = 140 kHz)		C_{iss}	-	-	5.0	pF
Reverse Transfer Capacitance (V_{DS} = -15 Vdc, V_{GS} = 0, f = 140 kHz)		C_{rss}	-	-	1.3	pF
Drain-Substrate Capacitance ($V_{D(sub)}$ = -10 Vdc, f = 140 kHz)		$C_{d(sub)}$	-	-	4.0	pF
Noise Voltage (R_S = 0, BW = 1.0 Hz, V_{DS} = -15 Vdc, I_D = -2.0 mAdc, f = 100 Hz)		e_n	-	300	-	$NV/\sqrt{Hz}$
(R_S = 0, BW = 1.0 Hz, V_{DS} = -15 Vdc, I_D = -2.0 mAdc, f = 1.0 kHz)			-	120	500	

FIGURE 1 – FORWARD TRANSCONDUCTANCE

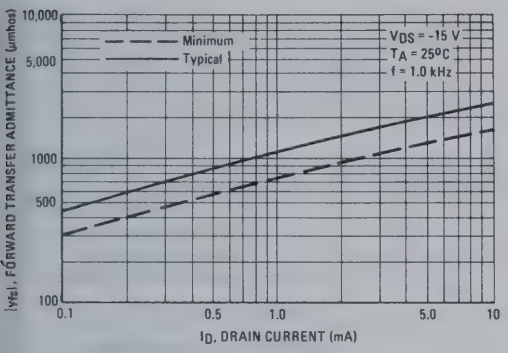


FIGURE 2 – OUTPUT TRANSCONDUCTANCE

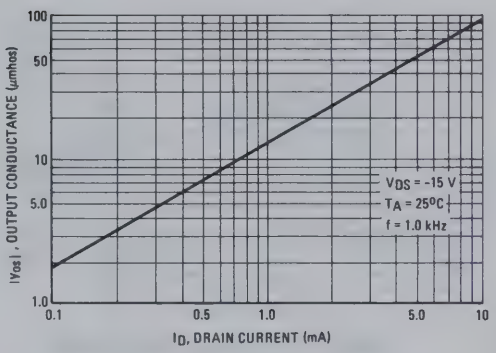


FIGURE 3 – FORWARD TRANSCONDUCTANCE versus TEMPERATURE

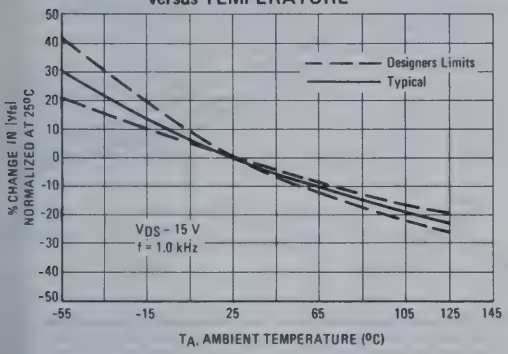


FIGURE 4 – BIAS CURVE

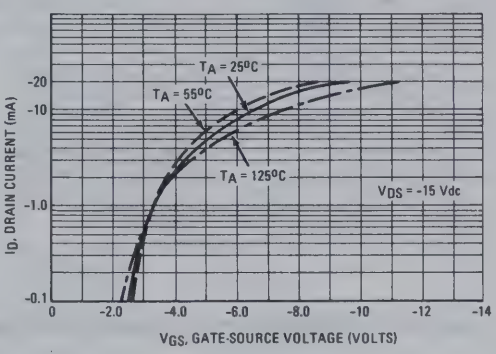


FIGURE 5 – "ON" DRAIN-SOURCE VOLTAGE

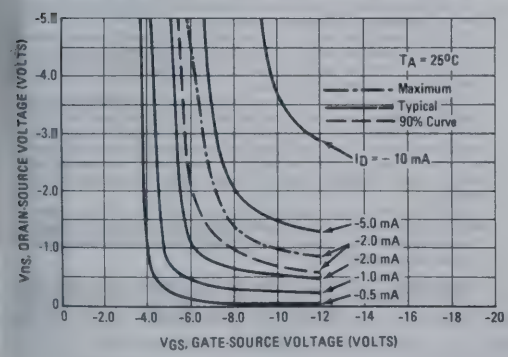
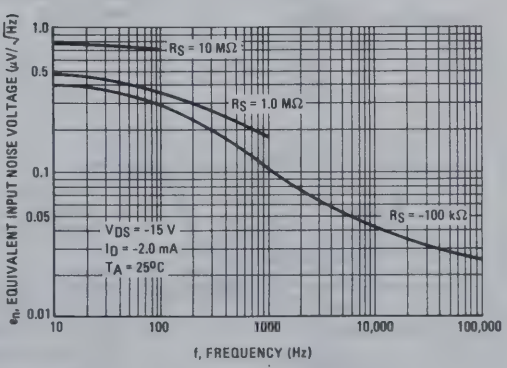


FIGURE 6 – EQUIVALENT INPUT NOISE VOLTAGE



SWITCHING CHARACTERISTICS

(T_A = 25°C)

FIGURE 7 – TURN-ON DELAY TIME

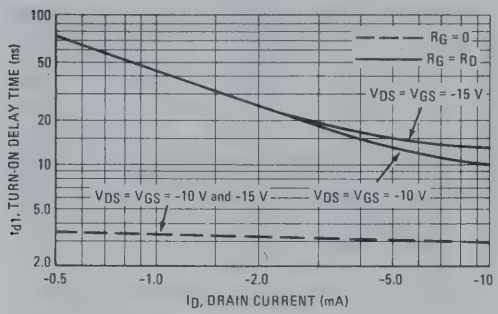


FIGURE 8 – RISE TIME

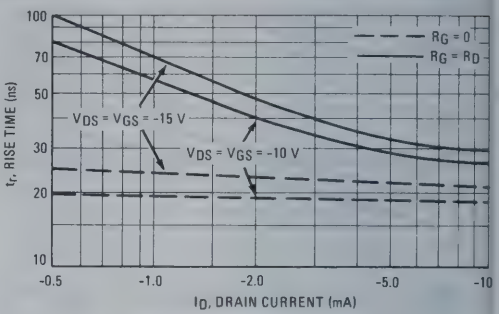


FIGURE 9 – TURN-OFF DELAY TIME

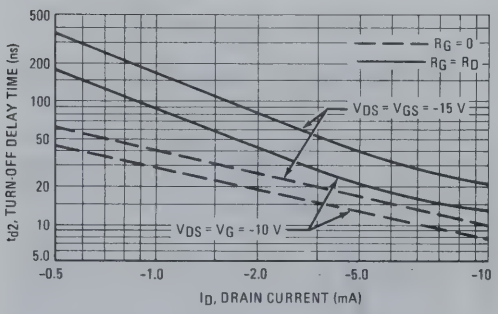


FIGURE 10 – FALL TIME

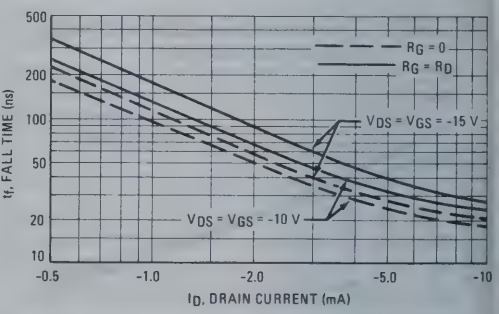
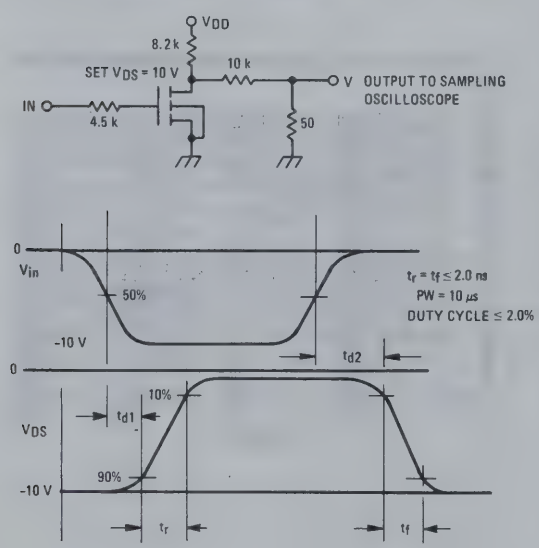


FIGURE 11 – SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 11. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

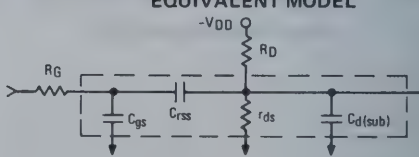
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_G (generator impedance) (Figure 12). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_G and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 5) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_G = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_G = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_G = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 12 – SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



3N169 (SILICON)
3N170
3N171

SILICON N-CHANNEL MOS FIELD-EFFECT TRANSISTORS

Enhancement Mode (Type C) transistors designed for low-power switching applications.

- Low Switching Voltages – $V_{GS(th)} \leqslant 3.0$ Vdc
- Fast Switching Times – $t_r \leqslant 10$ ns
- Low Drain-Source Resistance $r_{ds(on)}$ = 200 Ohms (Max)
- Low Reverse Transfer Capacitance C_{rss} = 1.3 pF (Max)
- Manufactured Using the New Silicon Nitride Process Resulting in a Stable $V_{GS(th)}$ and Gate Oxide Breakdown Protection to Typical Transients of ±150 Volts Peak

MOS FIELD-EFFECT TRANSISTORS

N-CHANNEL

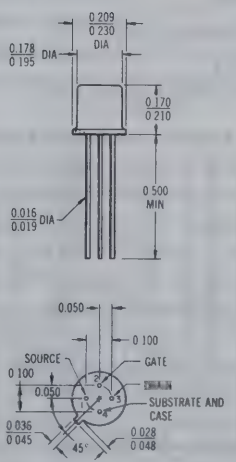
TYPE C



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
*Drain-Source Voltage	V_{DS}	25	Vdc
*Drain-Gate Voltage	V_{DG}	±35	Vdc
*Gate-Source Voltage	V_{GS}	±35	Vdc
*Drain Current	I_D	30	mAdc
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
*Power Dissipation @ T_C = 25°C *Derate above 25°C	P_D	800 4.56	mW mW/°C
Operating Junction Temperature	T_J	175	°C
*Storage Temperature Range	T_{stg}	−65 to +200	°C

*Indicates JEDEC Registered Data.



TO-72
CASE 20 (2)

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Substrate connected to source.

Characteristic		Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_{GS} = 0)		–	$V_{(BR)DSS}$	25	–	Vdc
*Gate Leakage Current		–	I_{GSS}			pAdc
(V_{GS} = –35 Vdc, V_{DS} = 0)				–	10	
(V_{GS} = –35 Vdc, V_{DS} = 0, T_A = 125°C)				–	100	
*Zero-Gate-Voltage Drain Current		–	I_{DSS}			nAdc
(V_{DS} = 10 Vdc, V_{GS} = 0)				–	10	
(V_{DS} = 10 Vdc, V_{GS} = 0, T_A = 125°C)				–	1.0	μAdc
***ON CHARACTERISTICS**						
Gate-Source Threshold Voltage (V_{DS} = 10 Vdc, I_D = 10 μAdc)	3N169	–	$V_{GS(th)}$	0.5	1.5	Vdc
	3N170			1.0	2.0	
	3N171			1.5	3.0	
"ON" Drain Current (V_{GS} = 10 Vdc, V_{DS} = 10 Vdc)		3	$I_{D(on)}$	10	–	mAdc
Drain-Source "ON" Voltage (I_D = 10 mAdc, V_{GS} = 10 Vdc)		–	$V_{DS(on)}$	–	2.0	Vdc
SMALL SIGNAL CHARACTERISTICS						
*Drain-Source Resistance (V_{GS} = 10 Vdc, I_D = 0, f = 1.0 kHz)		4	$r_{ds(on)}$	–	200	Ohms
Forward Transfer Admittance (V_{DS} = 10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)		1	$\|Y_{fs}\|$	1000	–	μmhos
*Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)		2	C_{rss}	–	1.3	pF
*Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)		2	C_{iss}	–	5.0	pF
*Drain-Substrate Capacitance ($V_{D(SUB)}$ = 10 Vdc, f = 1.0 MHz)		–	$C_{d(sub)}$	–	5.0	pF
***SWITCHING CHARACTERISTICS**						
Turn-On Delay Time	(V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = 10 Vdc, $V_{GS(off)}$ = 0, R_G' = 50 Ohms)	6,10	$t_{d(on)}$	–	3.0	ns
Rise Time		7,10	t_r	–	10	ns
Turn-Off Delay Time		8,10	$t_{d(off)}$	–	3.0	ns
Fall Time		9,10	t_f	–	15	ns

*Indicates JEDEC Registered Data.

FIGURE 1 – FORWARD TRANSFER ADMITTANCE

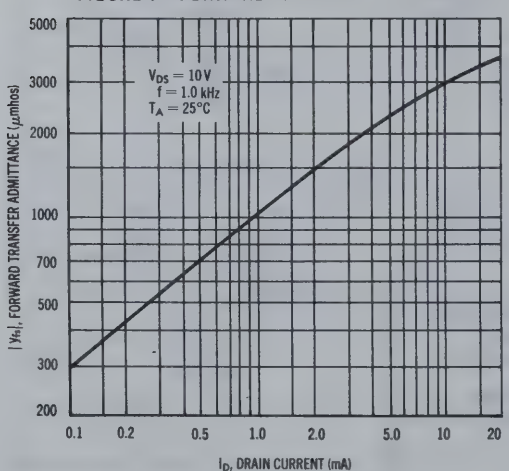


FIGURE 2 – CAPACITANCE

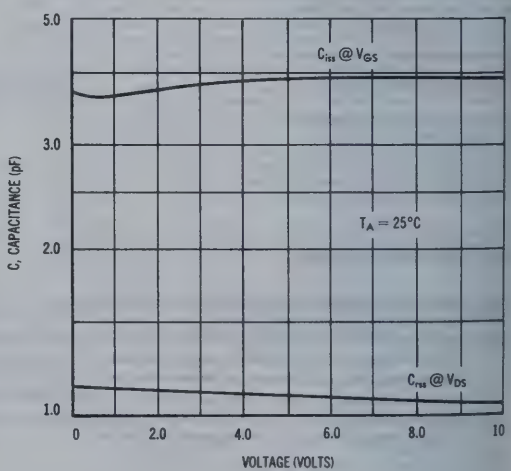


FIGURE 3 – TRANSFER CHARACTERISTICS

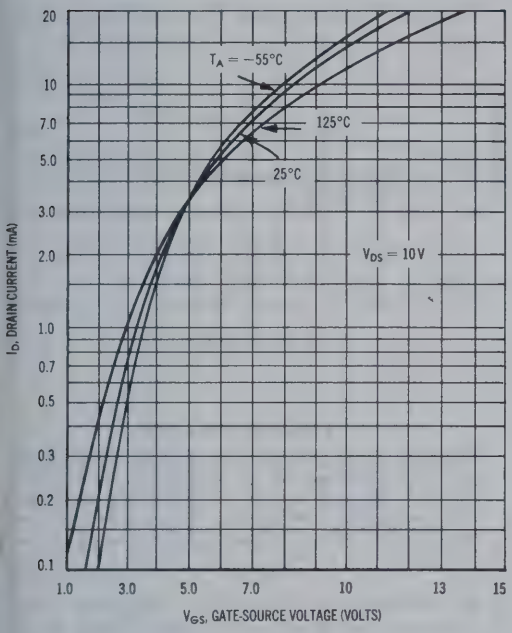


FIGURE 4 – DRAIN-SOURCE "ON" RESISTANCE

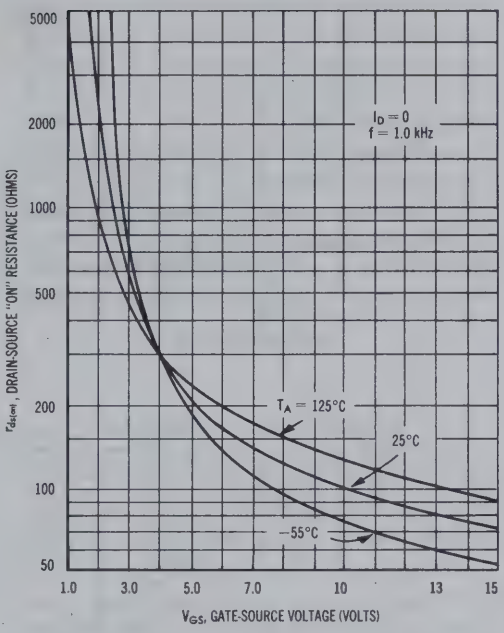
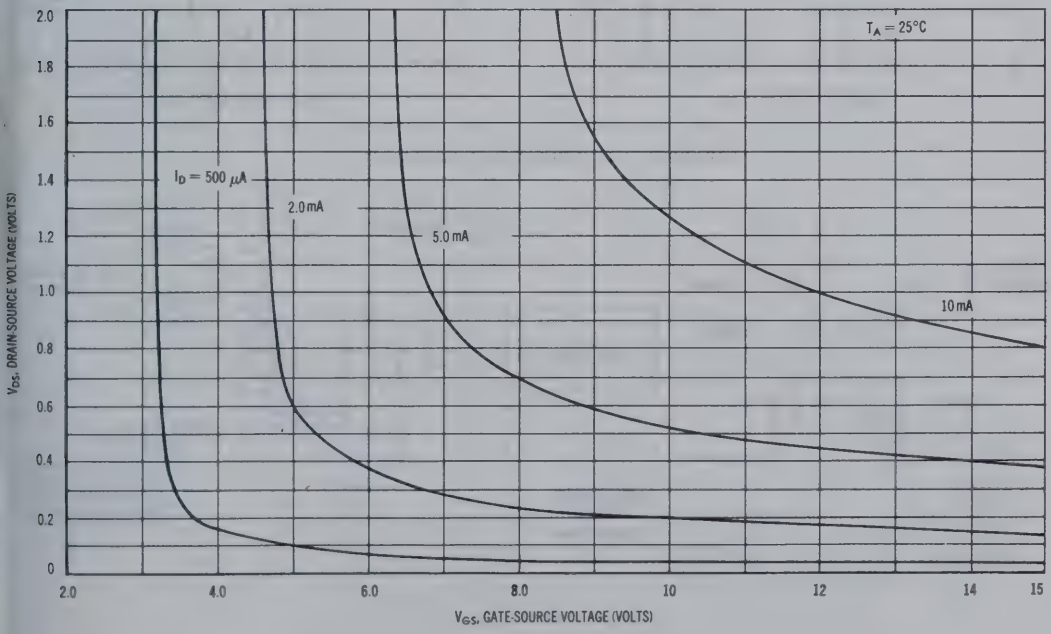


FIGURE 5 – "ON" DRAIN-SOURCE VOLTAGE



TYPICAL SWITCHING CHARACTERISTICS
$T_A = 25^oC$

FIGURE 6 – TURN-ON DELAY TIME

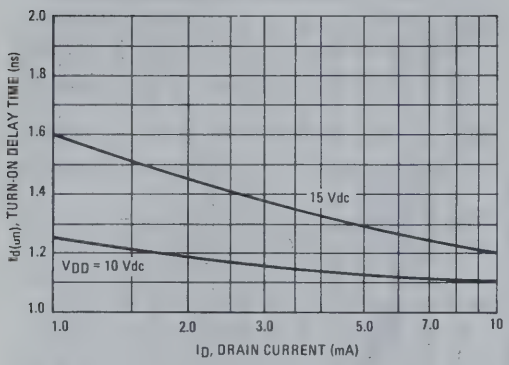


FIGURE 7 – RISE TIME

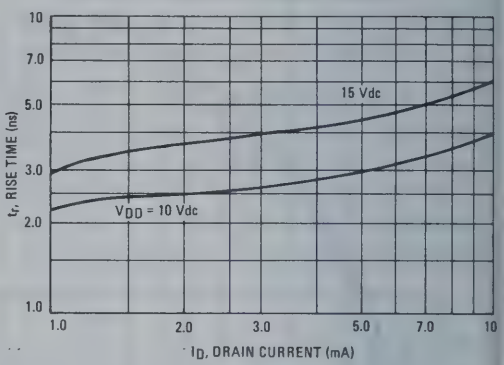


FIGURE 8 – TURN-OFF DELAY TIME

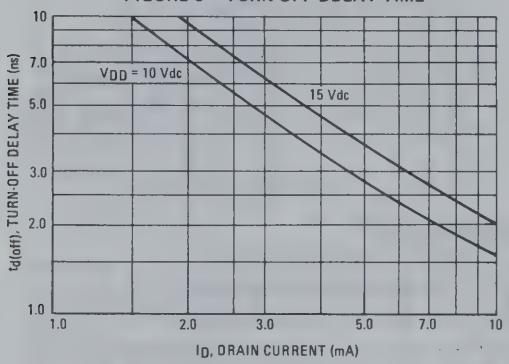


FIGURE 9 – FALL TIME

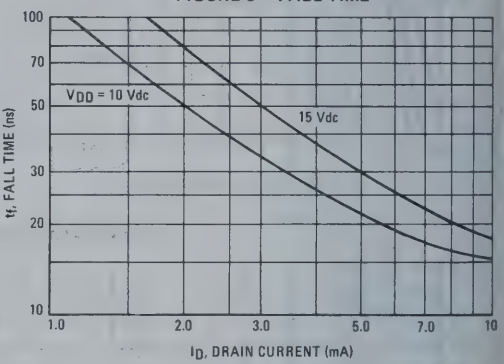
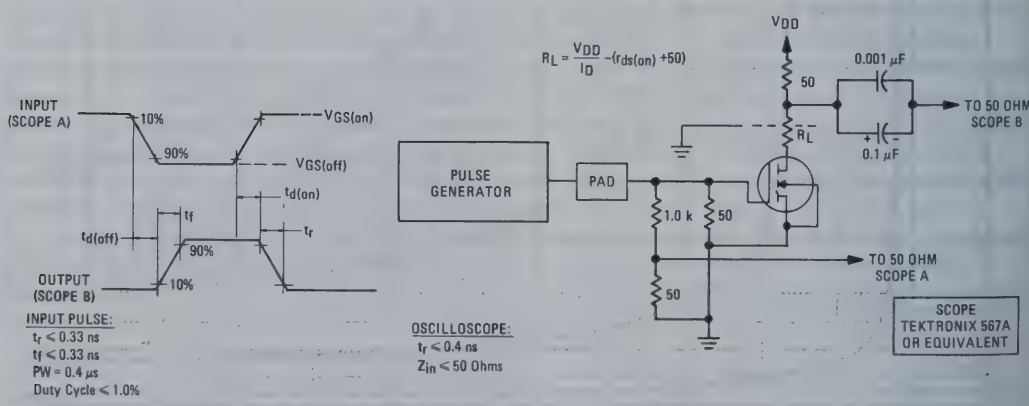


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

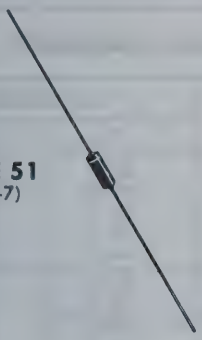


HOUSE NUMBERED DEVICE SPECIFICATIONS

DIODES
POWER VARACTORS
RECTIFIERS
RECTIFIER ASSEMBLIES
THYRISTORS & TRIGGERS
TRANSISTORS

1/4M2.4AZ thru 1/4M200Z (SILICON)

1/4 W
2.4 — 200 V



CASE 51
(DO-7)

Hermetically sealed, all-glass case with all external surfaces corrosion resistant. Cathode end, indicated by color band, will be positive with respect to anode end when operated in the zener region.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C
D C Power Dissipation: 1/4 Watt (Derate 1.67 mW/°C Above 25°C)

The type numbers specified have a standard voltage (V_Z) tolerance of ±20%. For closer tolerances, add suffix "10" for ±10% or "5" for ±5%. (3%, 2%, 1% tolerances also available.)

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_F = 1.5 V max @ 100 mA)

TYPE NO.	NOMINAL ZENER VOLTAGE @ I_{ZT} (V_Z) VOLTS	TEST CURRENT (I_{ZT}) mA	MAXIMUM ZENER IMPEDANCE (Z_{ZT}) @ I_{ZT} ohms	MAXIMUM DC ZENER CURRENT (I_{ZM}) mA	REVERSE LEAKAGE CURRENT		
					I_R MAX (μA)	TEST VOLTAGE Vdc*	
						V_{R1}	V_{R2}
1/4M2.4AZ	2.4	10	60	70	75	1	1
1/4M2.7AZ	2.7	10	60	65	75	1	1
1/4M3.0AZ	3.0	10	55	60	50	1	1
1/4M3.3AZ	3.3	10	55	55	50	1	1
1/4M3.6AZ	3.6	10	50	52	50	1	1
1/4M3.9AZ	3.9	10	50	49	25	1	1
1/4M4.3AZ	4.3	10	45	46	25	1.5	1.5
1/4M4.7AZ	4.7	10	35	42	10	1.5	1.5
1/4M5.1AZ	5.1	10	25	39	5	1.5	1.5
1/4M5.6AZ	5.6	10	20	36	5	1.5	1.5
1/4M6.2AZ	6.2	10	15	33	5	3.5	3.5
1/4M6.8Z	6.8	9.2	7.0	33	150	5.2	4.9
1/4M7.5Z	7.5	8.3	8.0	30	75	5.7	5.4
1/4M8.2Z	8.2	7.6	9.0	26	50	6.2	5.9
1/4M9.1Z	9.1	6.9	10	24	25	6.9	6.6
1/4M10Z	10	6.3	11	21	10	7.6	7.2
1/4M11Z	11	5.7	13	19	5	8.4	8.0
1/4M12Z	12	5.2	15	18	5	9.1	8.6
1/4M13Z	13	4.8	18	16	5	9.9	9.4
1/4M14Z	14	4.5	20	15	5	10.6	10.1
1/4M15Z	15	4.2	22	14	5	11.4	10.8
1/4M16Z	16	3.9	24	13	5	12.2	11.5
1/4M17Z	17	3.7	26	12.5	5	13.0	12.2
1/4M18Z	18	3.5	28	11.5	5	13.7	13.0
1/4M19Z	19	3.3	30	11.0	5	14.4	13.7
1/4M20Z	20	3.1	33	10.5	5	15.2	14.4
1/4M22Z	22	2.8	40	9.5	5	16.7	15.8
1/4M24Z	24	2.6	46	9.0	5	18.2	17.3
1/4M25Z	25	2.5	50	8.0	5	19.0	18.0
1/4M27Z	27	2.3	58	7.5	5	20.6	19.4
1/4M30Z	30	2.1	70	7.0	5	22.8	21.6

*V_{R1} — Test Voltage for 5% Tolerance Device V_{R2} — Test Voltage for 10% Tolerance Device
No Leakage Specified as 20% Tolerance Device

1/4M2.4AZ thru 1/4M200Z (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_F = 1.5 V max @ 100 mA) (continued)

TYPE NO.	NOMINAL ZENER VOLTAGE @ I_{ZT} (V_Z) VOLTS	TEST CURRENT (I_{ZT}) mA	MAXIMUM ZENER IMPEDANCE (Z_{ZT}) @ I_{ZT} ohms	MAXIMUM DC ZENER CURRENT (I_{ZM}) mA	REVERSE LEAKAGE CURRENT		
					I_R MAX (μA)	TEST VOLTAGE Vdc*	
						V_{R1}	V_{R2}
1/4M33Z	33	1.9	85	6.5	5	25.1	23.8
1/4M36Z	36	1.7	100	6.0	5	27.4	25.9
1/4M39Z	39	1.6	120	5.0	5	29.7	28.1
1/4M43Z	43	1.5	140	4.8	5	32.7	31.0
1/4M45Z	45	1.4	150	4.5	5	34.2	32.4
1/4M47Z	47	1.3	160	4.3	5	35.8	33.8
1/4M50Z	50	1.2	180	4.1	5	38.0	36.0
1/4M52Z	52	1.2	200	4.0	5	39.5	37.4
1/4M56Z	56	1.1	230	3.8	5	42.6	40.3
1/4M62Z	62	1.0	290	3.3	5	47.1	44.6
1/4M68Z	68	0.92	350	3.0	5	51.7	49.0
1/4M75Z	75	0.83	450	2.8	5	56.0	54.0
1/4M82Z	82	0.76	550	2.5	5	62.2	59.0
1/4M91Z	91	0.69	700	2.3	5	69.2	65.5
1/4M100Z	100	0.63	900	2.0	5	76.0	72.0
1/4M105Z	105	0.60	1000	1.9	5	79.8	75.6
1/4M110Z	110	0.57	1200	1.8	5	83.6	79.2
1/4M120Z	120	0.52	1500	1.7	5	91.2	86.4
1/4M130Z	130	0.48	1900	1.5	5	98.8	93.6
1/4M140Z	140	0.45	2200	1.4	5	106.4	100.8
1/4M150Z	150	0.42	2500	1.3	5	114.0	108.0
1/4M175Z	175	0.36	3300	1.1	5	133.0	126.0
1/4M200Z	200	0.31	4300	1.0	5	152.0	144.0

*V_{R1} – Test Voltage for 5% Tolerance Device V_{R2} – Test Voltage for 10% Tolerance Device

No Leakage Specified as 20% Tolerance Device

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

1 – Nominal zener voltages between those shown.

2 – Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.

a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible high zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.

b. Two or more units matched to one another with any specified tolerance.

3 – Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

.4M.64FR10
.4M1.36FR5
.4M1.36FR2
.4M2.04FR5
.4M2.04FR2

For Specifications, See 1N816 Data.

1M3.3ZS thru 1M200ZS

For Specifications, See 1N4728 Data.

AF139 (GERMANIUM)

PNP GERMANIUM AMPLIFIER TRANSISTOR

. . . designed for use in UHF RF amplifier, mixer and oscillator applications.

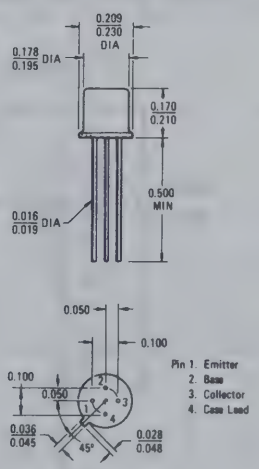
- Forward AGC Capability
- Unneutralized 800 MHz Power Gain — 11 dB (Typ)
- Noise Figure — NF = 8.2 dB (Max) @ f = 800 MHz
- Low Collector Base Time Constant — $r_b'C_c$ = 3.4 ps (Typ)

SELECTIVE METAL ETCH
PNP GERMANIUM AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	0.3	Vdc
Collector Current — Continuous	I_C	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	60 0.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +100	°C

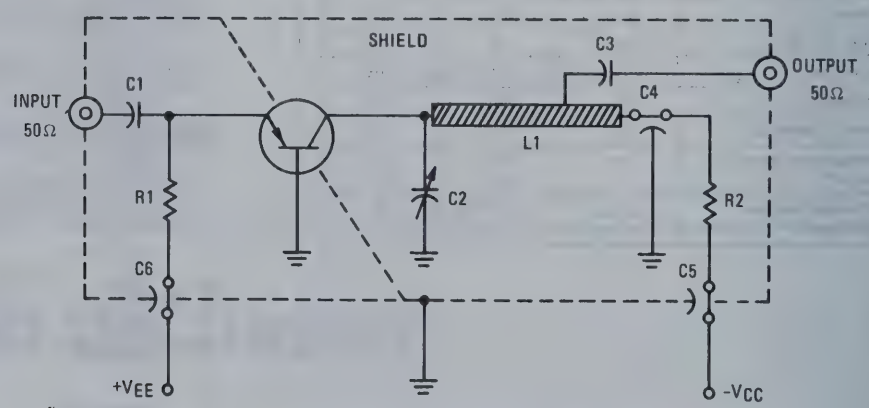


CASE 20 (10)
TO-72 PACKAGE

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–	–	500	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	–	8.0	μAdc
Emitter Cutoff Current (V_{BE} = 0.3 Vdc, I_C = 0)	I_{EBO}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.5 mAdc, V_{CE} = 12 Vdc)	h_{FE}	10	40	–	–
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	450	580	–	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CE} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}	–	0.23	0.30	pF
Collector-Base Time Constant (I_E = 1.5 mAdc, V_{CB} = 12 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	3.4	8.0	ps
Noise Figure (Figure 1)	NF				dB
(I_C = 1.5 mAdc, V_{CE} = 12 Vdc, R_S = 50 ohms, f = 800 MHz)		–	–	8.2	
(I_C = 1.5 mAdc, V_{CE} = 12 Vdc, R_S = 50 ohms, f = 860 MHz)		–	–	8.8	
FUNCTIONAL TEST					
Common-Base Amplifier Power Gain (Figure 1)	G_{pb}				dB
(I_C = 1.5 mAdc, V_{CE} = 12 Vdc, f = 800 MHz)		9.0	11	–	
(I_C = 1.5 mAdc, V_{CE} = 12 Vdc, f = 860 MHz)		7.5	–	–	

FIGURE 1 – 800 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



C1, C3 – 10 pF DUR-MICA
C4, C5, C6 – 240 pF FEEDTHROUGH ERIE OR EQUIVALENT
C2 – 0.4-6.0 pF JOHANSEN OR EQUIVALENT
R1 – 2.2 kΩ, 0.25 W
R2 – 100Ω, 0.25 W
L1 – SILVER PLATED BRASS STRIP 0.08" WIDE, 0.025" THICK. APPROX. LENGTH 1" – TAP @ 1/3 LENGTH

COMMON-BASE y PARAMETERS
$T_A = 25^oC$

FIGURE 2 – INPUT ADMITTANCE

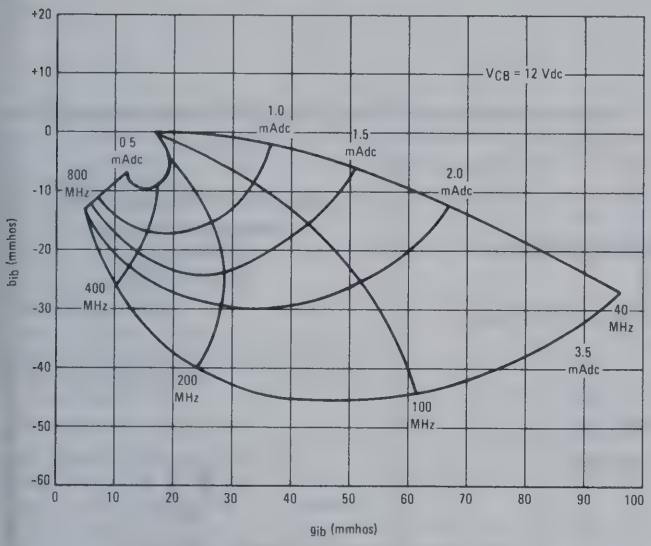


FIGURE 3 – REVERSE TRANSFER ADMITTANCE

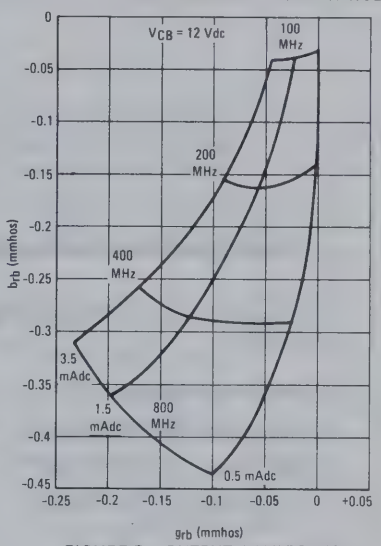


FIGURE 4 – FORWARD TRANSFER ADMITTANCE

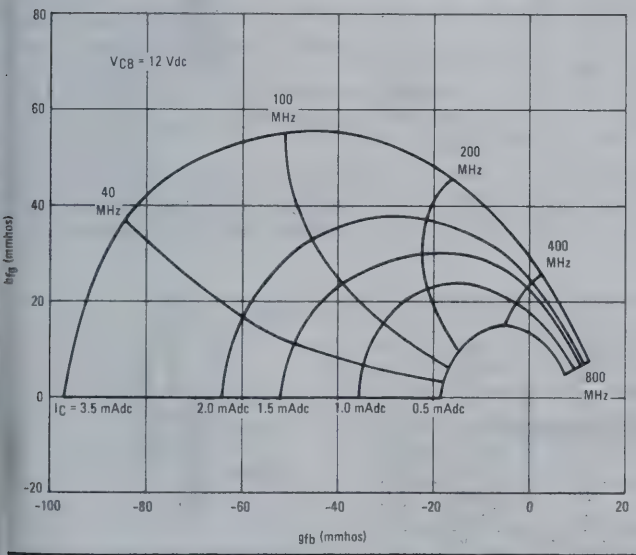


FIGURE 5 – OUTPUT ADMITTANCE

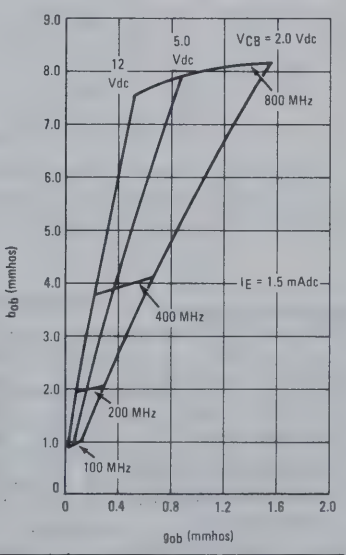


FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

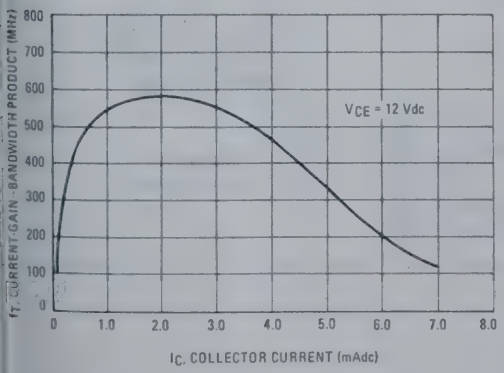
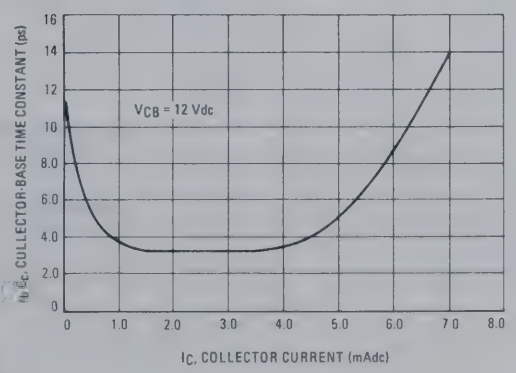


FIGURE 7 – COLLECTOR-BASE TIME CONSTANT



AF239 (GERMANIUM)

PNP GERMANIUM AMPLIFIER TRANSISTOR

. . . designed for use in UHF RF amplifier and autodyne converter applications.

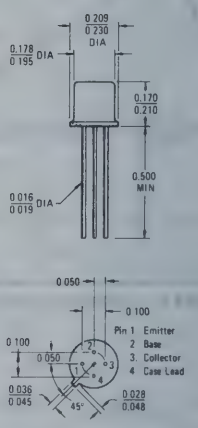
- Forward AGC Capability
- Unneutralized 800 MHz Power Gain — 14 dB (Typ)
- Noise Figure — NF = 5.0 dB (Typ) @ f = 800 MHz
- Low Collector Base Time Constant — $r_b'C_c$ = 2.0 ps (Typ)

SELECTIVE METAL ETCH
PNP GERMANIUM AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	0.3	Vdc
Collector Current — Continuous	I_C	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	60 0.8	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +100	°C

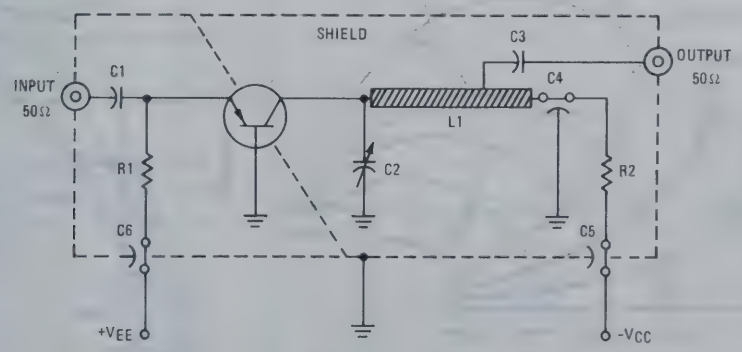


CASE 20 (10)
TO-72 PACKAGE

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–	–	500	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	–	8.0	μAdc
Emitter Cutoff Current (V_{BE} = 0.3 Vdc, I_C = 0)	I_{EBO}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.5 mAdc, V_{CE} = 12 Vdc)	h_{FE}	15	40	–	–
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	600	770	–	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CE} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{re}	–	0.23	0.30	pF
Collector-Base Time Constant (I_E = 1.5 mAdc, V_{CB} = 12 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	2.0	5.0	ps
Noise Figure (Figure 1)	NF				dB
(I_C = 1.5 mAdc, V_{CE} = 12 Vdc, R_S = 50 ohms, f = 800 MHz)		–	5.0	6.0	
(I_C = 1.5 mAdc, V_{CE} = 12 Vdc, R_S = 50 ohms, f = 860 MHz)		–	–	6.7	
FUNCTIONAL TEST					
Common-Base Amplifier Power Gain (Figure 1)	G_{pb}				dB
(I_C = 1.5 mAdc, V_{CE} = 12 Vdc, f = 800 MHz)		11.2	14	–	
(I_C = 1.5 mAdc, V_{CE} = 12 Vdc, f = 860 MHz)		–	13.2	–	

FIGURE 1 – 800 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



C1, C3 – 10 pF DUR-MICA
C4, C5, C6 – 240 pF FEEDTHROUGH ERIE OR EQUIVALENT
C2 – 0.4-6.0 pF JOHANSEN OR EQUIVALENT
R1 – 2.2 kΩ, 0.25 W
R2 – 100 Ω, 0.25 W
L1 – SILVER PLATED BRASS STRIP 0.08" WIDE, 0.025" THICK. APPROX. LENGTH 1" – TAP @ 1/3 LENGTH

COMMON-BASE y PARAMETERS
$T_A = 25^oC$

FIGURE 2 – INPUT ADMITTANCE

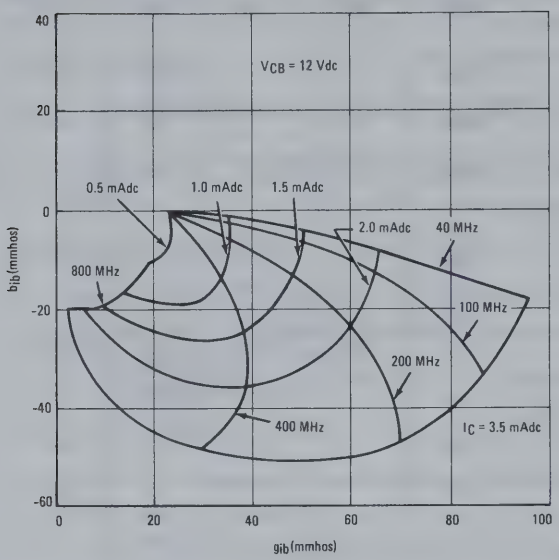


FIGURE 3 – REVERSE TRANSFER ADMITTANCE

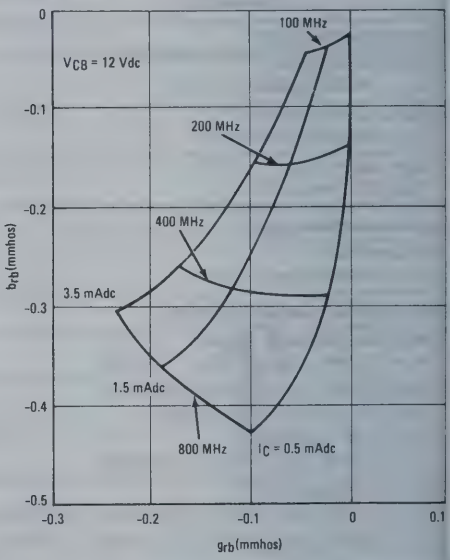


FIGURE 4 – FORWARD TRANSFER ADMITTANCE

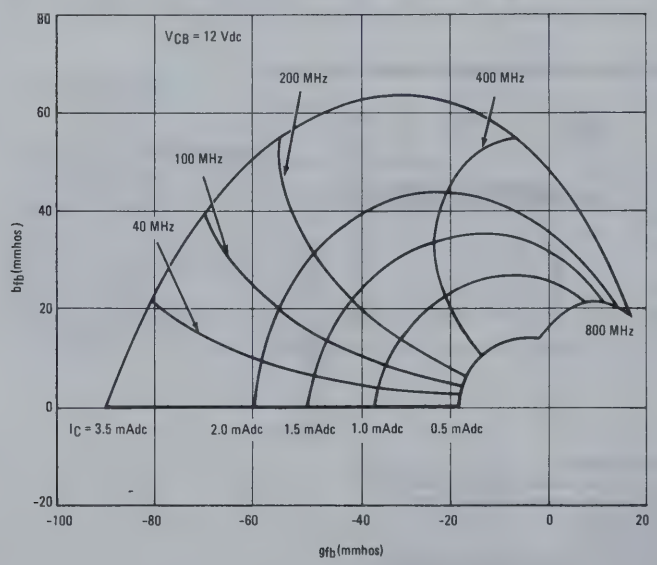


FIGURE 5 – OUTPUT ADMITTANCE

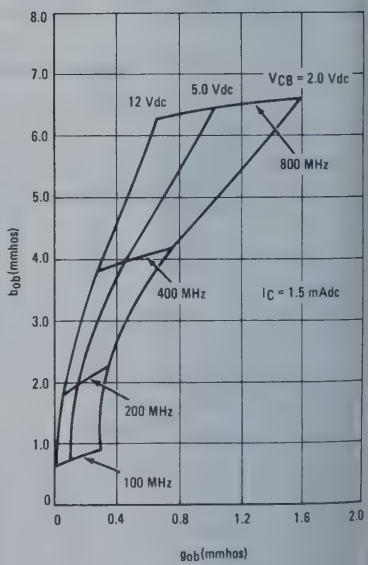


FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

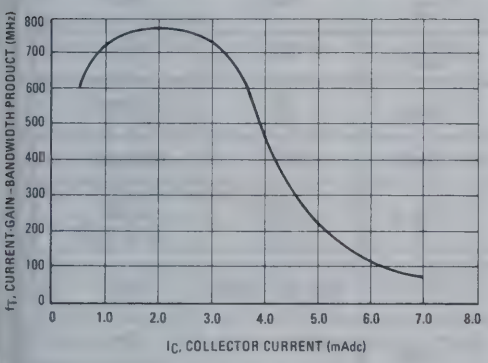
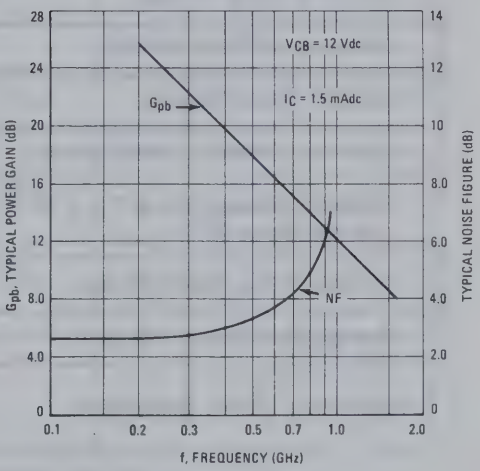


FIGURE 7 – TYPICAL POWER GAIN AND NOISE FIGURE
(See Figure 1)



MA100 (GERMANIUM)



PNP low noise germanium transistor, designed for audio amplifier applications. Feature stabilization bake for greater gain stability, and rugged quad-mount construction.

CASE 31(1)
(TO-5)

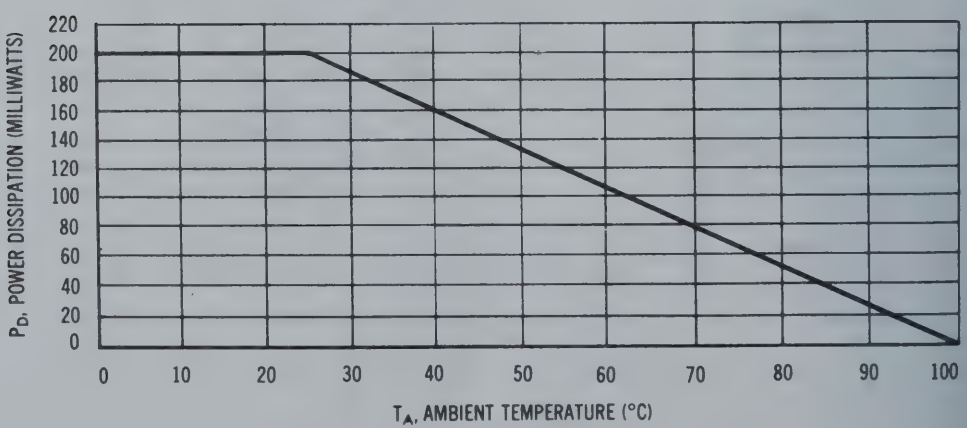
All leads isolated from case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current (Continuous)*	I_C*	500	mAdc
Collector Dissipation at T_A = 25°C Derate above 25°C	P_D	200 2.67	mW mW/°C
Junction Temperature Range	T_J	-65 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +100	°C

*Limited by power dissipation.

POWER-TEMPERATURE DERATING CURVE

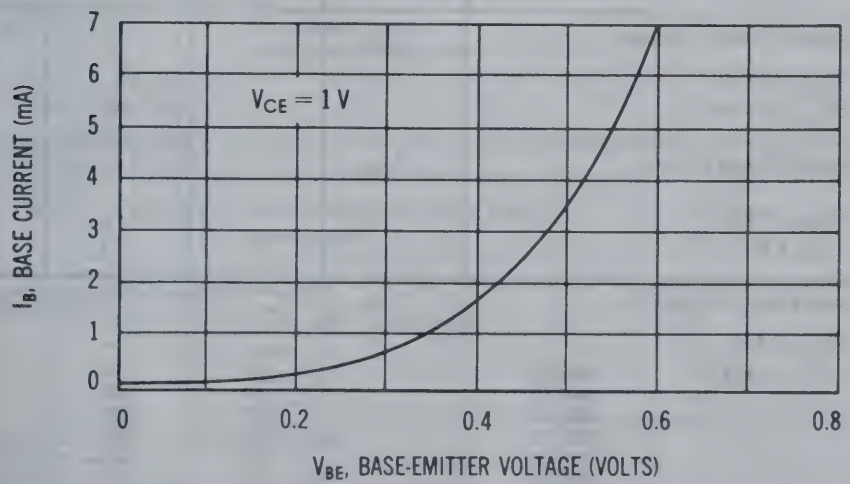


MA100 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	— —	100 10	μAdc
Emitter-Base Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)	I_{EBO}	—	10	μAdc
Collector-Emitter Leakage Current (V_{CE} = 60 Vdc, R_{BE} = 0)	I_{CES}	—	100	μAdc
Output Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	25	pF
Input Impedance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)	h_{ib}	26	40	ohms
Output Admittance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)	h_{ob}	0.1	1.0	μmhos
DC Current Gain (V_{CE} = 1 Vdc, I_C = 10 mAdc)	h_{FE}	30	—	—
Small-Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)	h_{fe}	50	190	—
Small-Signal Current Gain Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc)	$f_{\alpha b}$	1.0	—	MHz
Noise Figure (V_{CE} = 5 Vdc, I_C = 100 μAdc, R_S = 1 K ohms, f = 100 Hz)	NF	—	8.0	dB

BASE INPUT CURRENT versus BASE DRIVE VOLTAGE



MA112 thru MA117 (GERMANIUM)



CASE 31(1)
(TO-5)

All leads isolated from case

PNP Germanium transistors for economical circuit applications. Available with a wide variety of gain ranges.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	V
Collector-Base Voltage	V_{CB}	15	V
Emitter-Base Voltage	V_{EB}	15	V
Collector Current	I_C	200	mA
Storage Temperature Limits	T_{stg}	-55 to +85	°C
Power Dissipation @ T_A = +25°C	P_D	175	mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Current (V_{CE} = 15 V, R_{BE} = 10 KΩ)		I_{CER}	-	600	μA
Collector-Base Current (V_{CB} = 15 V, I_E = 0)		I_{CBO}	-	15	μA
Small Signal Current Gain (V_{CE} = 6 V, I_C = 1 mA)	MA112	h_{fe}	30	70	
	MA113		50	125	
	MA114		100	250	
	MA115		30	125	
	MA116		50	250	
	MA117		30	250	

MA200 thru MA206 (GERMANIUM)



CASE 31(1)
(TO-5)

Germanium PNP transistor designed for high-voltage applications in the audio frequency range, such as neon driver, solenoid or relay driver applications.

All leads isolated from case

MAXIMUM RATINGS ($T_A = 25°C$)

Rating	Symbol	MA200 MA202	MA201 MA203	MA204	MA205	MA206	Unit
Collector-Base Voltage	V_{CB}	105	105	90	75	60	Vdc
Collector-Emitter Voltage	V_{CE}	105	105	90	75	60	Vdc
Emitter-Base Voltage	V_{EB}	10	20	20	20	10	Vdc
Collector Current	I_C	200					mAdc
Emitter Current	I_E	200					mAdc
Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +100					^oC
Thermal Resistance	θ_{JA}	0.5					$^oC/mW$
Collector Dissipation at $T_A = 25^oC$ Derate above 25^oC	P_D	150 2.0					mW $mW/^oC$

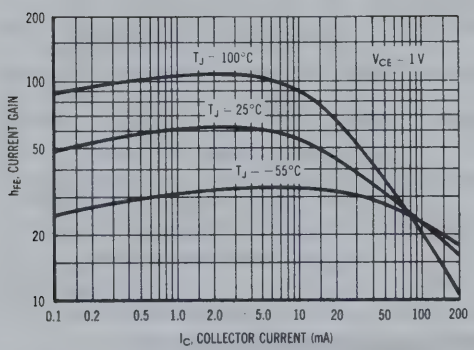
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 105 V, I_E = 0)	MA 200 thru MA203	I_{CBO}				μA
(V_{CB} = 90 V, I_E = 0)	MA204		—	12.0	50	
(V_{CB} = 75 V, I_E = 0)	MA205					
(V_{CB} = 60 V, I_E = 0)	MA206					
Collector-Base Cutoff Current (V_{CB} = 2.5 V, I_E = 0)		I_{CBO}	—	5.0	14	μA
Emitter-Base Cutoff Current (V_{EB} = 10 V, I_C = 0)	MA200, MA202, MA206	I_{EBO}	—	3.0	50	μA
(V_{EB} = 20 V, I_C = 0)	MA201, MA203, MA204, MA205		—	3.0	50	
Collector-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	—	0.11	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	—	0.22	0.40	Vdc
DC Current Gain (I_C = 5 mAdc, V_{CE} = 0.35 Vdc)	MA200, MA201, MA204, MA205, MA206	h_{FE}	20	—	—	—
	MA202, MA203		40	—	—	
DC Collector-Emitter Punch-Through Voltage (V_{CB} necessary to obtain V_{EB} of -1 V max, using instrument with Z_{in} > 11 megohm to measure V_{BE})		V_{PT}				Vdc
	MA200, MA201, MA202, MA203		105	—	—	
	MA204		90	—	—	
	MA205		75	—	—	
	MA206		60	—	—	
Small-Signal Short-Circuit Forward Current Transfer Ratio Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc)		$f_{\alpha b}$	—	1.0	—	MHz

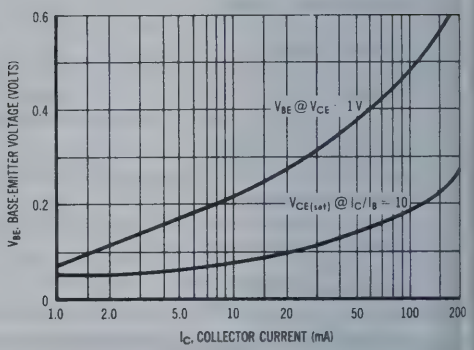
DC CHARACTERISTICS

($T_J = 25°C$ unless otherwise noted)

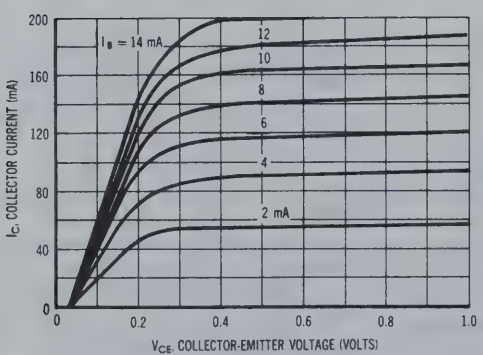
CURRENT GAIN



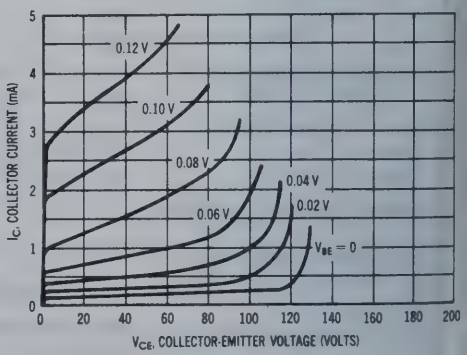
"ON" VOLTAGES



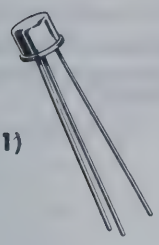
COLLECTOR SATURATION REGION



COLLECTOR HIGH VOLTAGE REGION



MA286 thru MA288 (GERMANIUM)



CASE 31(1)
(TO-5)

PNP germanium transistors for very economical circuit applications. Available with a wide variety of gain ranges.

All leads isolated from case

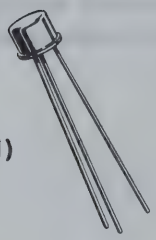
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	V
Collector-Base Voltage	V_{CB}	10	V
Emitter-Base Voltage	V_{EB}	10	V
Collector Current	I_C	200	mA
Storage Temperature Limits	T_{stg}	-55 to +85	°C
Power Dissipation @ T_A = +25°C	P_D	175	mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Current (V_{CE} = 10 V, R_{BE} = 10 KΩ)		I_{CER}	-	600	μA
Small Signal Current Gain (V_{CE} = 6 V, I_C = 1 mA)	MA286	h_{fe}	14	40	-
	MA287		30	250	
	MA288		180	-	

MA881 thru MA889 (GERMANIUM)



CASE 31(1)
(TO-5)

All leads isolated from case.

PNP germanium transistors for audio amplifier and medium-speed switching applications. Recommended as driver transistors for 50-60 Volt power transistors.

MAXIMUM RATINGS

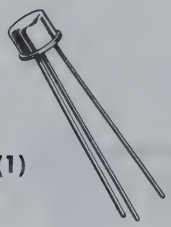
Rating	Symbol	Value	Unit
Collector-Base Voltage MA881 thru MA884 MA885 thru MA889	V_{CB}	 60 50	Vdc
Collector-Emitter Voltage MA881 thru MA884 MA885 thru MA889	V_{CES}	 60 50	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current (Continuous)*	I_{C*}	500	mAdc
Collector Dissipation at T_A = 25°C Derate above 25°C	P_D	200 2.67	mW mW/°C
Storage and Operating Temperature Range	T_{stg}, T_J	-50 to +100	°C

*Limited by power dissipation

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 30 Vdc, I_E = 0)	MA881 thru MA884		---	10	
(V_{CB} = 60 Vdc, I_E = 0)	MA881 thru MA884		---	100	
(V_{CB} = 25 Vdc, I_E = 0)	MA885 thru MA889		---	15	
(V_{CB} = 50 Vdc, I_E = 0)	MA885 thru MA889		---	100	
Emitter-Base Cutoff Current		I_{EBO}			μAdc
(V_{EB} = 15 Vdc, I_C = 0)	MA881 thru MA884		---	10	
	MA885 thru MA889		---	15	
Collector-Emitter Leakage Current		I_{CES}			μAdc
(V_{CE} = 60 Vdc, R_{BE} = 0)	MA881 thru MA884		---	100	
(V_{CE} = 50 Vdc, R_{BE} = 0)	MA885 thru MA889		---	100	
Output Capacitance		C_{ob}			pF
(V_{CB} = 6 Vdc, I_E = 0, f = 1 MHz)			---	25	
Input Impedance		h_{ib}			ohms
(V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)			26	40	
Output Admittance		h_{ob}			μmhos
(V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)			0.1	1.0	
DC Current Gain		h_{FE}			----
(V_{CE} = 1 Vdc, I_C = 10 mAdc)	MA881		30	---	
	MA882		40	---	
	MA883		75	---	
	MA884		125	---	
Small-Signal Current Gain		h_{fe}			----
(V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)	MA881, MA886		30	70	
	MA882, MA887		50	120	
	MA883, MA888		100	225	
	MA884, MA889		190	400	
	MA885		15	40	
Small-Signal Current Gain Cutoff Frequency		$f_{\alpha b}$			MHz
(V_{CB} = 6 Vdc, I_E = 1 mAdc)	MA881, MA886		0.75	---	
	MA882, MA887		1.0	---	
	MA883, MA888		1.25	---	
	MA884, MA889		1.75	---	
	MA885		0.5	---	

MA909 thru MA910 (GERMANIUM)



CASE 31(1)
(TO-5)

All leads isolated from case

PNP Germanium transistors for high-voltage neon driver, solenoid and relay driver circuits.

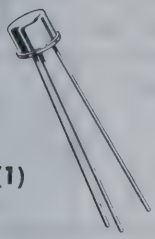
MAXIMUM RATINGS

Rating	Symbol	MA909	MA910	Unit
Collector-Base Voltage	V_{CB}	75	90	Volts
Collector-Emitter Voltage	V_{CEO}	75	90	Volts
Emitter-Base Voltage	V_{EB}	35	45	Volts
Collector Current	I_C	200		mA
Collector Dissipation at $T_C = 25°C$	P_D	150		mW
Junction and Storage Temperature	T_J, T_{stg}	100		°C

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			Adc
(V_{CB} = 2.5 Vdc, I_E = 0)	Both Types		-	14	
(V_{CB} = 75 Vdc, I_E = 0)	MA909		-	50	
(V_{CB} = 90 Vdc, I_E = 0)	MA910		-	50	
Emitter-Base Cutoff Current		I_{EBO}			Adc
(V_{EB} = 35 Vdc, I_C = 0)	MA909		-	50	
(V_{EB} = 45 Vdc, I_C = 0)	MA910		-	50	
Collector-Emitter Leakage Current		I_{CES}			Adc
(V_{CE} = 75 Vdc, R_{BE} = 0)	MA909		-	100	
(V_{CE} = 90 Vdc, R_{BE} = 0)	MA910		-	100	
Collector-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	-	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	-	0.40	Vdc
DC Current Gain (I_C = 5 mAdc, V_{CE} = 0.35 Vdc)		h_{FE}	20	-	-
Collector-Emitter Punch-Thru Voltage		V_{pt}			Vdc
(V_{fl} = 1.0 Vdc, R_{in} of VTVM - 10 to 12 Megohms)	MA909		75	-	
	MA910		90	-	

MA1702 thru MA1708 (GERMANIUM)



CASE 31(1)
(TO-5)

All leads isolated from case

PNP germanium transistors for audio amplifier and medium speed switching applications requiring high ac gain at low collector current or high dc gain at high collector current.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}		Vdc
MA1702		45	
MA1703 thru MA1705		25	
MA1706 thru MA1708		15	
Collector-Emitter Voltage	V_{CER}		Vdc
MA1702		30	
MA1703 thru MA1705		25	
MA1706 thru MA1708		15	
Emitter-Base Voltage	V_{EB}		Vdc
MA1702		30	
MA1703 thru MA1705		25	
MA1706 thru MA1708		4.5	
Collector Current (Continuous)*	I_C	500*	mAdc
Base Current (Continuous)*	I_B	50*	mAdc
Maximum Junction Temperature	T_J	100	°C
Storage Temperature Range	T_{stg}	-65 to +100	°C
Collector Dissipation, Ambient	P_D	200	mW
Derate Above 25° C		2.67	mW/° C

*Limited by power dissipation

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 1.5 Vdc, I_E = 0)	MA1702 thru MA1705		-	3.0	5.0	
(V_{CB} = 10 Vdc, I_E = 0, T_A = +71° C)	MA1702		-	-	100	
(V_{CB} = 15 Vdc, I_E = 0)	MA1706 thru MA1708		-	-	15	
(V_{CB} = 25 Vdc, I_E = 0)	MA1703 thru MA1705		-	-	15	
(V_{CB} = 30 Vdc, I_E = 0)	MA1702		-	-	10	
(V_{CB} = 45 Vdc, I_E = 0)	MA1702		-	-	50	
Emitter-Base Cutoff Current		I_{EBO}				μAdc
(V_{EB} = 4.5 Vdc, I_C = 0)	MA1706 thru MA1708		-	-	15	
(V_{EB} = 25 Vdc, I_C = 0)	MA1703 thru MA1705		-	-	15	
(V_{EB} = 30 Vdc, I_C = 0)	MA1702		-	3.0	10	
Collector-Emitter Leakage Current		I_{CER}				μAdc
(V_{CE} = 15 Vdc, R_{BE} = 10 K ohms)	MA1706 thru MA1708		-	-	600	
(V_{CE} = 25 Vdc, R_{BE} = 10 K ohms)	MA1703 thru MA1705		-	-	600	
(V_{CE} = 30 Vdc, R_{BE} = 10 K ohms)	MA1702		-	-	600	
Collector-Emitter Punch-Thru Voltage		V_{pt}				Vdc
(V_{fl} = 1.0 Vdc, VTVM impedance ≥ 1 megohm)	MA1702		30	-	-	
Output Capacitance		C_{ob}				pF
(V_{CB} = 6 Vdc, I_E - 0, f = 1 MHz)			-	10	20	
Noise Figure		NF				dB
(V_{CE} = 4.5 Vdc, I_E = 0.5 mA, R_g = 1 K, f = 1 kHz, Δf = 1 Hz)	MA1702		-	5.0	10	
Small-Signal Current Gain Cutoff Frequency		$f_{\alpha b}$				MHz
(V_{CB} = 6 Vdc, I_E = 1 mAdc)	MA1702		7.0	-	-	
	MA1703		3.0	-	-	
	MA1704		5.0	-	-	
	MA1705		6.0	-	-	
	MA1706		3.0			
	MA1707		4.0			
	MA1708		5.0			
Input Impedance		h_{ib}				Ohms
(V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)	MA1702 thru MA1705		25	-	35	
	MA1706 thru MA1708		25	-	37	
Output Admittance		h_{ob}				μmho
(V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)	MA1702		0.05	-	0.50	
Small Signal Current Gain		h_{fe}				-
(V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)	MA1702, MA1705, MA1708		500	-	-	
	MA1703, MA1706		200	-	500	
	MA1704, MA1707		350	-	800	
DC Current Gain		h_{FE}				-
(I_C = 20 mAdc, V_{CE} = 1 Vdc)	MA1702		350	-	-	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	MA1702, MA1705, MA1708		200	-	-	
	MA1703, MA1706		100	-	350	
	MA1704, MA1707		150	-	400	
(I_C = 200 mAdc, V_{CE} = 1 Vdc)	MA1702		135	-	-	
	MA1703		70	-	-	
	MA1704		110	-	-	
	MA1705		125	-	-	
Collector-Emitter Saturation Voltage		V_{CE} (sat)				Vdc
(I_C = 200 mAdc, I_B = 4.0 mAdc)	MA1702		-	-	0.260	

MAC1 (SILICON)
MAC2
MAC3

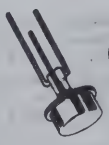
Silicon bi-directional thyristors designed primarily for full-wave ac control applications, such as heating and lighting; these TRIAC type thyristors switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering.



MAC1
(CASE 85)



MAC2
(CASE 86)



MAC3
(CASE 87L)

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted)
Applies to all case types

Rating	Symbol	Value	Unit
Peak Blocking Voltage* MAC1 - 2 MAC2 - 4 MAC3 - 6	V_{BOM}*	 50 200 400	Volts
RMS Conduction Current (T_C = 75°C)	I_A	8.0	Amp
Peak Surge Current (One-half cycle, 60 Hz) (T_J =.-42 to +100°C)	$I_{M(surge)}$	100	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t = 1.0 to 8.3 ms)	I^2t	40	A^2s
Peak Gate Power	P_{GM}	10	Watts
Average Gate Power	$P_{G(av)}$	0.5	Watt
Peak Gate Current	I_{GM}	2.0	Amp
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque (MAC2 Series)	-	15	in. lb.

* For either direction of blocking voltage. V_{BOM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for open or shorted gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Applies to all case types unless otherwise noted.

Characteristics	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Either direction) (Rated V_{BOM} @ T_J = 100°C, gate open)	I_{BOM}	-	-	2.0	mA
"On" Voltage (Either direction) (I_A = 5.0 Amp Peak)	$V_{(on)}$	-	1.0	1.4	Volts
Gate Trigger Current (Continuous dc, all modes) (Anode Voltage = 7.0 Vdc, R_L = 100 Ω)	I_{GT}	-	-	30	mA
Gate Trigger Voltage (Continuous dc, all modes) (Anode Voltage = 7.0 Vdc, R_L = 100 Ω)	V_{GT}	-	0.9	2.0	Volts
(Anode Voltage = Rated V_{BOM}, R_L = 100 Ω, T_J = 100°C)	V_{GNT}	0.2	-	-	
Holding Current (Either direction) (Anode Voltage = 7.0 Vdc, gate open)	I_{HO}	-	-	30	mA
Turn-On Time (I_A = 5.0 Adc, I_{GT} = 100 mAdc)	t_{on}	-	1.0	-	μs
Blocking Voltage Application Rate at Commutation (T_C = 75°C)	dv/dt	-	5.0	-	V/μs
Thermal Resistance, Junction to Case (Either direction)	θ_{JC}	-	-	2.0	°C/W
Thermal Resistance, Case to Ambient (MAC1, MAC3)	θ_{CA}	-	50	-	°C/W

FIGURE 1 — CURRENT DERATING

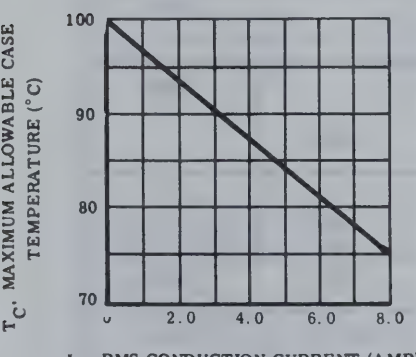
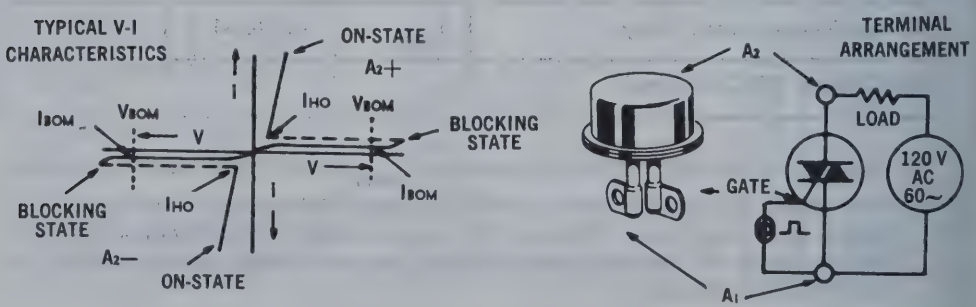


FIGURE 2 — TYPICAL COMPARISON OF PARAMETERS FOR VARIOUS MODES OF OPERATION*

Parameter	Mode Voltage Polarity (Relative to A_1)			
	A_2(+), G(+)	A_2(+), G(-)	A_2(-), G(-)	A_2(-), G
I_{GT}	0.7	0.8	0.9	1.0
V_{GT}	0.9	0.8	0.9	1.0
I_{HO}	0.8	-	1.0	-
$V_{(on)}$	0.9	-	1.0	-

* Values shown are normalized to the values obtained in the mode where highest values occur.

FIGURE 3 — CHARACTERISTICS AND SYMBOLS



MAC35-1 thru MAC35-7 (SILICON)
MAC36-1 thru MAC36-7



TRIAC
(THYRISTORS)

25 AMPERES RMS
25 thru 500 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for industrial and military applications for the control of ac loads in applications such as light dimmers, power supplies, heating controls, motor controls, welding equipment and power switching systems; or wherever full-wave, silicon gate controlled solid-state devices are needed.

- 25 Amperes RMS @ T_C = 67°C
- Low On-State Voltage — 1.5 Volts Maximum
- All-Diffused Junctions for Greater Uniformity



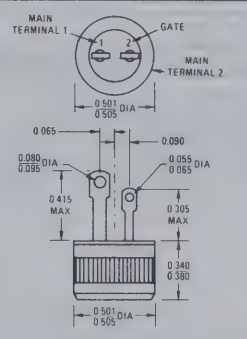
MAC 35 MAC 36

MAXIMUM RATINGS

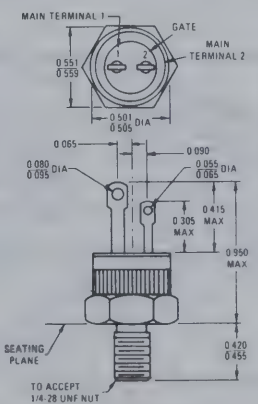
Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (1) (T_J = 110°C) MAC35 −1	V_{DRM}	25	Volts
MAC35 −2		50	
MAC35 3		100	
MAC36 4		200	
MAC35 −5		300	
MAC36 6		400	
MAC36 −7		500	
On-State Current RMS	$I_{T(RMS)}$	25	Amp
Peak Surge Current (One Full cycle, 60 Hz, T_J = −40 to +110°C)	I_{TSM}	225	Amp
Circuit Fusing Considerations (T_J = −40 to +110°C, t = 1.0 to 8.3 ms)	I^2t	210	A^2s
Peak Gate Power (2)	P_{GM}	5.0	Watts
Average Gate Power	$P_{G(AV)}$	0.5	Watt
Peak Gate Current (2)	I_{GM}	2.0	Amp
Operating Junction Temperature Range	T_J	−40 to +110	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C
Stud Torque	–	30	in. lb.

(1) For either direction of blocking voltage. V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) T_J = 110°C, 1.0 second maximum duration; 5.0% duty cycle, I_{TM} = 10 Amp.



CASE 174 (3) MAC 35



CASE 175 (3) MAC 36

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 110°C	I_{DRM}	–	–	4.0	mA
On-State Voltage (Either Direction) I_{TM} = 35 A Peak	V_{TM}	–	1.3	1.5	Volts
Gate Trigger Current, Continuous dc (1) Main Terminal Voltage = 7.0 Vdc, R_L = 47 ohms					
MT2(+)G(+); MT2(–)G(–)	I_{GT}	–	20	75	mA
MT2(+)G(–); MT2(–)G(+)	I_{GT}	–	30	100	mA
Gate Trigger Voltage, Continuous dc (1) Main Terminal Voltage = 7.0 Vdc, R_L = 47 ohms					
MT2(+)G(+); MT2(–)G(–)	V_{GT}	–	1.0	3.0	Volts
MT2(+) G(–); MT2(–)G(+)	V_{GT}	-	1.2	3.0	Volts
Gate Trigger Voltage, Continuous dc – All Modes Main Terminal Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C	V_{GD}	0.2	–	–	Volt
Holding Current (Either Direction) Main Terminal Voltage = 7.0 Vdc, Gate Open, Initiating Current = 150 mA	I_H	–	10	75	mA
Turn-On Time I_{TM} = 25 Adc, I_{GT} = 200 mA	t_{on}	–	1.0	–	μs
Critical Forward Voltage Application Rate (Exponential Rise of Voltage) @ V_{DRM}, T_J = 110°C, Gate Open	dv/dt	–	100	–	V/μs
Thermal Resistance, Junction to Case	θ_{JC}	–	–	1.0	°C/W

(1) All voltage polarity reference to main terminal 1.

FIGURE 1 – MAXIMUM THERMAL RESPONSE

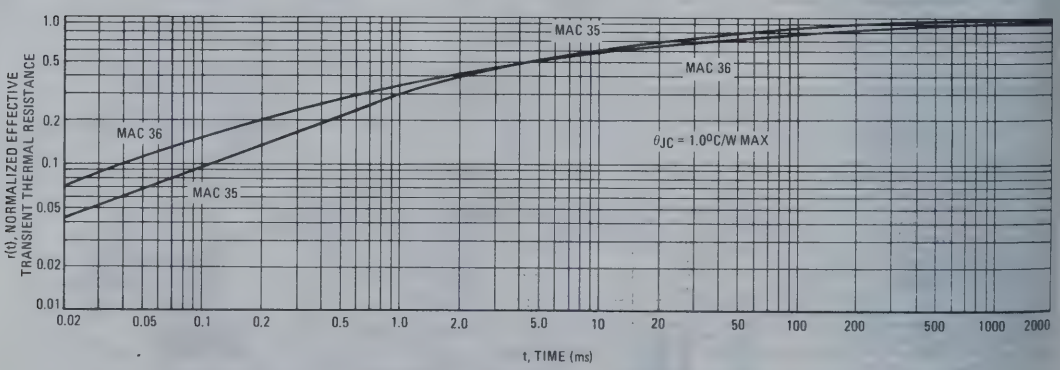


FIGURE 2 – AVERAGE CURRENT DERATING

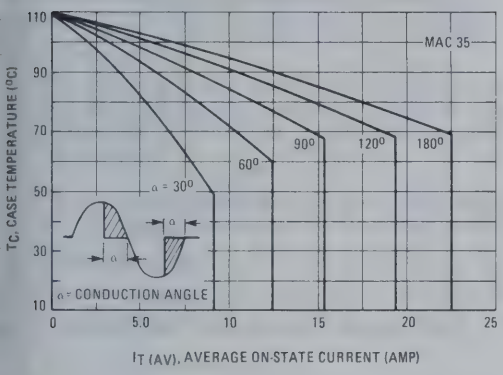


FIGURE 3 – RMS CURRENT DERATING

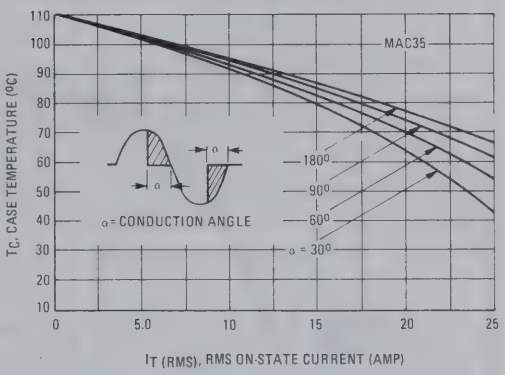


FIGURE 4 – AVERAGE CURRENT DERATING

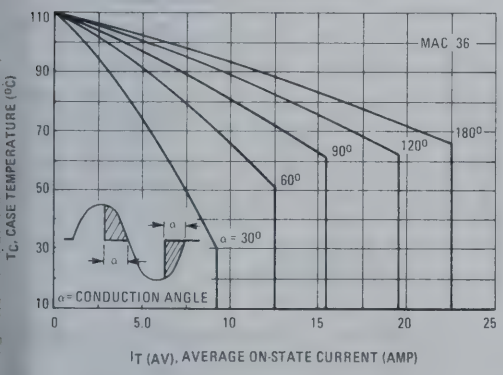


FIGURE 5 – RMS CURRENT DERATING

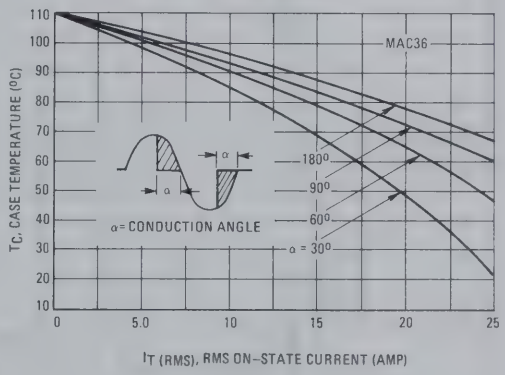


FIGURE 6 – POWER DISSIPATION versus AVERAGE CURRENT

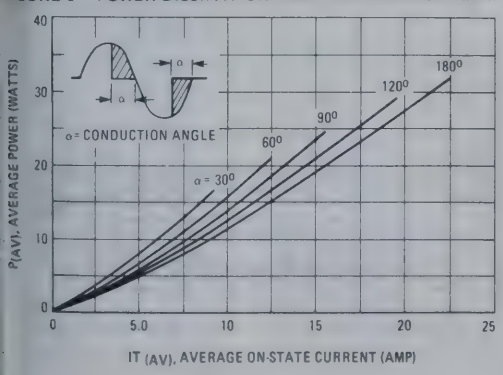


FIGURE 7 – POWER DISSIPATION versus RMS CURRENT

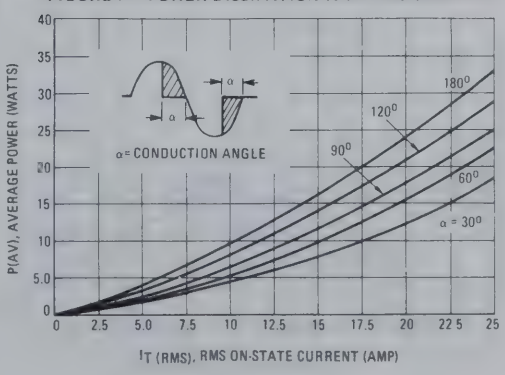


FIGURE 8 – MAXIMUM ON-STATE CHARACTERISTICS

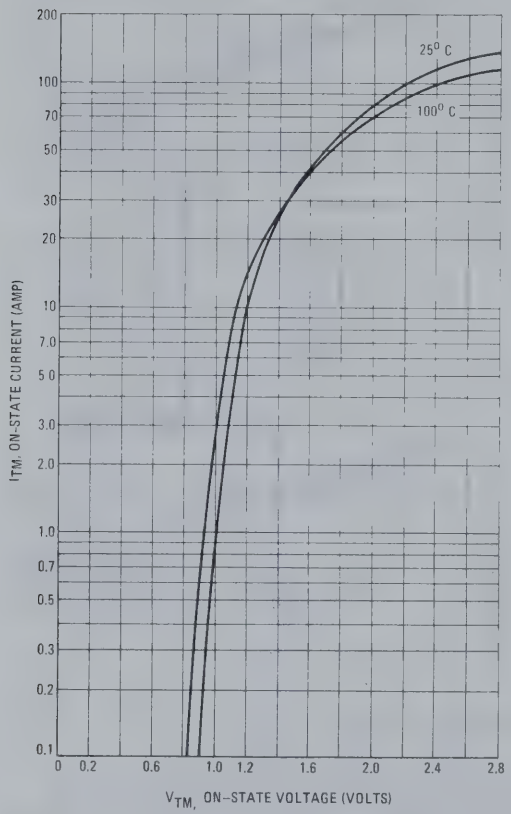


FIGURE 9 – MAXIMUM MULTI-CYCLE SURGE RATING

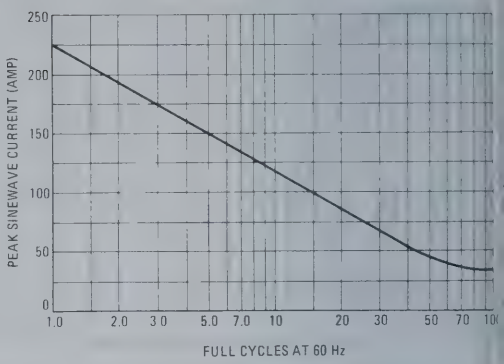


FIGURE 10 – TYPICAL HOLDING CURRENT

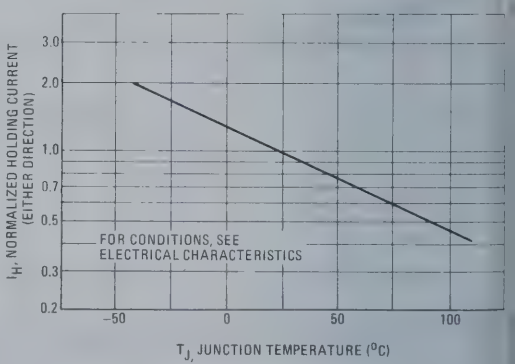


FIGURE 11 – TYPICAL GATE TRIGGER CURRENT

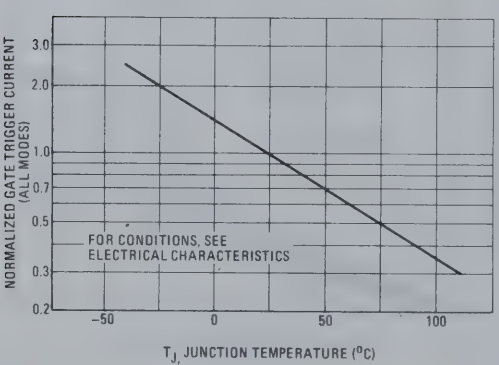
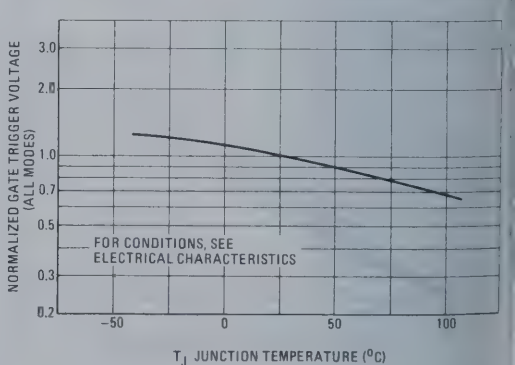


FIGURE 12 – TYPICAL GATE TRIGGER VOLTAGE



MBD101 (SILICON)

SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for UHF mixer applications but suitable also for use in detector and ultra-fast switching circuits. Supplied in an inexpensive plastic package for low-cost, high-volume consumer requirements.

- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Low Noise Figure – 7.0 dB Max @ 1.0 GHz
- Very Low Capacitance – Less Than 1.0 pF @ Zero Volts
- High Forward Conductance – 0.48 Volts (Typ) @ I_F = 10 mA

SILICON HOT-CARRIER UHF MIXER DIODE



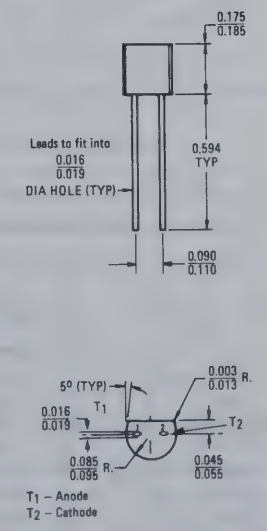
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	4.0	5.0	–	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	C_T	–	0.88	1.0	pF
Forward Voltage (I_F = 10 mA)	V_F(1)	–	0.48	0.60	Volts
Noise Figure (f = 1.0 GHz, Note 2)	NF	–	6.0	7.0	dB
Reverse Leakage (V_R = 3.0 V)	I_R	–	0.02	0.25	μA
Series Inductance (Note 3) (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	6.0	–	nH
Case Capacitance (Note 1) (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.18	–	pF

(1) Matched sets available. Contact Motorola Sales Office with specific requirements.



CASE 182-1

TYPICAL CHARACTERISTICS
(T_A = 25°C unless noted)

FIGURE 1 – REVERSE LEAKAGE

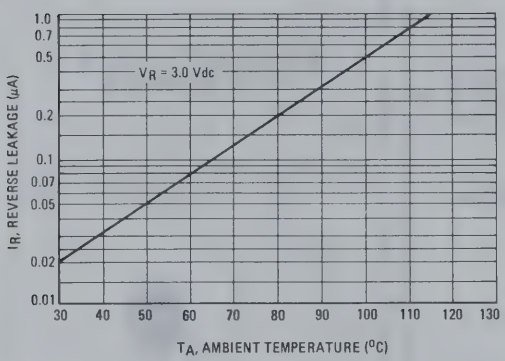


FIGURE 2 – FORWARD VOLTAGE

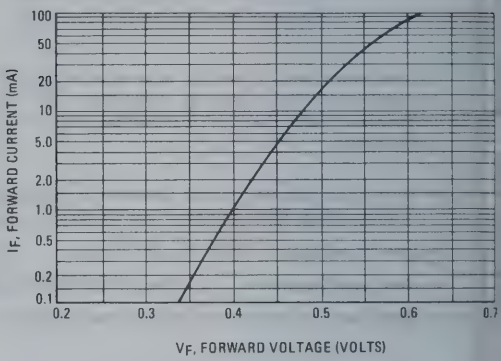


FIGURE 3 – CAPACITANCE

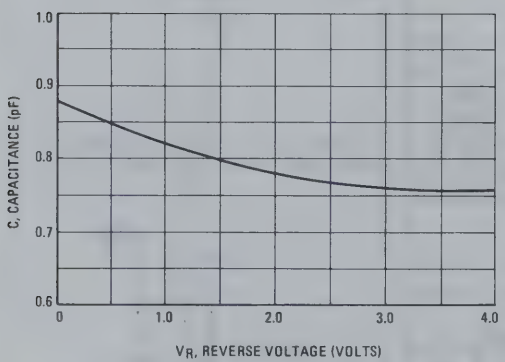


FIGURE 4 – NOISE FIGURE

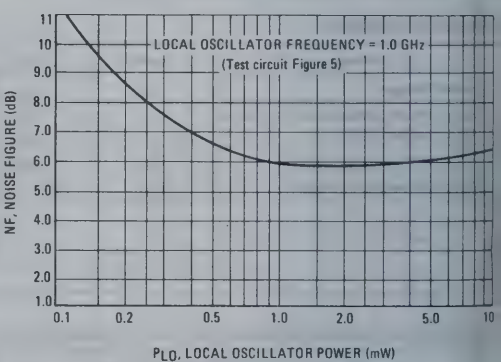
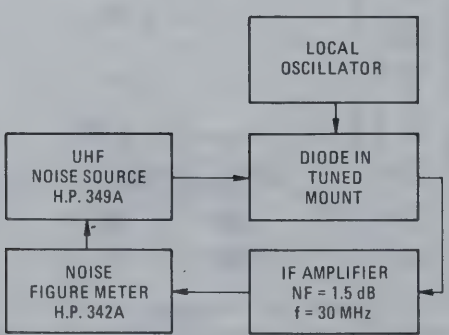


FIGURE 5 – NOISE FIGURE TEST CIRCUIT



NOTES ON TESTING AND SPECIFICATIONS

Note 1 – C_C and C_T are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Note 2 – Noise figure measured with diode under test in tuned diode mount using UHF noise source and local oscillator (LO) frequency of 1.0 GHz. The LO power is adjustec for 1.0 mW. IF amplifier NF = 1.5 dB, f = 30 MHz, see Figure 5.

Note 3 – L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

MBD501 (SILICON)
MBD701



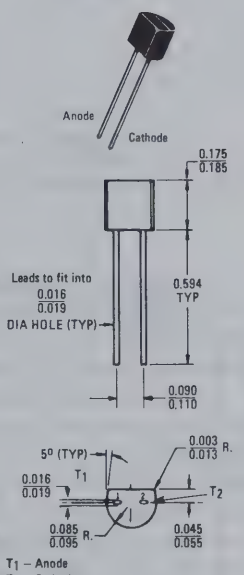
SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for high-efficiency UHF and VHF detector applications. Readily adaptable to many other fast switching RF and digital applications. Supplied in an inexpensive plastic package for low-cost, high-volume consumer and industrial/commerical requirements.

- The Schottky Barrier Construction Provides Ultra-Stable Characteristics By Eliminating the "Cat-Whisker" or "S-Bend" Contact
- Extremely Low Minority Carrier Lifetime – 100 ps (Max)
- Very Low Capacitance – 1.0 pF
- High Reverse Voltage – to 70 Volts
- Low Reverse Leakage – 200 nA (Max)

HIGH-VOLTAGE SILICON HOT-CARRIER DETECTOR AND SWITCHING DIODES

50-70 VOLTS



CASE 182-1

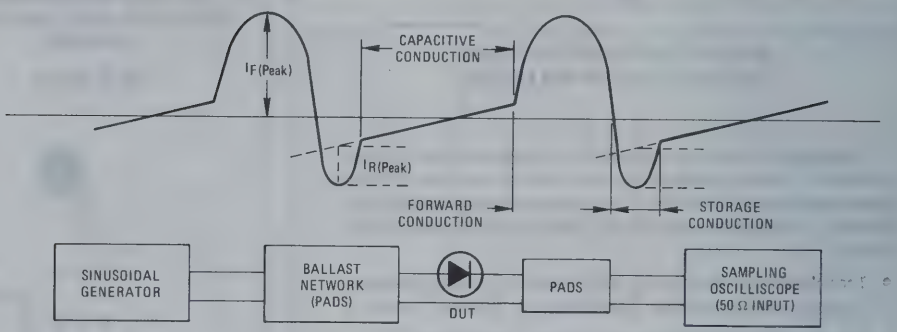
MAXIMUM RATING (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage MBD501 MBD701	V_R	 50 70	Volts
Forward Power Dissipation @ T_A = 25°C Derate Above 25°C	P_F	500 5.0	mW mW/°C
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	MBD501 MBD701	$V_{(BR)R}$	 50 70	 – –	 – –	Volts
Total Capacitance, Figure 1 (V_R = 20 Volts, f = 1.0 MHz)		C_T	–	0.5	1.0	pF
Minority Carrier Lifetime, Figure 2 (I_F = 5.0 mA, Krakauer Method)		τ	–	15	100	ps
Reverse Leakage, Figure 3 (V_R = 25 V) (V_R = 35 V)	 MBD501 MBD701	I_R	 – –	 7.0 9.0	 200 200	nAdc
Forward Voltage, Figure 4 (I_F = 10 mAdc)		V_F	–	1.0	1.2	Vdc
Series Inductance (f = 250 MHz, Lead Lenth ≈1/16")		L_S	–	6.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Lenth ≈1/16")		C_C	–	0.18	–	pF

KRAKAUER METHOD OF MEASURING LIFE TIME



TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – TOTAL CAPACITANCE

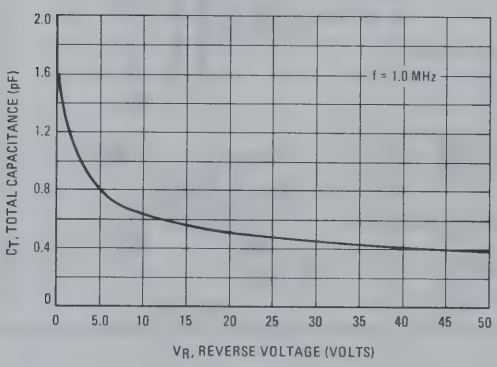


FIGURE 2 – MINORITY CARRIER LIFETIME

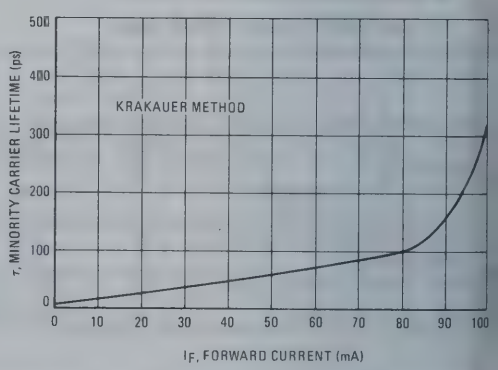


FIGURE 3 – REVERSE LEAKAGE

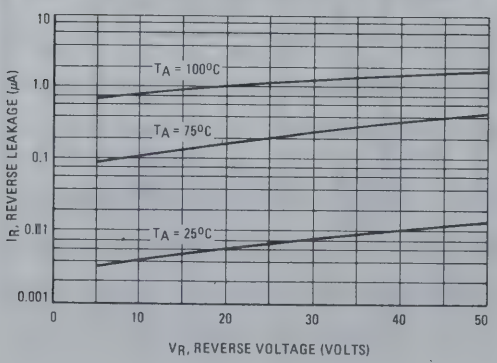
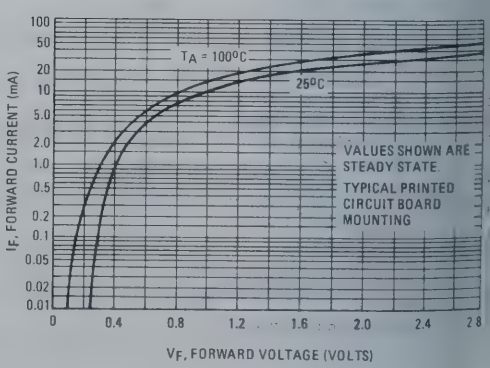


FIGURE 4 – FORWARD VOLTAGE



MBD5500A (SILICON)

HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlay contact.

- Extremely Low V_F
- Low Power Loss/High Efficiency
- Low Stored Charge, Majority Carrier Conduction
- High Surge Capacity
- Industry Standard Package

Designers Data for "Worst Case" Conditions

The Designers Data Sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

HOT CARRIER POWER RECTIFIER

50 AMPERES
20 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage	V_{RRM}	20	Volts
Working Peak Reverse Voltage	V_{RWM}	20	Volts
DC Blocking Voltage	V_R	20	Volts
Non-Repetitive Peak Reverse Voltage (half-wave, single phase, 60 Hz peak)	V_{RSM}	24	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	14	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 2) $T_C = 50^oC$	I_O	50	Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 5)	I_{FSM}	800	Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.3	$^oC/W$

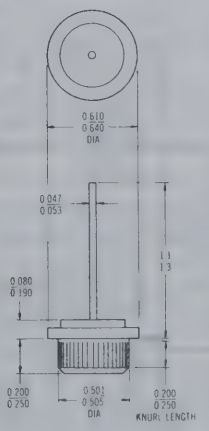
MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

FINISH: All external surfaces corrosion-resistant and the terminal lead is readily solderable.

POLARITY: Cathode to case.

MOUNTING POSITIONS: Any



CASE 43
(DO-21)

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Instantaneous Forward Voltage Drop (i_F = 100 Amp, T_C = 25°C) (i_F = 10 Amp, T_C = 25°C)	V_F	 0.75 0.35	Volts
Instantaneous Reverse Current (V_R = 20 V, T_C = 25°C) (V_R = 20 V, T_C = 100°C)	I_R	 75 300	mA

FIGURE 1 – THERMAL RESPONSE

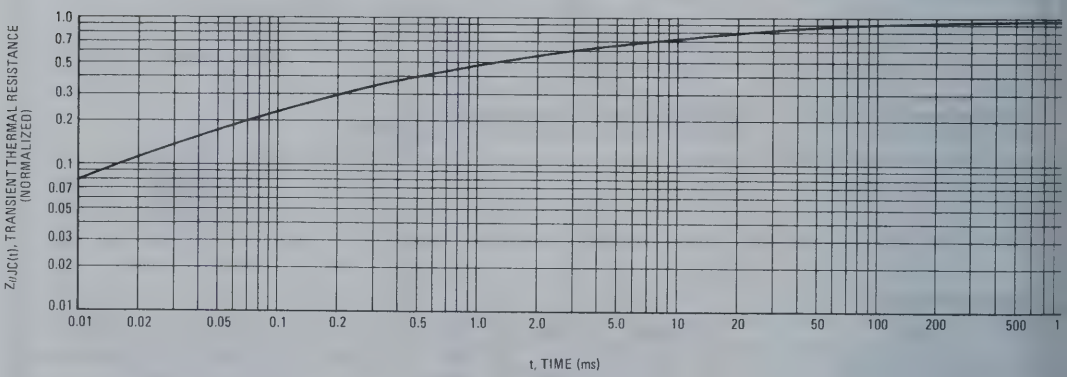


FIGURE 2 – MAXIMUM ALLOWABLE CURRENT

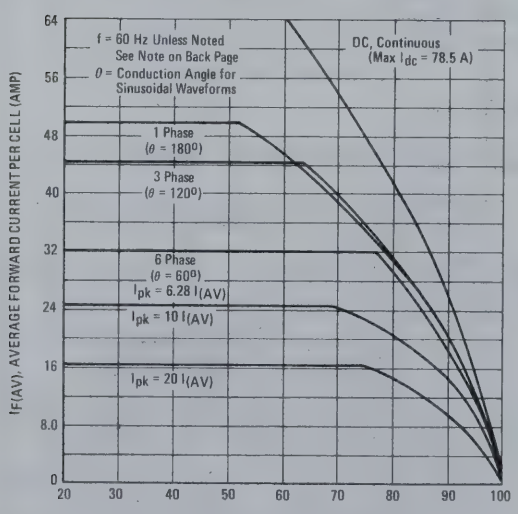


FIGURE 3 – MAXIMUM POWER DISSIPATION

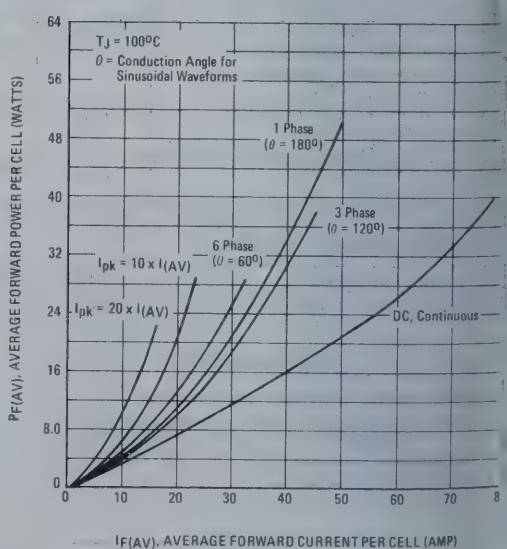


FIGURE 4 – FORWARD VOLTAGE

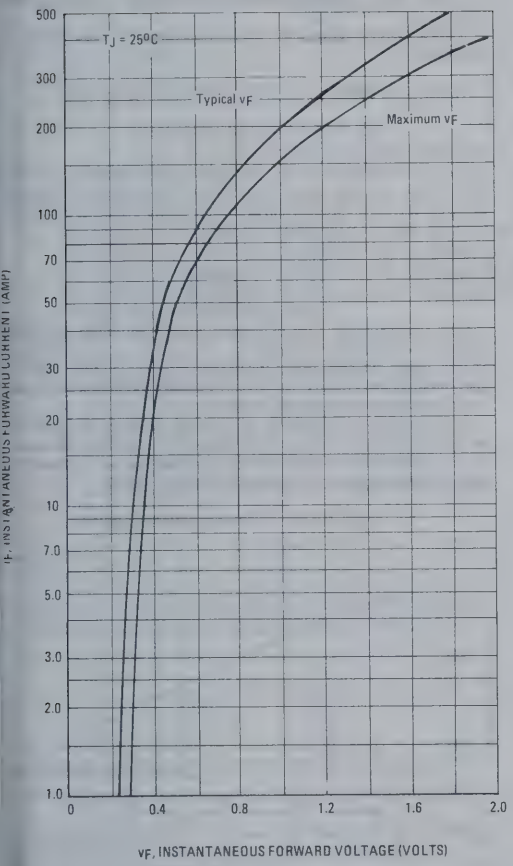


FIGURE 5 – MAXIMUM SURGE CAPABILITY

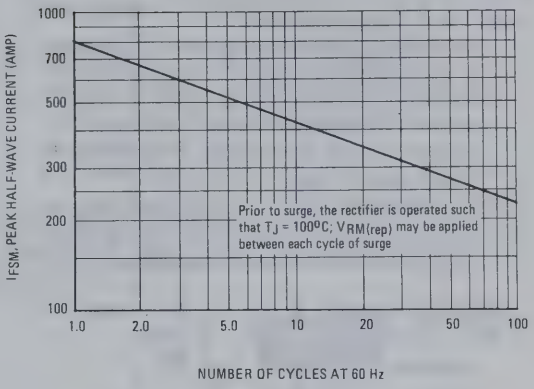


FIGURE 6 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

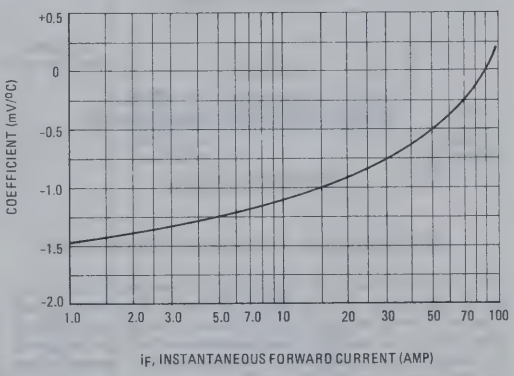


FIGURE 7 – REVERSE LEAKAGE

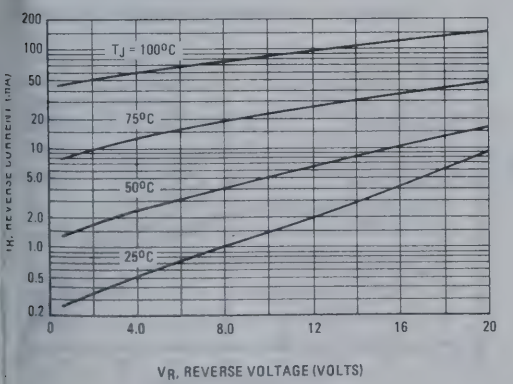
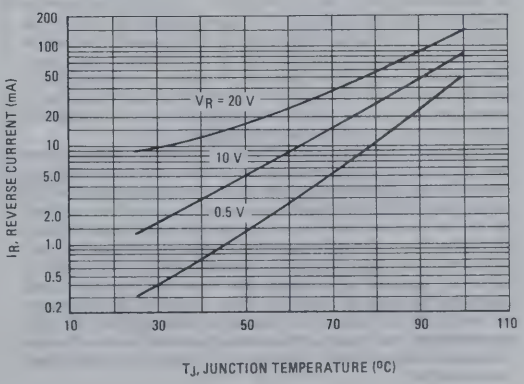


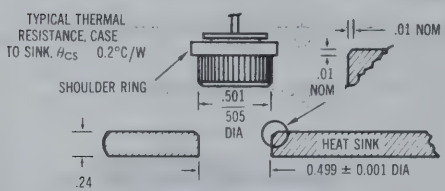
FIGURE 8 – REVERSE LEAKAGE



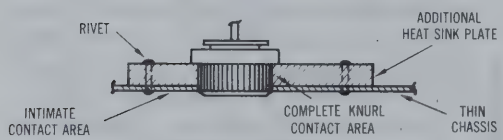
MOUNTING PROCEDURES

The Motorola MBD5500A rectifier is designed to be press-fitted in a heat sink to attain full device ratings. Recommended procedures for this type of mounting are as follows:

1. Drill a hole in the heat sink 0.499 ± 0.001 inch in diameter.
2. Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.
3. The depth and width of the break should be 0.010 inch maximum to retain maximum heat sink surface contact.
4. To prevent damage to the rectifier during press-in, the pressing force should be applied only on the shoulder ring of the rectifier case as shown.
5. The pressing force should be applied evenly about the shoulder ring to avoid tilting or canting of the rectifier case in the hole during the press-in operation. Also, the use of a light industrial lubricant will be of considerable aid.



HEAT SINK MOUNTING



THIN-CHASSIS MOUNTING

NOTES ON HIGH FREQUENCY OPERATION

Since current flow in the MBD5500A is the result of majority carrier conduction, it is not subject to normal diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 9)

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance which lowers the dc output voltage.

The current rating shown in Figure 2 is based on the restriction that the junction temperature can not exceed 100°C when reverse voltage is applied; however, temperatures over 100°C are permitted during forward current conduction. At an input frequency of 60 Hz, the time available for cooling permits a significant increase in the maximum allowable current over that value if junction temperatures were never allowed to exceed 100°C. However, as operating frequency is increased, the time available for cooling eventually decreases to the point where it is no longer significant; for the MBD5500 this point is reached at approximately 10 kHz. Consequently the maximum allowable case temperature for all frequencies above 10 kHz (see Figure 10) may be calculated from the expression:

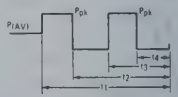
$$T_{C(Max)} = 100^{o}C - \theta_{JC} P_D$$

Values for P_D may be obtained from Figure 3 for sinusoidal waveforms.

At frequencies below 10 kHz, the following relationship is applicable:

$$T_{C(Max)} = 100^{o}C - \theta_{JC} [P_{(AV)} + (P_{pk} - P_{(AV)}) r(t_1) - P_{pk} r(t_2) + P_{pk} r(t_3) - P_{pk} r(t_4)]$$

The time reference is the time when reverse voltage is applied; $r(t_1)$, $r(t_2)$, etc., are taken from Figure 1 at times corresponding to t_1, t_2, etc.; the other factors are identified on the diagram below.



Peak power, P_{pk}, may be conservatively estimated by determining an equivalent rectangular current pulse of amplitude equal to the peak current, and multiplying by V_F at that current. Additional information on using thermal response data is contained in Motorola Application Note AN-292.

For convenience, derating information is given in Figure 10 for frequencies of 1.0 KC, 10 KC and above. Approximate values for allowable current for other frequencies can be obtained by interpolation between the curves of Figures 2 and 10.

FIGURE 9 – TYPICAL CAPACITANCE

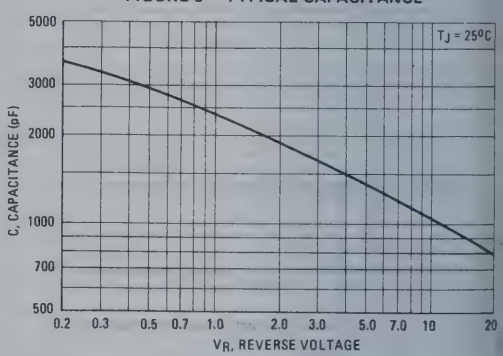
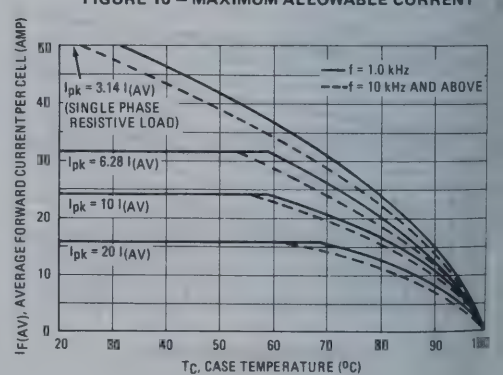


FIGURE 10 – MAXIMUM ALLOWABLE CURRENT



MBS4991 (SILICON)
MBS4992



SILICON BIDIRECTIONAL SWITCH

. . . designed for full-wave triggering in Triac phase control circuits, half-wave SCR triggering application and as voltage level detectors. Supplied in an inexpensive plastic TO-92 package for high-volume requirements, this low-cost plastic package is readily adaptable for use in automatic insertion equipment.

- Low Switching Voltage – 8.0 Volts Typical
- Uniform Characteristics in Each Direction
- Low On-State Voltage – 1.7 Volts Maximum
- Low Off-State Current – 0.1 μA Maximum
- Low Temperature Coefficient – 0.02 %/°C Typical

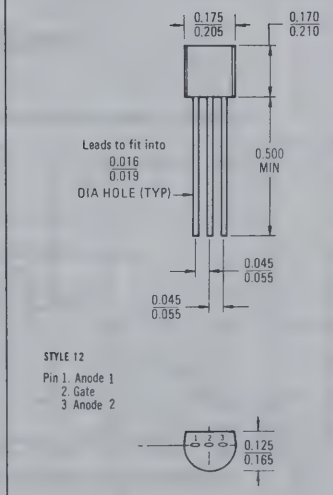
SILICON BIDIRECTIONAL SWITCH (PLASTIC)

6.0–10 VOLTS
300 mW



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation	P_D	300	mW
DC Forward Anode Current	I_F	200	mA
DC Gate Current (off-state only)	$I_G(off)$	5.0	mA
Repetitive Peak Forward Current (1.0% Duty Cycle, 10 μs Pulse Width, T_A = 100°C)	$I_{FM}(rep)$	2.0	Amp
Non-Repetitive Forward Current 10 μs Pulse Width, T_A = 25°C	$I_{FM}(nonrep)$	6.0	Amp
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



CASE 29–02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Switching Voltage		V_S				Vdc
	MBS4991		6.0	8.0	10	
	MBS4992		7.5	8.0	9.0	
Switching Current		I_S				μAdc
	MBS4991		–	175	350	
	MBS4992		–	90	120	
Switching Voltage Differential		$\lvert V_{S1}-V_{S2}\rvert$				Vdc
	MBS4991		–	0.3	0.5	
	MBS4992		–	0.1	0.2	
Gate Trigger Current		I_{GF}				μAdc
(V_F = 5.0 Vdc R_L = 1.0 K ohm)	MBS4992		–	–	100	
Holding Current		I_H				mAdc
	MBS4991		–	0.7	1.5	
	MBS4992		–	0.2	0.5	
Off-State Blocking Current		I_B				μAdc
(V_F = 5.0 Vdc, T_A = 25°C)	MBS4991		–	0.08	1.0	
(V_F = 5.0 Vdc, T_A = 85°C)	MBS4991		–	6.0	10	
(V_F = 5.0 Vdc, T_A = 25°C)	MBS4992		–	0.08	0.1	
(V_F = 5.0 Vdc, T_A = 100°C)	MBS4992		–	6.0	10	
Forward On-State Voltage		V_F				Vdc
(I_F = 175 mAdc)	MBS4991		–	1.4	1.7	
(I_F = 200 mAdc)	MBS4992		–	1.5	1.7	
Peak Output Voltage (C_c = 0.1 μF, R_L = 20 ohms, Figure 7)		V_o	3.5	4.8	–	Vdc
Turn-On Time (Figure 8)		t_{on}	–	1.0	–	μs
Turn-Off Time (Figure 9)		t_{off}	–	30	–	μs
Temperature Coefficient of Switching Voltage		T_C	–	+0.02	–	%/°C

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SWITCHING VOLTAGE

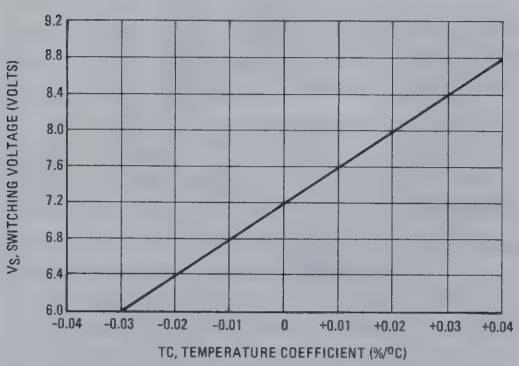


FIGURE 2 – SWITCHING CURRENT versus TEMPERATURE

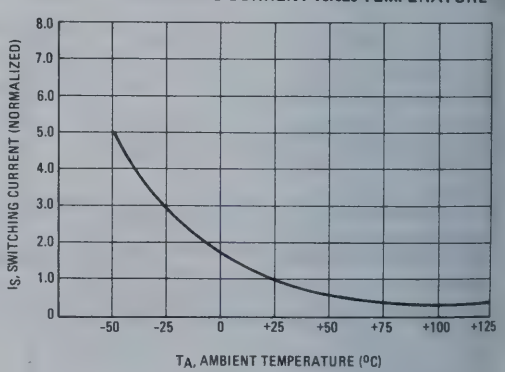


FIGURE 3 – HOLDING CURRENT versus TEMPERATURE

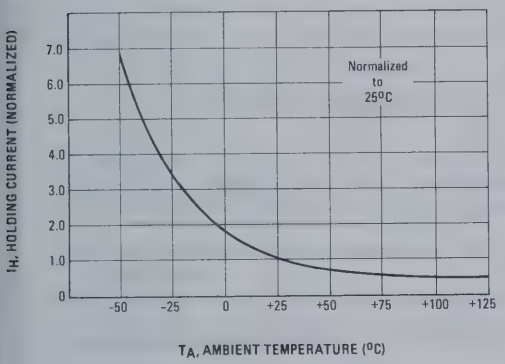


FIGURE 4 – OFF-STATE BLOCKING CURRENT versus TEMPERATURE

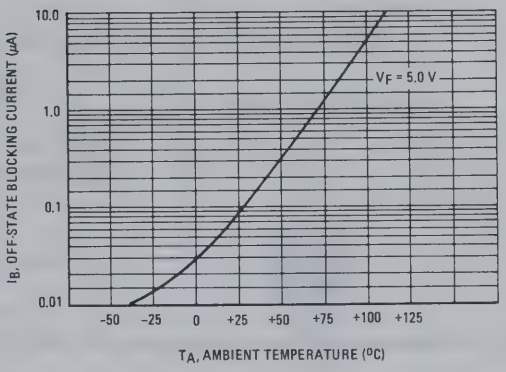


FIGURE 5 – ON-STATE VOLTAGE versus FORWARD CURRENT

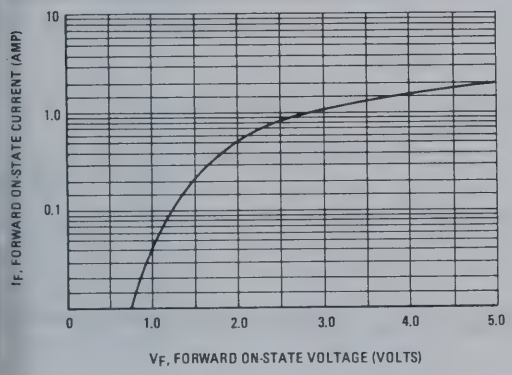


FIGURE 6 – OUTPUT VOLTAGE (FUNCTION OF R_L AND C_c)

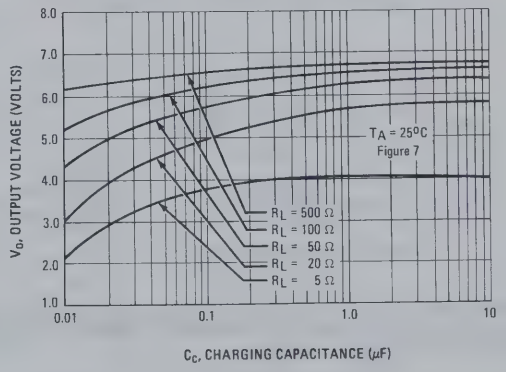


FIGURE 7 – PEAK OUTPUT VOLTAGE TEST CIRCUIT

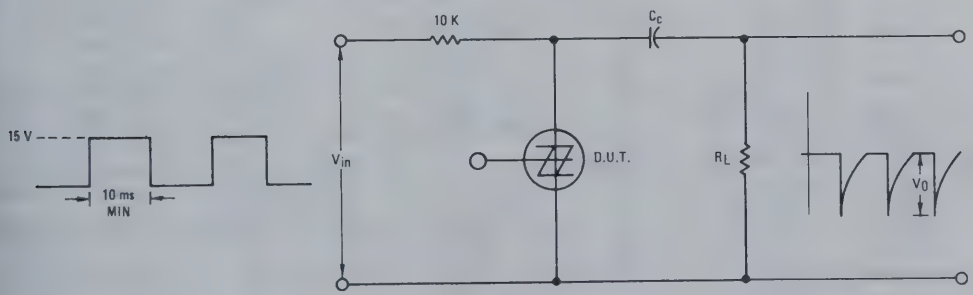
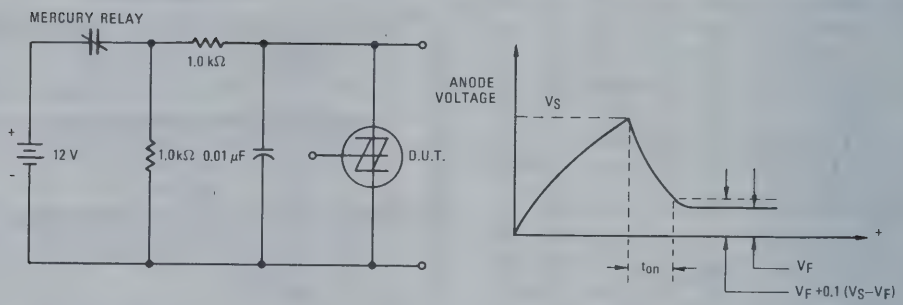
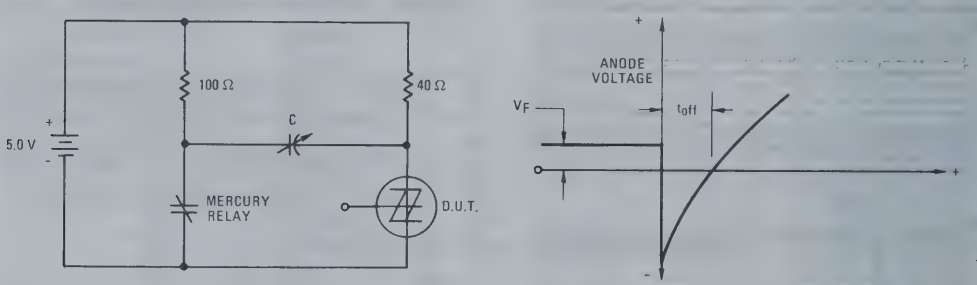


FIGURE 8 – TURN-ON TIME TEST CIRCUIT



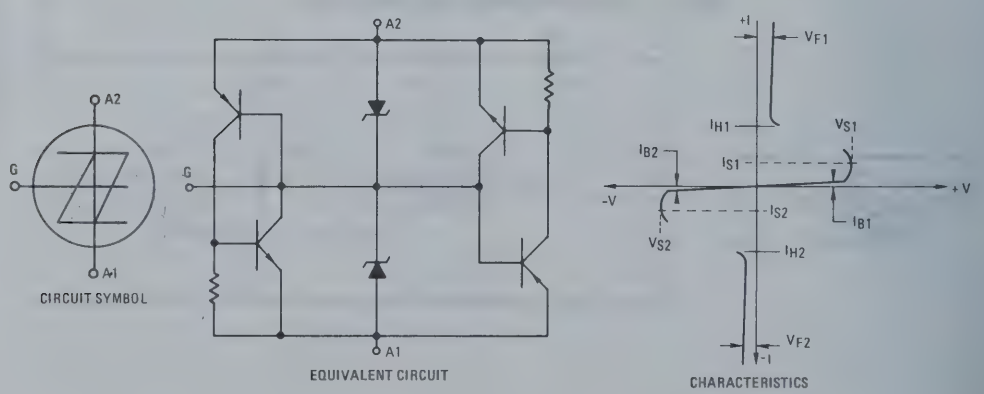
Turn-on time is measured from the time V_S is achieved to the time when the anode voltage drops to within 90% of the difference between V_S and V_F.

FIGURE 9 – TURN-OFF TIME TEST CIRCUIT



With the SBS in conduction and the relay contacts open, the contacts are closed and the anode is driven negative. C is decreased, and when the anode voltage becomes positive, the SBS remains off. The turn-off time, t_{off}, is the time between initial contact closure and the point where the anode voltage passes through zero volts.

FIGURE 10 – DEVICE EQUIVALENT CIRCUIT, CHARACTERISTICS AND SYMBOLS



MCA1911N, P series MCA2011N, P series

6.8 Volts **8.6 Volts**

MCA2111N, P series

9.5 Volts

MCA2211N, P series

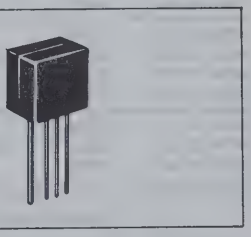
11 Volts

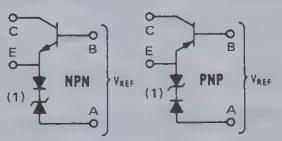
REFERENCE AMPLIFIERS

. . . designed for use in regulated power supplies as a combination voltage reference element and error voltage amplifier, providing temperature compensation for excellent reference voltage stability.

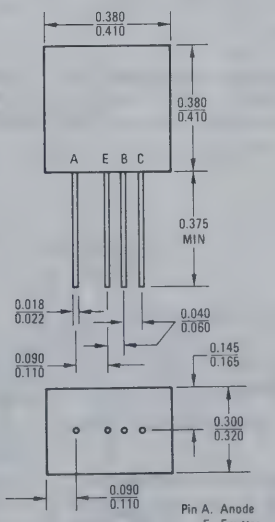
- Available With Either PNP or NPN Polarity for Versatility of Circuit Design
- Specified With a Variety of Reference Voltage Stability Factors Allowing for a Wide Selection of the Most Economical Device to Meet Circuit Requirements
- Available for Operation in Three Different Test Temperature Ranges: 0 to +75°C, -55 to +100°C, -55 to +150°C
- Guaranteed Maximum Impedance
- "In-Line" Leads – Ideal for Automatic Insertion

REFERENCE AMPLIFIERS





(1) MCA1911 Series uses only zener diode and transistor.



CASE 212-(2)
(Formerly Case 181)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Zener Current	I_Z	20	mA
Collector Current	I_C	20	mA
Collector-Emitter Voltage	V_{CEO}	30	Volts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Value		Unit
		Min	Max	
Nominal Reference Voltage (I_Z = 5.0 mA, V_{CE} = 3.0 V, I_C = 250 μA)	V_{REF}	6.8 - 11 (Nom) (Table 1)		Volts
Maximum Reference Voltage Change with Temperature (I_Z = 5.0 mA, V_{CE} = 3.0 V, I_C = 250 μA)	ΔV_{REF}	(Table 1)		Volts
Zener Impedance (I_{ZT} = 5.0 mA, I_{ac} = 10% I_Z) MCA1911N, P; MCA2011N,P; Series MCA2211N,P Series	Z_{ZT}	– –	40 120	ohms
Collector-Emitter Breakdown Voltage (I_C = 250 μA)	BV_{CEO}	30	–	Volts
Collector-Cutoff Current (V_{CB} = 45 V) (V_{CB} = 45 V, T_A = 150°C)	I_{CBO}	– –	0.05 10	μA
DC Current Gain (I_C = 250 μA, V_{CE} = 3.0 V)	h_{FE}	50	300	–
Small-Signal Transconductance (V_{CE} = 3.0 V, I_C = 250 μA, f = 1.0 kHz)	g_{fe}	6500	–	μmhos

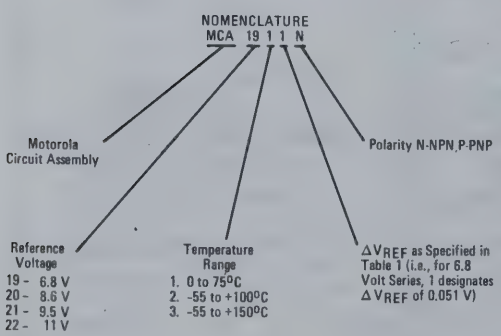
TABLE 1 – ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Type Number (Note 1)	Max Voltage Change (Note 2) ΔV_{REF} (Volts)	@ Test Temperature (°C)	Reference Voltage V_{REF} (Volts)
6.8 Volt Series (I_{ZT} = 5 mA)			
MCA1911N	0.051	0, +25, +75	6.8 ± 10%
MCA1912N	0.025		
MCA1913N	0.010		
MCA1914N	0.005		
MCA1921N	0.105	-55, 0, +25, +75, +100	6.8 ± 5%
MCA1922N	0.052		
MCA1923N	0.020		
MCA1924N	0.010		
MCA1931N	0.139	-55, 0, +25, +75, +100, +150	6.8 ± 5%
MCA1932N	0.069		
MCA1933N	0.026		
MCA1934N	0.013		
9.5 Volt Series (I_{ZT} = 5 mA)			
MCA2111N	0.071	0, +25, +75	9.5 ± 10%
MCA2112N	0.035		
MCA2113N	0.014		
MCA2114N	0.007		
MCA2121N	0.147	-55, 0, +25, +75, +100	9.5 ± 5%
MCA2122N	0.073		
MCA2123N	0.028		
MCA2124N	0.014		
MCA2131N	0.194	-55, 0, +25, +75, +100, +150	9.5 ± 5%
MCA2132N	0.097		
MCA2133N	0.038		
MCA2134N	0.019		

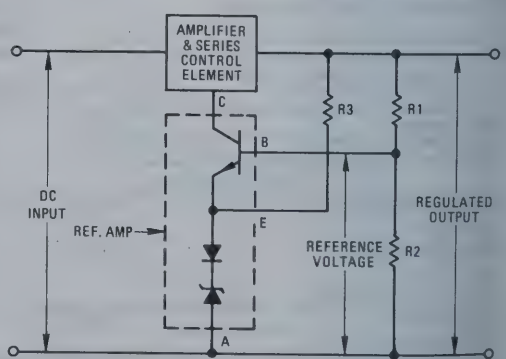
Type Number (Note 1)	Max Voltage Change (Note 2) ΔV_{REF} (Volts)	@ Test Temperature (°C)	Reference Voltage V_{REF} (Volts)
8.6 Volt Series (I_{ZT} = 5 mA)			
MCA2011N	0.060	0, +25, +75	8.6 ± 10%
MCA2012N	0.030		
MCA2013N	0.012		
MCA2014N	0.006		
MCA2021N	0.124	-55, 0, +25, +75, +100	8.6 ± 5%
MCA2022N	0.062		
MCA2023N	0.024		
MCA2024N	0.012		
MCA2031N	0.164	-55, 0, +25, +75, +100, +150	8.6 ± 5%
MCA2032N	0.082		
MCA2033N	0.032		
MCA2034N	0.016		
11 Volt Series (I_{ZT} = 5 mA)			
MCA2211N	0.082	0, +25, +75	11 ± 10%
MCA2212N	0.041		
MCA2213N	0.016		
MCA2214N	0.008		
MCA2221N	0.170	-55, 0, +25, +75, +100	11 ± 5%
MCA2222N	0.085		
MCA2223N	0.034		
MCA2224N	0.017		
MCA2231N	0.225	-55, 0, +25, +75 +100, +150	11 ± 5%
MCA2232N	0.112		
MCA2233N	0.044		
MCA2234N	0.022		

NOTES:

1. Type numbers listed are NPN polarity. For PNP polarity devices substitute "P" suffix – e.g.: MCA1911N (NPN)
   MCA1911P (PNP)
2. ΔV_{REF} is the maximum voltage variation over the specified test temperature range, verified by tests at specified points within the range.

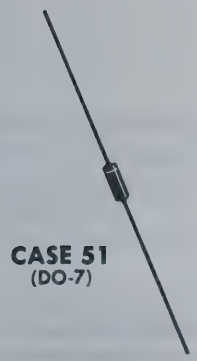


TYPICAL APPLICATION IN REGULATED POWER SUPPLIES



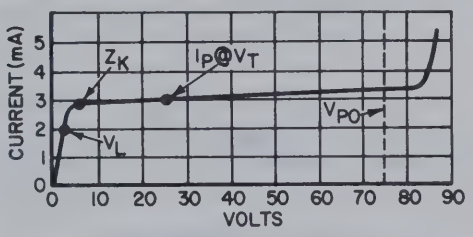
MCL1300 thru MCL1304 (SILICON)

Field-effect current limiting diodes designed for applications requiring a current reference or a constant current over a specified voltage range.



CASE 51
(DO-7)

CURRENT-LIMITER CHARACTERISTICS AND SYMBOL IDENTIFICATION
(See Notes 1 thru 6)



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Junction and Storage Temperature: -65°C to +200°C

Peak Operating Voltage: See Table

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Type Number	Nominal Pinch-Off Current Note 1 I_P (mA)	Tol. (mA)	Test Volt. Note 2 V_T (volts)	Limiter Imped. Note 3 Z_T (min) (megohms)	Knee Imped. at 6 V Note 4 Z_K (min) (megohms)	Limiting Voltage Note 5 V_L (max) (volts)	Peak Operating Voltage Note 6 V_{PO} (volts)
MCL1300	0.5	±0.3	25	4.000	0.500	1.0	75
MCL1301	1.0	±0.6	25	0.800	0.200	1.5	75
MCL1302	2.0	±0.6	25	0.400	0.100	2.0	75
MCL1303	3.0	±0.6	25	0.300	0.050	2.0	75
MCL1304	4.0	±0.6	25	0.250	0.025	2.5	75

These specifications are preliminary. Selections may be made to obtain nominal currents between those shown, as well as tighter tolerance units.

SYMBOL DEFINITIONS:

Note 1 I_P - The pinch-off current is the guaranteed current at a specified V_T. I_P is specified as a nominal with a tolerance.

Note 2 V_T - The test voltage for measurement of I_P.

Note 3 Z_T - The impedance at the test voltage, V_T, specified. To provide the most constant current Z_T should be as high as possible; thus a minimum Z_T is specified. Z_T is derived from the 90 cycle per second current which results when an AC voltage having an RMS value equal to 10% of the test voltage (V_T) is superimposed on V_T.

Note 4 Z_K - Knee impedance is specified as a minimum also since again the highest value is desired. V_K is established as 6.0 V for convenience.

Note 5 V_L - Limiting Voltage. This specification is provided with Z_K to indicate the sharp knee of the device. The specification is analogous to I_R and Z_K of a zener diode. V_L a maximum specification is measured at 80% on I_P tolerance.

Note 6 V_{PO} - The peak-operating voltage is provided and indicates the maximum voltage to be applied to the device. The specification is necessary since the device is either power limited or breakdown limited beyond this specified voltage.

MCR406-1 (SILICON)
thru
MCR406-4



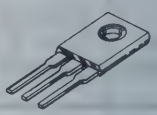
PLASTIC THYRISTORS

. . . Annular† PNPN devices designed for high volume consumer applications, such as temperature, light, and speed control, process and remote control, and warning systems where reliability of operation is important. Sensitive gate trigger permits operation as a switch directly from low level sensors.

- Annular† Passivated Surface for Reliability and Uniformity
- True Power Rated – 4.0 Amp @ T_C = 97°C
- Low Level Gate Characteristics – I_{GT} = 200 μA @ T_A = 25°C
- Higher Surge Current Rating – I_{TSM} = 30 Amp
- Flat, Rugged, Thermopad†† Construction – for Low Thermal Resistance, High Heat Dissipation, and Durability

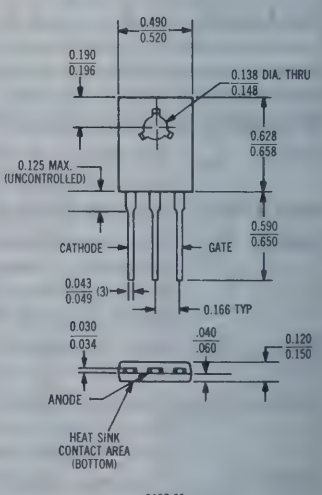
PLASTIC SILICON CONTROLLED RECTIFIERS

4.0 AMPERES RMS
30 thru 200 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) MCR406-1	V_{RRM}	30	Volts
MCR406-2		60	
MCR406-3		100	
MCR406-4		200	
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	4.0	Amp
Peak Forward Surge Current (1/2 cycle, 60 Hz, T_J = -40 to +110°C)	I_{TSM}	30	Amp
Circuit Fusing Considerations (T_J = -40 to 110°C, t = 1.0 to 8.3 ms)	I^2t	3.6	A^2s
Peak Gate Power – Forward	P_{GFM}	0.5	Watt
Average Gate Power – Forward	$P_{GF(AV)}$	0.1	Watt
Peak Gate Current – Forward	I_{GFM}	0.2	Amp
Peak Gate Voltage – Reverse	V_{GRM}	6.0	Volts
Operating Junction Temperature Range	T_J	-40 to +110	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Torque (6-32 screw) (Note 2)	–	12	in. lb.



CASE 90

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 Ohms)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 110°C) Note 1	MCR406-1	V_{DRM}	30	–	–	Volts
	MCR406-2		60	–	–	
	MCR406-3		100	–	–	
	MCR406-4		200	–	–	
Peak Forward Blocking Current (Rated V_{DRM} @ T_J = 110°C)		I_{DRM}	–	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_J = 110°C)		I_{RRM}	–	–	100	μA
Forward "On" Voltage (I_{TM} = 4.0 A peak)		V_{TM}	–	–	2.2	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)		I_{GT}	–	–	200	μA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)		V_{GT}	–	–	0.8	Volts
(Anode Voltage = Rated V_{DRM}, R_L = 100 Ohms, T_J = 110°C)		V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 Vdc)		I_H	–	–	3.0	mA
Turn-On Time		t_{on}	Circuit Dependent. Consult Manufacturer.			
Turn-Off Time		t_{off}				
Forward Voltage Application Rate (T_J = 110°C)		dv/dt	–	10	–	V/μs
Thermal Resistance, Junction to Case		θ_{JC}	–	–	2.0	°C/W
Thermal Resistance, Junction to Ambient		θ_{JA}	–	–	50	°C/W

NOTES:

1. V_{DRM} and V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.

   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C. For optimum results, an activated flux (oxide removing) is recommended.

FIGURE 1 – CASE TEMPERATURE versus CURRENT

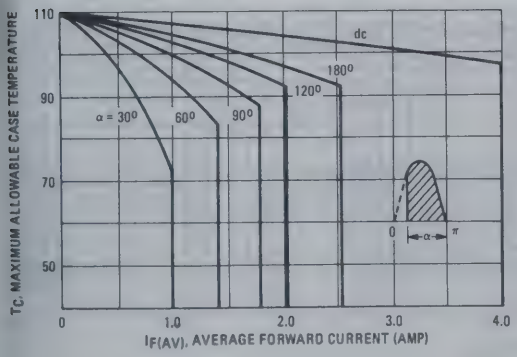


FIGURE 2 – AMBIENT TEMPERATURE versus CURRENT

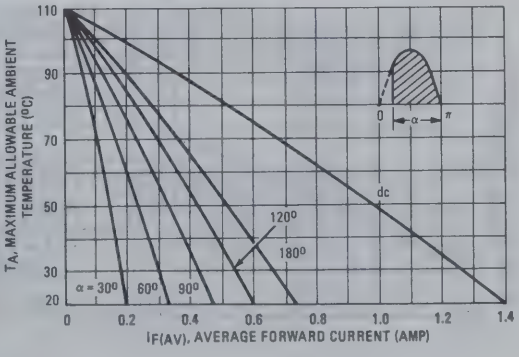


FIGURE 3 – FORWARD CONDUCTION CHARACTERISTICS

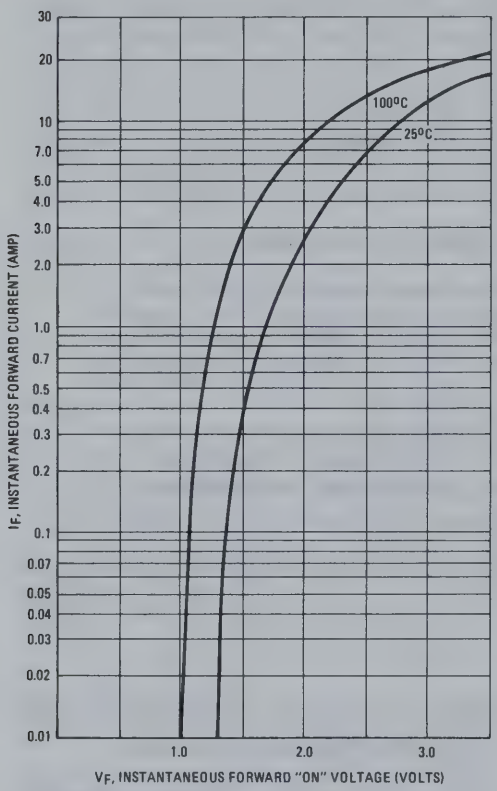


FIGURE 4 – P_D, POWER DISSIPATION

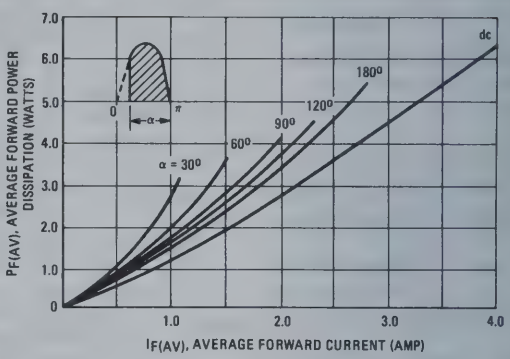


FIGURE 5 – 60 Hz SURGES

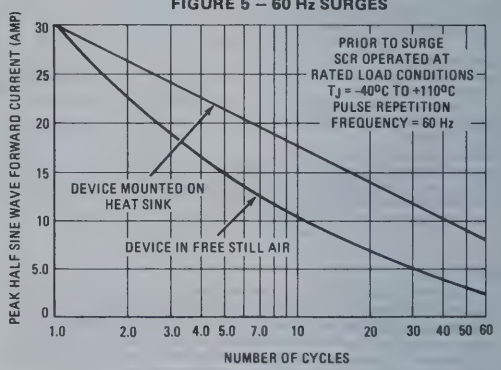


FIGURE 6 – THERMAL RESPONSE

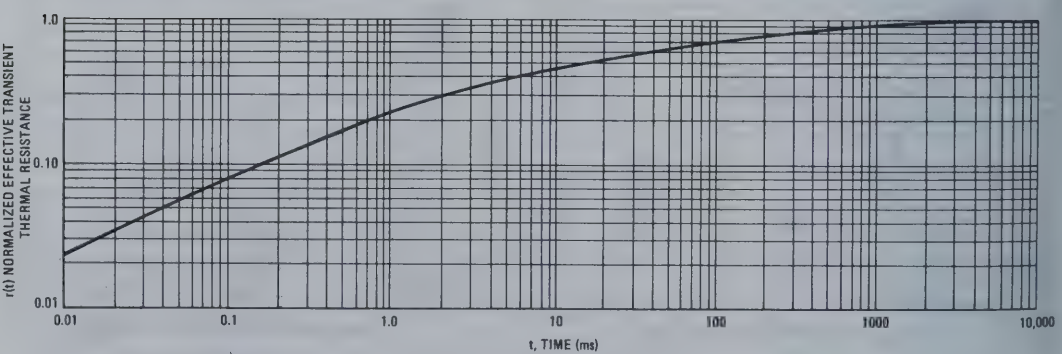


FIGURE 7 – TYPICAL GATE TRIGGER CURRENT

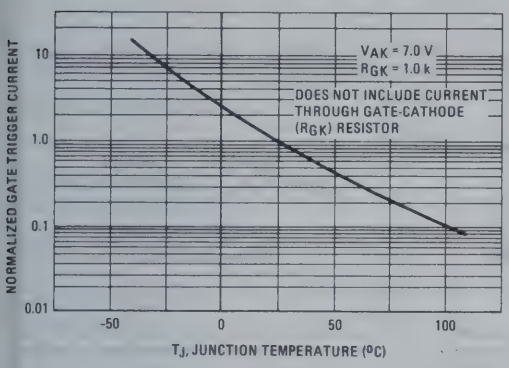


FIGURE 8 – TYPICAL GATE TRIGGER VOLTAGE

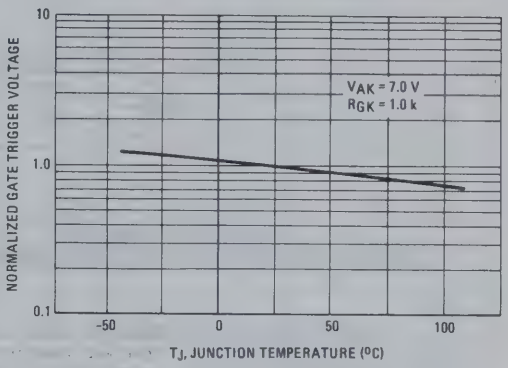
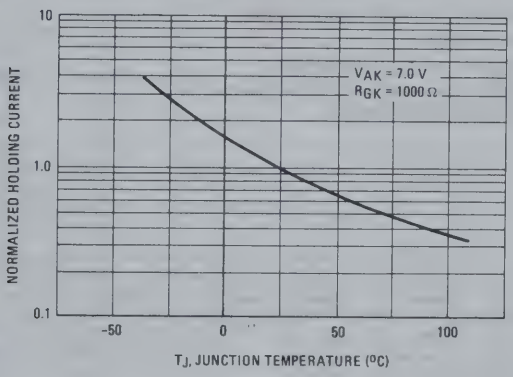


FIGURE 9 – TYPICAL HOLDING CURRENT



SELECTED THYRISTOR-TRIGGER APPLICATION NOTES

AN-227A – Thyristor Trigger Circuits for Power-Control Applications
AN-240 – SCR Power Control Fundamentals
AN-290A – Mounting Procedure for, and Thermal Aspects of, Thermopad Plastic Power Devices
AN-295 – Suppressing RFI in Thyristor Circuits
AN-453 – Zero Point Switching Techniques

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Motorola Semiconductor Products, Inc.
P.O. Box 20924
Phoenix, Arizona 85036

MCR407-1 (SILICON)
thru
MCR407-4



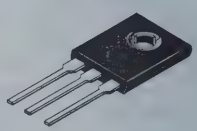
PLASTIC THYRISTORS
(PLASTIC SILICON CONTROLLED RECTIFIERS)

. . . Annular PNPN devices designed for high volume consumer applications such as temperature, light, and speed control; process and remote control, and warning systems where reliability of operation is important.

- Annular Passivated Surface for Reliability and Uniformity
- Power Rated at Economical Prices
- Practical Level Triggering and Holding Characteristics
- Flat, Rugged, Thermopad Construction--for Low Thermal Resistance, High Heat Dissipation and Durability

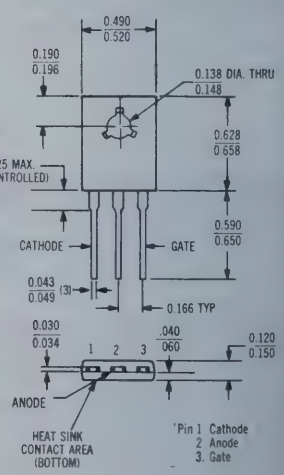
PLASTIC SILICON CONTROLLED RECTIFIERS

4.0 AMPERES RMS
30 thru 200 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) MCR407-1 -2 -3 -4	V_{RRM}	 30 60 100 200	Volts
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	4.0	Amp
Peak Forward Surge Current (½ cycle, 60 Hz, T_J = −40 to +110°C)	I_{TSM}	20	Amp
Circuit Fusing Considerations (T_J = −40 to +110°C) t = 1.0 to 8.3 ms)	I^2t	1.6	A^2s
Peak Gate Power - Forward	P_{GFM}	0.5	Watt
Average Gate Power - Forward	$P_{GF(AV)}$	0.1	Watt
Peak Gate Current - Forward	I_{GFM}	0.2	Amp
Peak Gate Voltage - Reverse	V_{GRM}	6.0	Volts
Operating Junction Temperature Range	T_J	−40 to +110	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C
Mounting Torque (6-32) (Note 2)	—	12	in. lb.



CASE 90 (1)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Characteristics	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 110°C) Note 1 MCR407-1	V_{DRM}	30	–	–	Volts
-2		60	–	–	
-3		100	–	–	
-4		200	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 110°C)	I_{DRM}	–	–	100	μA
Peak Reverse Blocking Current (Rated V_{RRM}, T_J = 110°C)	I_{RRM}	–	–	100	μA
On State Voltage (I_{TM} = 4.0 A)	V_{TM}	–	–	2.6	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage - 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)	I_{GT}	–	–	500	μA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)	V_{GT}	–	–	1.0	Volts
(Anode Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C)	V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 Vdc, T_C = 25°C)	I_H	–	–	5.0	mA
Turn-Off Time	t_{on}	Circuit Dependent Consult Manufacturer			
Turn-Off Time	t_{off}				
Forward Voltage Application Rate (T_J = 110°C)	dv/dt	–	10	–	V/μs
Thermal Resistance, Junction to Case	θ_{JC}	–	–	2.0	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	–	–	50	°C/W

NOTES:

1. V_{DRM} and V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.
2. Torque rating applies with use of torque washer (Shakeproof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.

   For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C. For optimum results, an activated flux (oxide removing) is recommended.

FIGURE 1 – CASE TEMPERATURE versus CURRENT

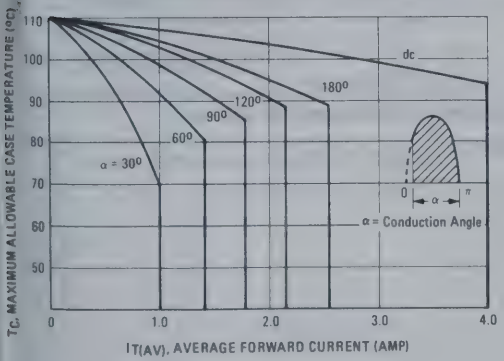
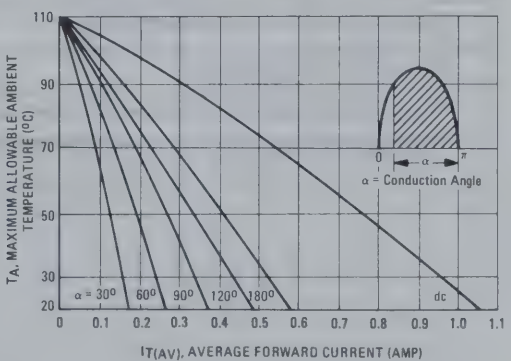
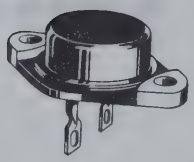


FIGURE 2 – AMBIENT TEMPERATURE versus CURRENT



MCR649-1 thru MCR649-7 (SILICON)



CASE 61 (TO-41) **CASE 54** (TO-3 Modified)

Industrial-type, silicon controlled rectifiers in a "diamond" package for applications requiring a high surge-current rating or low thermal resistance. For units with pins (TO-3) specify devices MCR649P-1 thru MCR649P-7.

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	V_{ROM}*		Volts
MCR649-1		25	
-2		50	
-3		100	
-4		200	
-5		300	
-6		400	
-7		500	
Forward Current RMS (All Conduction Angles)	I_f	20	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C; t ≦ 8.3 ms)	I^2t	275	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -40 to +100°C)	$I_{FM(surge)}$	260	Amp
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2.0	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5.0	
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

*V_{ROM} for all types can be applied on a continuous dc basis without incurring damage.

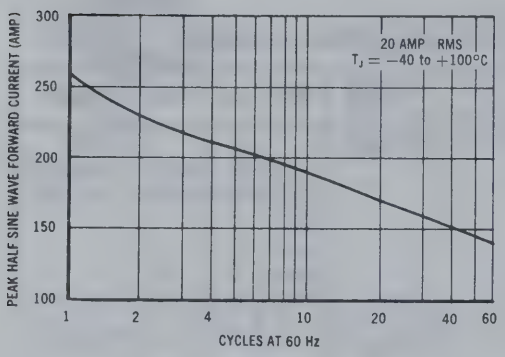
V_{ROM} ratings apply for zero or negative gate voltage.

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

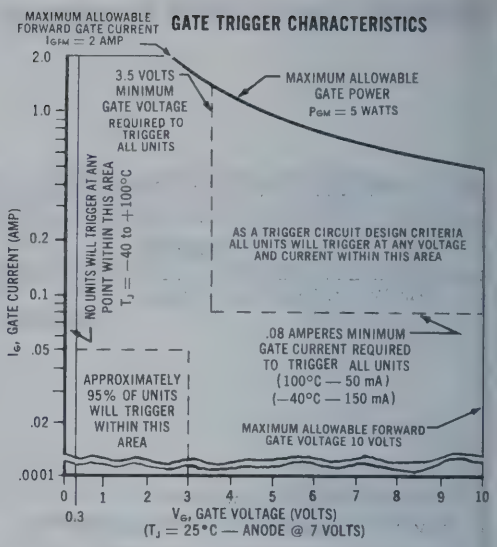
Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage ($T_J = 100°C$)	V_{FOM}				Volts
MCR649-1		25	—	—	
-2		50	—	—	
-3		100	—	—	
-4		200	—	—	
-5		300	—	—	
-6		400	—	—	
-7		500	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, $T_J = 100°C$)	I_{FOM}	—	—	5.0	mA
Peak Reverse Blocking Current (Rated V_{FOM} with gate open, $T_J = 100°C$)	I_{ROM}	—	—	5.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)	I_{GT}	—	30	80	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)	V_{GT}	—	1.0	3.5	Volts
(Anode Voltage = Rated V_{FOM}, $R_L = 50\Omega$, $T_J = 100°C$)	V_{GNT}	0.3	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	20	—	mA
Forward On Voltage ($I_F = 20$ Adc)	V_F	—	1.1	1.5	Volts
Turn-On Time ($t_d + t_r$) ($I_G = 50$ mA, $I_F = 10$ A)	t_{on}	—	1.0	—	μs
Turn-Off Time ($I_F = 10$ A, $I_R = 10$ A, dv/dt = 20 V/ μs min, $T_J = 100°C$) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)	t_{off}	—	25	—	μs
Forward Voltage Application Rate (Gate open, $T_J = 100°C$)	dv/dt				V/ μs
MCR649-1 thru MCR649-4		—	20	—	
MCR649-5 thru MCR649-7		—	30	—	
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	1.5	°C/W

MCR649-1 thru MCR649-7 (continued)

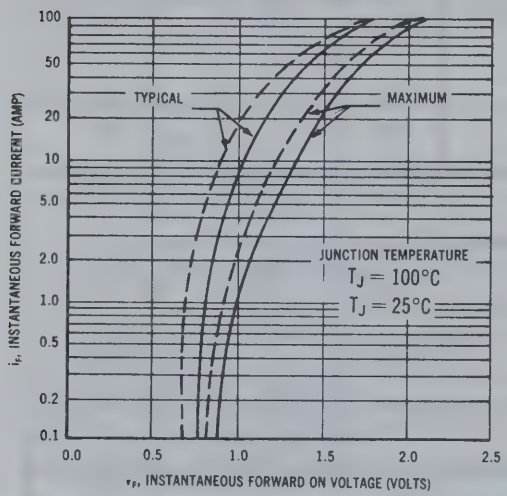
MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT



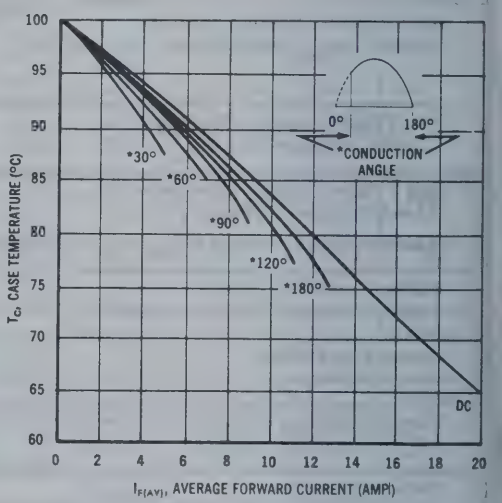
GATE TRIGGER CHARACTERISTICS



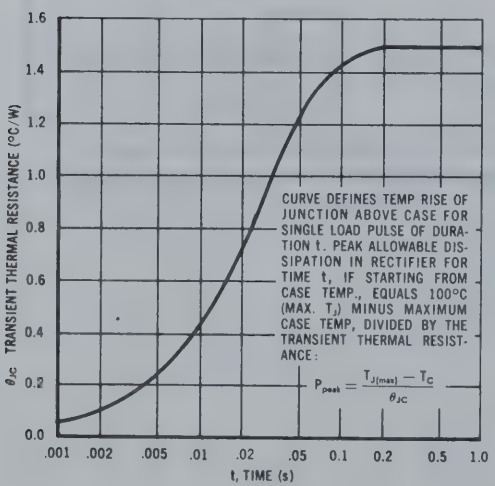
LOW CURRENT LEVEL



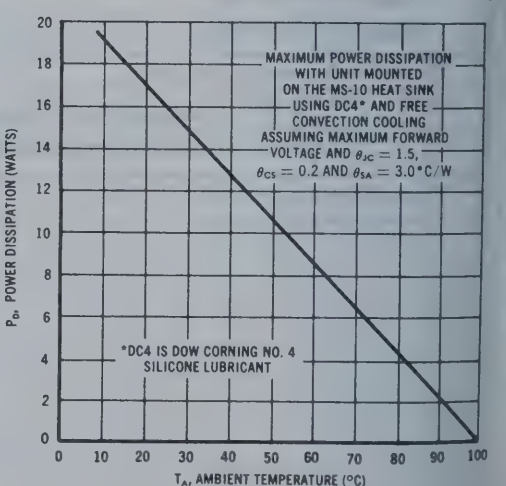
MAXIMUM ALLOWABLE CASE TEMPERATURE



MAXIMUM TRANSIENT THERMAL RESISTANCE JUNCTION TO CASE



POWER DERATING CURVE



MCR729-5 thru MCR729-10 (SILICON)



CASE 63

Fast-switching, high-voltage silicon controlled rectifiers especially designed and characterized for radar, proximity fuse, beacon and similar pulse applications.

MAXIMUM RATINGS (T_J = 105°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*	50	Volts
Forward Current RMS	I_f	2.0	Amp
Repetitive Pulse Current (PW = 10 μs)	$I_{FM(pulse)}$	100	Amp
Average Forward Power	$P_{F(AV)}$	5.0	Watts
Peak Gate Power - Forward	P_{GFM}	20	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	1.0	Watt
Peak Gate Current - Forward	I_{GFM}	5.0	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 10	Volts
Operating Junction Temperature Range	T_J	-65 to+ 105	°C
Storage Temperature Range	T_{stg}	-65 to + 150	°C
Stud Torque	—	15	in. lb.

*Characterized for unilateral applications where reverse blocking capability is not important. Higher V_{ROM} rated units available on request.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 105°C) MCR729-5	V_{FOM}*	300	—	—	Volts
-6		400	—	—	
-7		500	—	—	
-8		600	—	—	
-9		700	—	—	
-10		800	—	—	
Peak Forward Blocking Current (Rated V_{FOM}, T_J = 105°C, gate open)	I_{FOM}	—	0.2	2.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 ohms)	I_{GT}	—	10	50	mAdc
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 ohms)	V_{GT}	—	0.8	1.5	Volts
Holding Current (Anode Voltage = 7 Vdc, gate open)	I_{HO}	5.0	15	—	mA
Forward On Voltage (I_f = 2 Adc)	V_F	—	1.1	1.5	Volts
Dynamic Forward On Voltage (0.5 μs after 50% pt, I_G = 200 mA, I_{pulse} = 30 Amps)	$V_{F(on)}$	—	15	25	Volts
Turn-On Time (t_d + t_r) (I_G = 200 mA)	t_{on}				ns
(I_{pulse} = 30 Amps peak)	—	—	200	—	
(I_{pulse} = 100 Amps peak)		—	400	—	
Turn-On Time Variation (T_J = +25°C to +105°C and -65°C to +25°C)	Δt_{on}	—	±50	—	ns
Pulse Turn-Off Time	$t_{off(pulse)}$	—	15	—	μs
Test Conditions: PFN discharge; Forward Current = 30 A pulse; Reverse Current = 5 A; Rep. Rate = 100 pps; Duty cycle = 0.05%; Forward Voltage = rated V_{FOM}; T_C = 85°C; dv/dt = 250 V/μs; Reverse anode voltage applied during turn-off interval = rated V_{FOM}; Reverse gate bias during turn-off interval = -6 V; Gate Trigger Pulse: 200 mA, 1 μs wide, 2 ns rise time. Turn-off time measured from 90% pt. of forward, current decay to 10% pt. of reapplied forward voltage.					
Forward Voltage Application Rate (T_J = 105°C, gate open)	dv/dt	50	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	—	3.0	°C/W

*Other voltage units available upon request.

MCR846 series (SILICON)



CASE 63

Silicon controlled rectifiers for low-power switching and control applications requiring blocking to 200 volts and load currents to 2 amp.

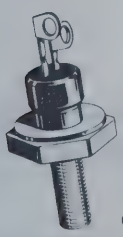
MAXIMUM RATINGS (T_J = 105°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage MCR846-1 -2 -3 -4	$V_{ROM(rep)}$	 25 50 100 200	Volts
Forward Current RMS (all conduction angles)	I_f	2.0	Amp
Circuit Fusing Considerations (T_J = -65 to +105°C; t ≦ 8.3 ms)	I^2t	35	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +105°C)	$I_{FM(surge)}$	30	Amp
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2.0	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 10	Volts
Operating Junction Temperature Range	T_J	-65 to +105	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	15	in. lb.

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage ($T_J = 105°C$) MCR846-1	V_{FOM}	25	—	—	Volts
-2		50	—	—	
-3		100	—	—	
-4		200	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, $T_J = 105°C$)	I_{FOM}	—	—	2.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} with gate open, $T_J = 105°C$)	I_{ROM}	—	—	2.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 100\Omega$)	I_{GT}	—	10	50	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 100\Omega$)	V_{GT}	—	0.8	1.5	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	15	—	mA
Forward On Voltage ($I_F = 2$ Adc)	V_F	—	1.3	1.6	Volts
Turn-On Time ($t_d + t_r$) ($I_G = 50$ mA, $I_F = 2$ A)	t_{on}	—	0.5	—	μs
Turn-Off Time ($I_F = 2$ A, $I_R = 10$ A, dv/dt = 50 V/μs) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)	t_{off}	—	6.0	—	μs
Forward Voltage Application Rate ($T_J = 105°C$, gate open)	dv/dt	50	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	—	3.0	°C/W

MCR1336-5 (SILICON)
thru
MCR1336-10



CASE 63

Fast switching, high-voltage thyristors especially designed for pulse modulator applications in radar and other similar equipment.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* (T_J = 105°C)	$V_{ROM(rep)}$*	50	Volts
Repetitive Peak Forward Current (PW = 3.0 μs, Duty Cycle = 0.6%, T_C = 85°C max)	$I_{FM(rep)}$	300	Amp
Current Application Rate**	di/dt**	1000	A/μs
Peak Gate Power-Forward	P_{GFM}	20	Watts
Average Gate Power-Forward	$P_{GF(AV)}$	1.0	Watt
Peak Gate Current-Forward	I_{GFM}	5.0	Amp
Peak Gate Voltage-Forward Reverse***	V_{GFM} V_{GRM}***	7.0 7.0	Volts
Operating Junction Temperature Range	T_J	-65 to +105	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque	-	15	in. lb.

*Characterized for unilateral applications where reverse blocking capability is not important. Higher voltage units available upon request. $V_{ROM(rep)}$ may be applied as a continuous dc voltage for zero or negative gate voltage but positive gate voltage must not be applied concurrently with a negative potential on the anode. When checking blocking capability, do not permit the applied voltage to exceed the rated voltage.

**Minimum Gate Trigger Pulse: i_G = 500 mA, PW = 1.0 μs, t_r = 20 ns.

***Do not reverse bias gate during forward conduction if anode current exceeds 10 amperes.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage* (T_C = 105°C)	V_{FOM}*				Volts
MCR1336 -5		300	-	-	
MCR1336 -6		400	-	-	
MCR1336 -7		500	-	-	
MCR1336 -8		600	-	-	
MCR1336 -9		700	-	-	
MCR1336 -10		800	-	-	
Peak Forward and Reverse Blocking Current (Rated V_{FOM} and V_{ROM}, T_C = 105°C, gate open)	I_{FOM}	-	-	2.0	mA
	I_{ROM}	-	-	2.0	
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)	I_{GT}	-	-	40	mA
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = -65°C)		-	-	100	
Gate Trigger Voltage (Continuous dc) (Anode Voltage = rated V_{FOM}, R_L = 100 ohms, T_C = 105°C)	V_{GT}	0.2	-	-	Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)		-	-	1.25	
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = -65°C)		-	-	2.0	
Holding Current (Anode Voltage = 7.0 Vdc, gate open, T_C = 105°C)	I_{HO}	1.0	-	-	mA
(Anode Voltage = 7.0 Vdc, gate open, T_C = 25°C)		-	-	50	
Forward "On" Voltage (I_I = 1.0 Adc, PW = 1.0 ms max, Duty cycle ≤ 1.0%)	V_F	-	-	2.0	Volts
Dynamic Forward "On" Voltage (0.5 μs after 50% decay point on dynamic forward voltage waveform) Forward Current: 100 A pulse (PFN discharge circuit) Gate Pulse: at 500 mA, PW = 1.0 μs, t_r = 20 ns	$V_{F(on)}$	-	45	-	Volts
Turn-On Time					ns
Delay Time	t_d	-	75	-	
Rise Time	t_r	-	75	-	
Forward Current: 100 A Pulse (Capacitor discharge circuit) Gate Pulse: at 500 mA, PW = 1.0 μs, t_r = 20 ns					
Pulse Turn-Off Time Test Conditions: PFN discharge; Forward Current = 100 A pulse; Reverse Current = 5.0 A, T_C = 85°C, dv/dt = 250 V/μs to Rated V_{FOM}; Reverse anode voltage during turn-off interval = 0 V; Reverse gate bias during turn-off interval = 6.0 V.	$t_{off(pulse)}$	-	7.0	-	μs
Forward Voltage Application Rate (Linear Rise of Voltage) (T_C = 105°C, gate shorted)	dv/dt	250	-	-	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	-	-	2.5	°C/W

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. When checking forward or reverse blocking capability, these devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage. Other voltage units available upon request.

MCR1718-5 (SILICON)
thru
MCR1718-8

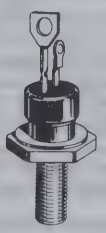
THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . fast switching, high-voltage thyristors especially designed for pulse modulator applications.

- High-Voltage Capability from 300 to 600 Volts
- Repetitive Pulse Current to 1000 Amp
- Pulse Repetition as High as 4000 pps
- Current Application Rate as High as 1000 A/μs

THYRISTORS
PNPN

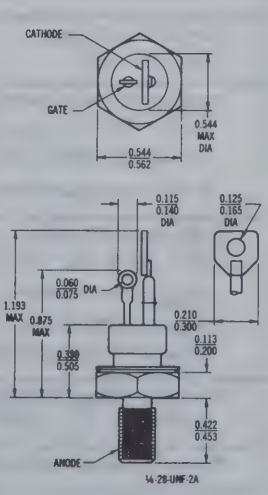
1000 AMPERE PULSE
300 thru 600 VOLTS



MAXIMUM RATINGS ($T_J = 125°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* MCR1718-5 -6 -7 -8	$V_{ROM(rep)}$*	300 400 500 600	Volts
Peak Reverse Blocking Voltage (Transient) (Non-Recurrent 5 ms (max.) MCR1718-5 -6 -7 -8	$V_{ROM(non-rep)}$	400 500 600 700	Volts
Forward Current RMS	I_T	25	Amp
Peak Repetitive Pulse Current (1-10 μs Pulse Width)	$I_{FM(pulse)}$	1000	Amp
Current Application Rate (up to 1000 Adc peak)	di/dt	1000	A/μs
Circuit Fusing Considerations (T_J = -65 to +125°C; t ≤ 1.0 ms)	I^2t	250	A^2s
Dynamic Average Power (T_C = 65°C)	$P_{F(AV)}$	30	Watts
Peak Gate Power - Forward	P_{GFM}	20	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	1.0	Watt
Peak Gate Current - Forward	I_{GFM}	5.0	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 10	Volts
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	30	in. lb.

*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.



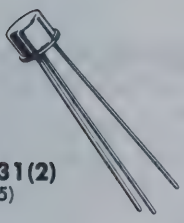
CASE 64
TO-48

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C) MCR1718-5	V_{FOM}*	300	—	—	Volts
-6		400	—	—	
-7		500	—	—	
-8		600	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 125°C)	I_{FOM}	—	—	8.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} with gate open, T_J = 125°C)	I_{ROM}	—	—	8.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	I_{GT}	—	10	50	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50Ω, T_C = 25°C)	V_{GT}	—	0.8	1.5	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50Ω, T_J = 125°C)	V_{GNT}	0.25	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open, T_C = 25°C)	I_{HO}	5.0	15	—	mA
(Anode Voltage = 7 Vdc, Gate Open, T_J = 125°C)		—	6.0	—	
Forward On Voltage (I_F = 25 Adc)	V_F	—	1.1	1.3	Volts
Dynamic Forward On Voltage (I_{GT} = 500 mA, I_{pulse} = 500 Amps)	$V_{F(on)}$				Volts
(1.0 μs after start (10% pt.) of I_{pulse})		—	30	—	
(5.0 μs after start (10% pt.) of I_{pulse})		—	5.0	—	
Pulse Turn-Off Time (I_F = 500A, I_R = 10 A, dv/dt = 20 V/ μs) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage) (Conductive Charging Circuit - Circuit dependent)	t_{off}	—	20	—	μs
Forward Voltage Application Rate (Gate Open, T_J = 125°C)	dv/dt	—	50	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	—	2.0	°C/W

*V_{FOM} for all types can be supplied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

MCR1906-1 thru MCR1906-4 (SILICON)



CASE 31(2)
(TO-5)

Thyristors (silicon controlled rectifiers) designed for applications in control systems and sensing circuits where low level gating and holding characteristics are necessary.

MAXIMUM RATINGS (T_J = 100° C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) MCR1906-1 MCR1906-2 MCR1906-3 MCR1906-4	$V_{RXM(rep)}$	 25 50 100 200	Volt
Forward Current RMS (All Conduction Angles)	I_f	1.6	Amp
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -40 to +100° C) No Repetition Until Thermal Equilibrium is Restored	$I_{FM(surge)}$	15	Amp
Peak Gate Power Forward	P_{GFM}	0.1	Watt
Average Gate Power Forward	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current Forward	I_{GFM}	0.1	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	6.0 6.0	Volt
Operating Junction Temperature Range	T_J	-65 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Lead Solder Temperature (>1/16" From Case, 10 sec. max.)	-	+230	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Characteristic	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1) MCR1906-1 MCR1906-2 MCR1906-3 MCR1906-4	V_{FXM}	 25 50 100 200	 - - - -	Volt
Peak Reverse Blocking Current (Note 3) (Rated V_{RXM}, T_J = 100°C)	I_{RXM}	-	500	μA
Peak Forward Blocking Current (Rated V_{FXM}, T_J = 100°C)	I_{FXM}	-	500	μA
Forward "On" Voltage (Pulsed, 1.0 ms max, Duty Cycle ≤ 1.0%) (I_F = 1.0 Adc peak)	V_F	-	1.75	Volt
Gate Trigger Current (Note 2) (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 ohms)	I_{GT}	-	1.0	mAdc
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 ohms) (Anode Voltage = Rated V_{FXM}, R_L = 100 ohms, T_J = 100°C)	V_{GT} V_{GNT}	- 0.1	1.0 -	Volt
Holding Current (Anode Voltage = 7.0 V)	I_{HX}	-	5.0	mA
Turn-On Time	t_{on}	Circuit dependent, consult manufacturer		
Turn-Off Time	t_{off}			

NOTES: 1. V_{RXM} and V_{FXM} can be applied for all types on a continuous dc basis without incurring damage. Thyristor devices shall not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

2. R_{GK} current is not included in measurement.

3. Thyristor devices shall not have a positive bias applied to the gate concurrently with a negative potential applied to the anode.

FIGURE 1 – CASE TEMPERATURE versus CURRENT

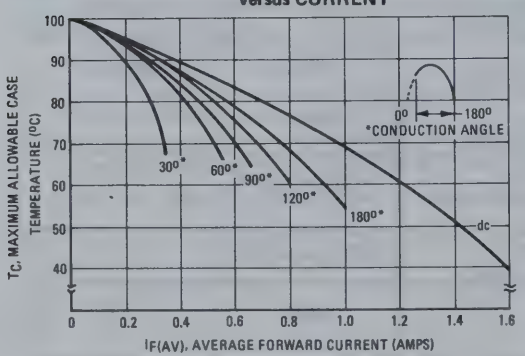
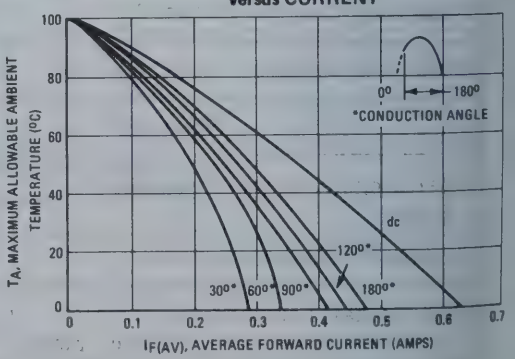


FIGURE 2 – AMBIENT TEMPERATURE versus CURRENT



MCR1907-1 thru MCR1907-6 (SILICON)



CASE 64
(TO-48)

Fast turn-on, fast turn-off silicon controlled rectifiers for high-frequency applications requiring blocking to 400 volts and load currents to 25 amp.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*		Volts
MCR1907-1		25	
-2		50	
-3		100	
-4		200	
-5		300	
-6		400	
Peak Reverse Blocking Voltage (Non-Recurrent 5 ms (max.)	$V_{ROM(non-rep)}$		Volts
MCR1907-1		35	
-2		75	
-3		150	
-4		300	
-5		400	
-6		500	
Forward Current RMS (All Conduction Angles)	I_f	25	Amp
Circuit Fusing Considerations (T_J = -65 to +125°C; t ≦ 8.3 ms)	I^2t	75	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)	$I_{FM(surge)}$	150	Amp
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current — Forward	I_{GFM}	2.0	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5.0	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	30	in. lb.

*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

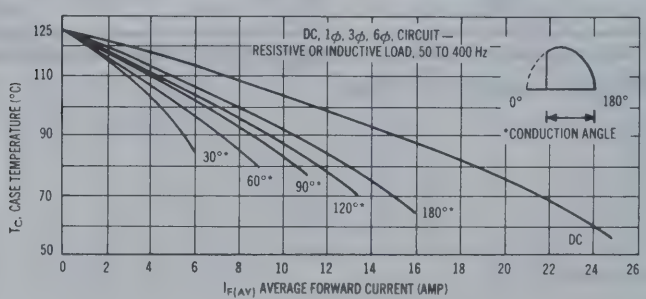
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C) MCR1907-1	V_{FOM}*	25	—	—	Volts
-2		50	—	—	
-3		100	—	—	
-4		200	—	—	
-5		300	—	—	
-6		400	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 125°C)	I_{FOM}	—	—	4.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} with gate open, T_J = 125°C)	I_{ROM}	—	—	4.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50Ω)	I_{GT}	—	15	30	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	V_{GT}	—	—	1.5	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50Ω, T_J = 125°C)	V_{GNT}	0.25	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	12	—	mA
Forward On Voltage (I_F = 20 Adc)	V_F	—	1.4	1.7	Volts
Turn-On Time (I_G = 200 mA, I_F = 10 A)	t_{on}	—	0.5	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A, dv/dt = 30 V/μs min.) (V_{FXM} = rated voltage) T_J = 125°C (V_{RXM} = rated voltage)	t_{off}	—	—	12	μs
Forward Voltage Application Rate (T_J = 125°C, gate open)	dv/dt	30	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	1.7	°C/W

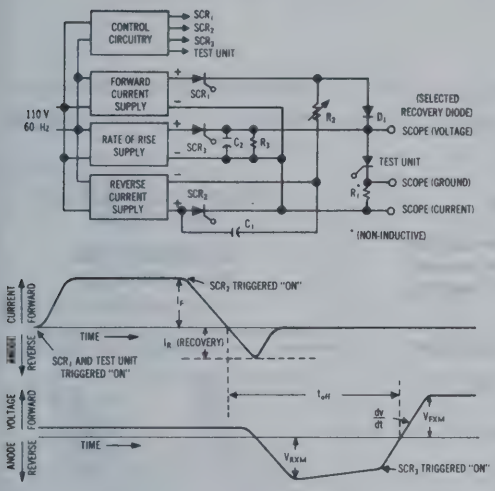
*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage.

Ratings apply for zero or negative gate voltage. These devices should never be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

CURRENT DERATING



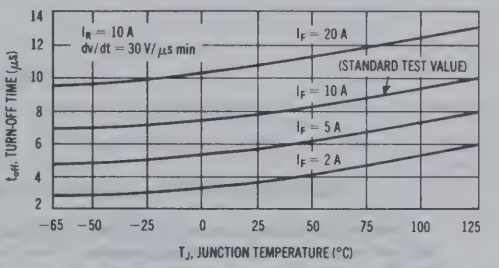
TURN-OFF TIME TEST CIRCUIT †



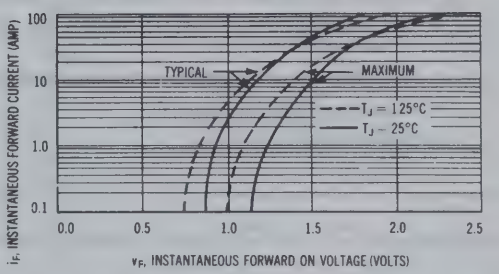
Forward conduction current is passed through the device (SCR_1 and test device triggered on). The anode is then driven negative (SCR_2 triggered on), causing reverse current to flow. The anode-to-cathode potential goes negative with a decrease in reverse current. Forward voltage is then applied to the anode of the device (SCR_3 triggered on). The device has fully recovered when it regains its ability to block the reapplied forward voltage.

† Consult manufacturer for further circuit information.

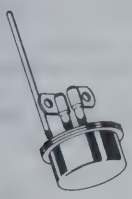
TYPICAL TURN-OFF TIME versus PEAK FORWARD CURRENT AND JUNCTION TEMPERATURE



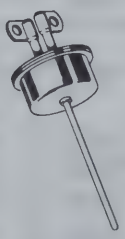
FORWARD CONDUCTING CHARACTERISTICS



MCR2604-1 thru MCR2604-8
MCR2605-1 thru MCR2605-8



CASE 87
MCR2604-1
thru
MCR2604-8



CASE 88
MCR2605-1
thru
MCR2605-8

These series of silicon controlled rectifiers are electrically identical to the 2N4151 thru 2N4198 series, but are available in the cases illustrated.

MCR2315 SERIES (SILICON)
MCR2614L SERIES

SILICON CONTROLLED RECTIFIERS

. . . designed for applications requiring blocking voltages through 400 volts and rms currents through 8.0 amperes. These devices are available in a choice of space-saving, economical packages for mounting versatility.

- Low Forward Voltage Drop – Typically 1.0 Volt at 5.0 A at 25°C
- Fast, Stable Switching Times – Typically 1.0 μs Turn-On, 12 μs Turn-Off at 25°C
- All-Diffused Junctions for Greater Parameter Uniformity
- Fatigue-Free Solder Construction
- Glass-to-Metal Hermetic Seal

SILICON CONTROLLED RECTIFIERS

8.0 AMPERES RMS
25 thru 400 VOLTS



MCR2315
CASE 86



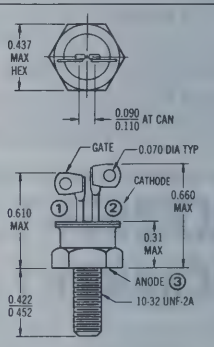
MCR2614L
CASE 87L

MAXIMUM RATINGS

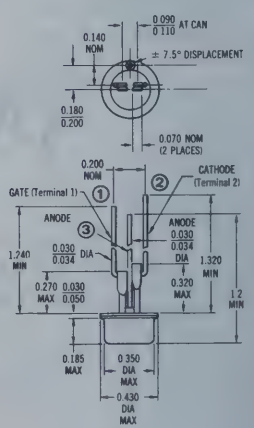
Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	V_{RRM} *		Volts
MCR2315 −1		25	
MCR2315 −2		50	
MCR2315 −3		100	
MCR2614L −4		200	
MCR2614L −5		300	
MCR2614L −6		400	
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	8.0	Amp
Peak Surge Forward Current (One cycle, 60 Hz, T_J = −40 to +100°C)	I_{TSM}	80	Amp
Circuit Fusing Considerations (T_J = −40 to +100°C; t ≤ 8.3 ms)	I^2t	40	A^2s
Peak Gate Power – Forward	P_{GFM}	5.0	Watts
Average Gate Power – Forward	$P_{GF(AV)}$	0.5	Watt
Peak Forward Gate Current	I_{GFM}	2.0	Amp
Peak Gate Voltage			Volts
Forward	V_{GFM}	10	
Reverse	V_{GRM}	10	
Operating Junction Temperature Range	T_J	−40 to +100	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C
Stud Torque (MCR2315 series)		15	in. lb.

*$V_{RRM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.



CASE 86



CASE 87L

ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted)

Apply to all case types unless otherwise noted

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage* (T_J = 100°C)	V_{DRM}*				Volts
MCR2315, MCR2614L -1		25	—	—	
MCR2315, MCR2614L -2		50	—	—	
MCR2315, MCR2614L -3		100	—	—	
MCR2315, MCR2614L -4		200	—	—	
MCR2315, MCR2614L -5		300	—	—	
MCR2315, MCR2614L -6		400	—	—	
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 100°C, gate open)	I_{DRM}	—	—	3.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, T_J = 100°C, gate open)	I_{RRM}	—	—	3.0	mA
On State Voltage (I_{TM} = 5.0 Adc)	V_{TM}	—	1.0	1.6	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100Ω)	I_{GT}	—	10	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ω)	V_{GT}	—	0.6	1.5	Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_J = 100°C)	V_{GD}	0.2	—	—	
Holding Current (Anode Voltage = 7.0 Vdc, gate open)	I_H	—	10	50	mA
Turn-On Time (I_{TM} = 5.0 Adc, I_{GT} = 20 mAdc)	t_{on}	—	1.0	—	μs
Turn-Off Time (I_{TM} = 5.0 Adc, I_R = 5.0 Adc)	t_{off}	—	15	—	μs
(I_{TM} = 5.0 Adc, I_R = 5.0 Adc, T_J = 100°C)		—	30	—	
Forward Voltage Application Rate (T_J = 100°C)	dv/dt	—	50	—	V/μs
Thermal Resistance, Junction to Case MCR2614L	θ_{JC}	—	1.5	2.7	°C/W
MCR2315		—	1.8	3.0	
Thermal Resistance, Case to Ambient** MCR2614L	θ_{CA}	—	50**	—	°C/W

*V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability in a manner that the voltage applied exceeds the rated blocking voltage.

**Applies for the worst-case conditions of: (a) highest θ_{CA} package configuration, (b) leads terminated at end points, (c) temperature measured at hottest spot on device (center of case bottom), and (d) still air mounting.

FIGURE 1 – CURRENT DERATING - HALF WAVE

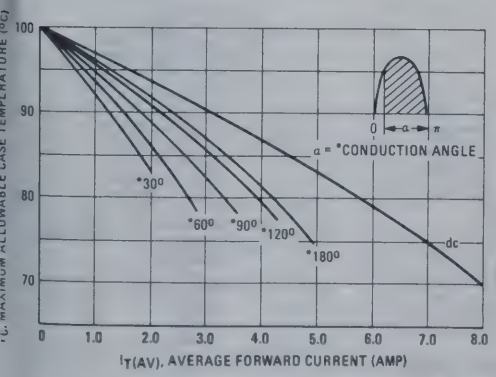
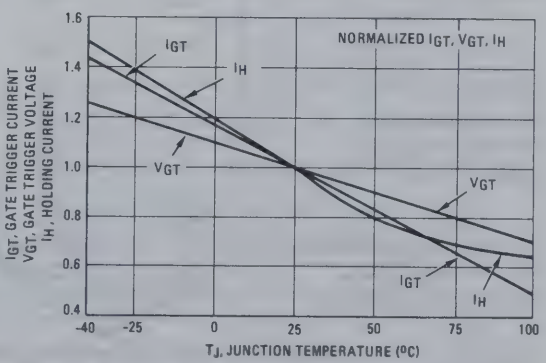


FIGURE 2 – TYPICAL PARAMETER VARIATIONS versus TEMPERATURE



MCR3818-1 thru MCR3818-8 (SILICON)
MCR3918-1 thru MCR3918-8

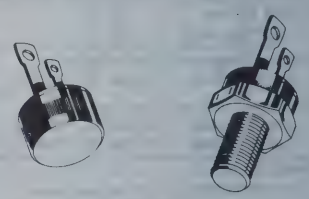
THYRISTORS
PNPN

20 AMPERES RMS
25 thru 600 VOLTS

THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies, battery chargers, temperature, motor, light and welder controls.

- Economical for a Wide Range of Uses
- High Surge Current — I_{TSM} = 240 Amp
- Low Forward "On" Voltage — 1.2 V (Typ) @ I_{TM} = 20 Amp
- Practical Level Triggering and Holding Characteristics — 10 mA (Typ) @ $T_C = 25^oC$
- Rugged Construction in Either Pressfit or Stud Package

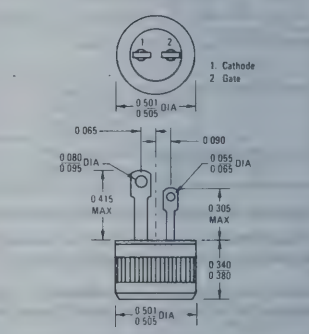


MCR3818 Series MCR3918 Series

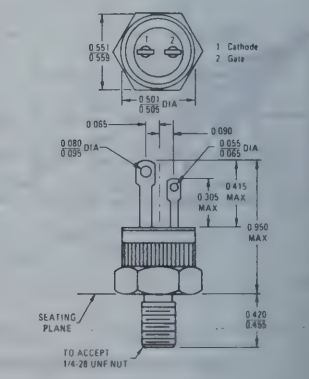
MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage	-1	V_{RRM}(1)	25	Volts
	-2		50	
	-3		100	
MCR3818	-4		200	
	-5		300	
MCR3918	-6		400	
	-7		500	
	-8		600	
Non-repetitive Peak Reverse Blocking Voltage (t ≤ 5.0 ms)	-1	V_{RSM}	35	Volts
	-2		75	
	-3		150	
MCR3818	-4		300	
	-5		400	
MCR3918	-6		500	
	-7		600	
	-8		700	
Forward Current RMS		$I_{T(RMS)}$	20	Amp
Peak Surge Current (one cycle, 60 Hz) (T_J = -40 to +100°C)		I_{TSM}	240	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C) (t = 1.0 to 8.3 ms)		I^2t	235	A^2s
Peak Gate Power		P_{GM}	5.0	Watt
Average Gate Power		$P_{G(AV)}$	0.5	Watt
Peak Forward Gate Current		I_{GM}	2.0	Amp
Peak Gate Voltage				Volts
Forward		V_{GFM}	10	
Reverse		V_{GRM}	10	
Operating Junction Temperature Range		T_J	-40 to +100	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Stud Torque (MCR3918 Series)		–	30	in. lb.

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode.



CASE 174 (1)



CASE 175 (1)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 100°C)	V_{DRM}(1)				Volts
MCR3818 -1		25	–	–	
MCR3818 -2		50	–	–	
MCR3818 -3		100	–	–	
MCR3818 -4		200	–	–	
MCR3918 -5		300	–	–	
MCR3918 -6		400	–	–	
MCR3918 -7		500	–	–	
MCR3918 -8		600	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 100°C)	I_{DRM}	–	1.0	5.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 100°C)	I_{RRM}	–	1.0	5.0	mA
Forward "On" Voltage (I_{TM} = 20 A Peak)	V_{TM}	–	1.2	1.5	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)	I_{GT}	–	10	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)	V_{GT}	–	0.7	1.5	Volts
(Anode Voltage = Rated V_{DRM}, R_L = 100 Ω, T_J = 100°C)	V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 V, gate open)	I_H	–	10	50	mA
Turn-On Time ($t_d + t_r$) (I_{TM} = 20 Adc, I_{GT} = 40 mAdc)	t_{on}	–	1.0	–	μs
Turn-Off Time	t_{off}				μs
(I_{TM} = 10 A, I_R = 10 A)		–	15	–	
(I_{TM} = 10 A, I_R = 10 A, T_J = 100°C)		–	25	–	
Forward Voltage Application Rate (T_J = 100°C)	dv/dt	–	50	–	V/μs
Thermal Resistance, Junction to Case	θ_{JC}				°C/W
MCR3818		–	–	1.5	
MCR3918		–	–	1.6	

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

FIGURE 1 – CURRENT DERATING

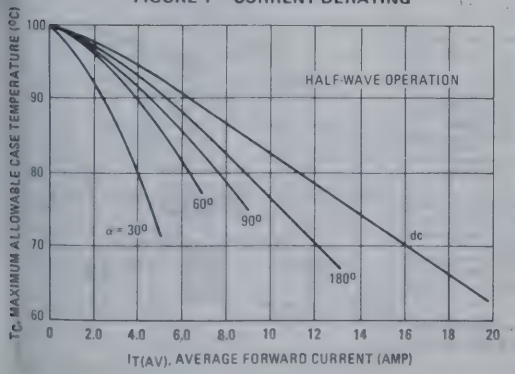
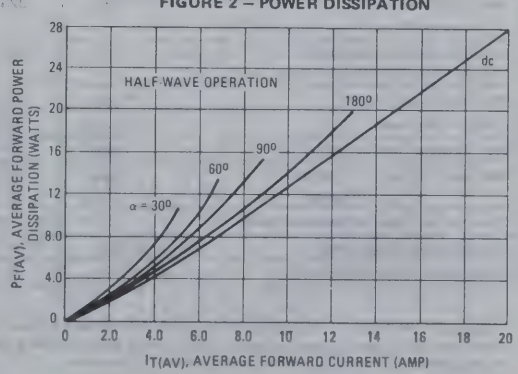


FIGURE 2 – POWER DISSIPATION



MCR3835-1 thru MCR3835-8 (SILICON)
MCR3935-1 thru MCR3935-8

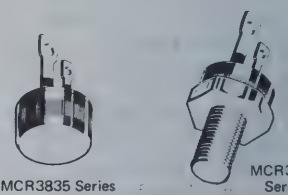
THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies, battery chargers, temperature, motor, light and welder controls.

- Economical for a Wide Range of Uses
- High Surge Current – I_{TSM} = 325 Amp
- Low Forward "On" Voltage – 1.2 V (Typ) @ I_{TM} = 35 Amp
- Practical Level Triggering and Holding Characteristics – 10 mA (Typ) @ T_C = 25°C
- Rugged Construction in Either Pressfit or Stud Package

THYRISTORS
PNPN

35 AMPERES RMS
25 thru 600 VOLTS



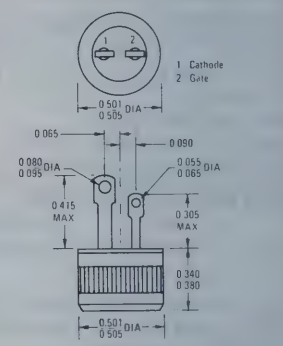
MCR3835 Series

MCR3935 Series

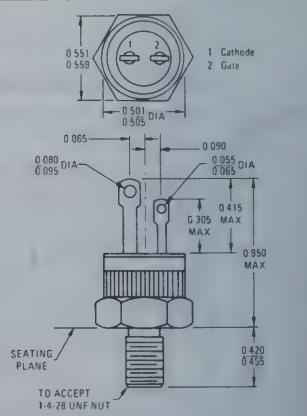
MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage		V_{RRM}(1)		Volts
MCR3835	-1		25	
	-2		50	
	-3		100	
	-4		200	
MCR3935	-5		300	
	-6		400	
	-7		500	
	-8		600	
Non-Repetitive Peak Reverse Blocking Voltage ($t \leq 5.0$ ms)		V_{RSM}		Volts
MCR3835	-1		35	
	-2		75	
	-3		150	
	-4		300	
MCR3935	-5		400	
	-6		500	
	-7		600	
	-8		700	
Forward Current RMS		$I_{T(RMS)}$	35	Amp
Peak Surge Current (One cycle, 60 Hz) (T_J = -40 to +100°C)		I_{TSM}	325	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C) (t = 1.0 to 8.3 ms)		I^2t	435	A^2s
Peak Gate Power		P_{GFM}	5.0	Watts
Average Gate Power		$P_{GF(AV)}$	0.5	Watt
Peak Forward-Gate Current		I_{GFM}	2.0	Amp
Peak Gate Voltage – Forward		V_{GFM}	10	Volts
Reverse		V_{GRM}	10	
Operating Junction Temperature Range		T_J	-40 to +100	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Stud Torque (MCR3935 Series)		–	30	in. lb.

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode.



CASE 174 (1)



CASE 175 (1)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 100°C)		V_{DRM}(1)				Volts
	MCR3835 -1		25	–	–	
	MCR3835 -2		50	–	–	
	MCR3835 -3		100	–	–	
	MCR3835 -4		200	–	–	
	MCR3935 -5		300	–	–	
	MCR3935 -6		400	–	–	
	MCR3935 -7		500	–	–	
	MCR3935 -8		600	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 100°C)		I_{DRM}	–	1.0	5.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 100°C)		I_{RRM}	–	1.0	5.0	mA
Forward "On" Voltage (I_{TM} = 35 A Peak)		V_{TM}	–	1.2	1.5	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)		I_{GT}	–	10	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)		V_{GT}	–	0.7	1.5	Volts
(Anode Voltage = Rated V_{DM}, R_L = 100 Ω, T_J = 100°C)		V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 V, gate open)		I_H	–	10	50	mA
Turn-On Time ($t_d + t_r$) (I_{TM} = 35 Adc, I_{GT} = 40 mAdc)		t_{on}	–	1.0	–	μs
Turn-Off Time		t_{off}				μs
(I_{TM} = 10 A, I_R = 10 A)			–	15	–	
(I_{TM} = 10 A, I_R = 10 A, T_J = 100°C)			–	25	–	
Forward Voltage Application Rate (T_J = 100°C)		dv/dt	–	50	–	V/μs
Thermal Resistance, Junction to Case	MCR3835	θ_{JC}	–	–	1.2	°C/W
	MCR3935		–	–	1.3	

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

FIGURE 1 – CURRENT DERATING

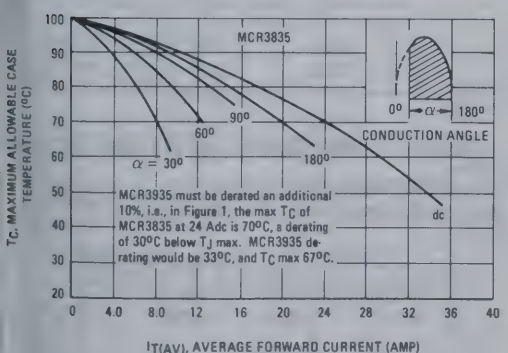
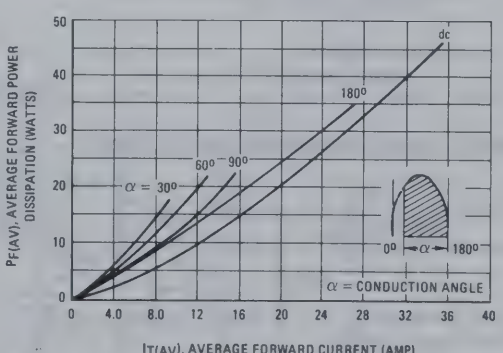


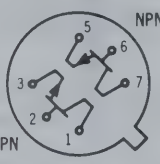
FIGURE 2 – TYPICAL POWER DISSIPATION



MD708, F (SILICON)
MD708A, F
MD708B, F

Dual NPN silicon annular transistors designed for high-speed, logic switching and space saving considerations. Matched pairs are available for differential amplifier applications.

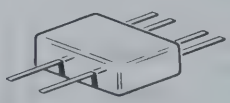


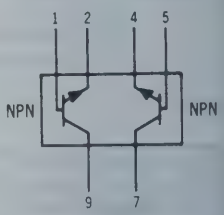


CASE 32

PINS 4 AND 8 OMITTED

MD708
MD708A
MD708B





CASE 33
(TO-89)

MD708F
MD708AF
MD708BF

Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	200		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can		300	400	mW
Derate above 25°C		1.7	2.3	mW/°C
Flat Package		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

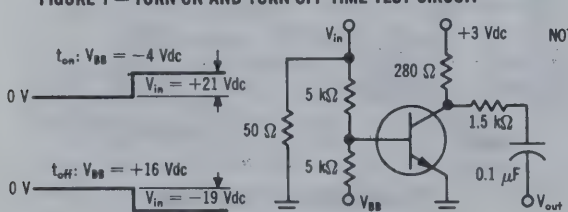
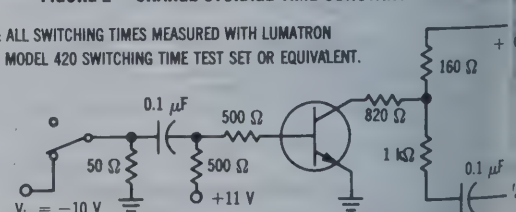


FIGURE 2 — CHARGE-STORAGE TIME CONSTANT TEST CIRCUIT

NOTE: ALL SWITCHING TIMES MEASURED WITH LUMATRON MODEL 420 SWITCHING TIME TEST SET OR EQUIVALENT.



ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	0.015	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = +150°C)		—	50	
ON CHARACTERISTICS				
DC Current Gain* (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}*	40	—	—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		40	200	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		35	—	
(I_C = 150 mAdc, V_{CE} = 5.0 Vdc)		30	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.2	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)		—	0.35	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.5	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)		—	0.95	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	1.1	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	7.0	pF
Charge-Storage Time Constant (Figure 2) (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	—	25	ns
Turn-On Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	t_{on}	—	35	ns
Turn-Off Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	t_{off}	—	75	ns
MATCHING CHARACTERISTICS				
DC Current Gain Ratio** (I_C = 10 mAdc, V_{CE} = 1 Vdc) MD708A, MD708AF	h_{FE1}/h_{FE2}**	0.9	1.0	—
MD708B, MD708BF		0.8	1.0	
Base Voltage Differential (I_C = 10 mAdc, V_{CE} = 1 Vdc) MD708A, MD708AF	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5	mVdc
MD708B, MD708BF		—	10	
Base Voltage Differential Gradient (I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55 to +125°C) MD708A, MD708AF	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C
MD708B, MD708BF		—	20	

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

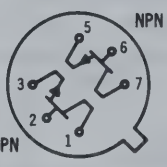
**The lowest h_{FE} reading is taken as h_{FE1} for this test.

MD918, F (SILICON)
MD918A, F
MD918B, F

Dual NPN silicon annular transistors designed for ultra-high frequency oscillator and amplifier applications and for differential amplifier applications requiring a matched pair of transistors with a high degree of parameter uniformity under varying environmental conditions.

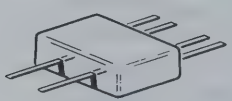


CASE 32C

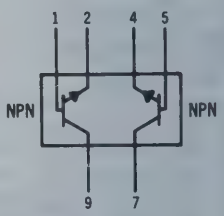


PINS 4 AND 8 OMITTED

MD918
MD918A
MD918B



CASE 33
(TO-89)



MD918F
MD918AF
MD918BF

Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ $T_A = 25°C$	P_D			
Metal Can		300	400	mW
Derate above 25°C		1.7	2.3	mW/°C
Flat Package		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C

ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 3 mAdc, I_B = 0)		BV_{CEO}	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 1 μAdc, I_E = 0)		BV_{CBO}	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	0.010	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)			—	1.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 1 mAdc, V_{CE} = 5 Vdc)		h_{FE}	50	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	—	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	—	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	600	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	—	1.7	pF
(V_{CB} = 0, I_E = 0, f = 140 kHz)			—	3.0	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	—	2.0	pF
Noise Figure (I_C = 1 mAdc, V_{CE} = 6 Vdc, f = 60 MHz, R_S = 400 ohms)		NF	—	6.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio* (I_C = 1 mAdc, V_{CE} = 5 Vdc)	MD918A, MD918AF	h_{FE1}/h_{FE2}*	0.9	1.0	—
	MD918B, MD918BF		0.8	1.0	
Base Voltage Differential (I_C = 1 mAdc, V_{CE} = 5 Vdc)	MD918A, MD918AF	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5	mVdc
	MD918B, MD918BF		—	10	
Base Voltage Differential Change (I_C = 1 mAdc, V_{CE} = 5 Vdc, T_A = -55 to +125°C)	MD918A, MD918AF	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C
	MD918B, MD918BF		—	20	

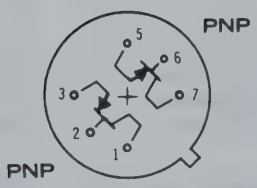
*The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD984 (SILICON)

PNP silicon annular dual transistor for high-speed switching and amplifier applications.



CASE 32C



PINS 4 AND 8 OMITTED
PIN CONNECTIONS
(BOTTOM VIEW)

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	40		Vdc
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	200		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation (25°C Case Temperature) Derate above 25°C	P_D	 1.6 9.1	 3.0 17.2	 W mW/°C
Total Device Dissipation (25°C Ambient Temperature) Derate above 25°C	P_D	 0.5 2.9	 0.6 3.4	 W mW/°C

ELECTRICAL CHARACTERISTICS (each side)

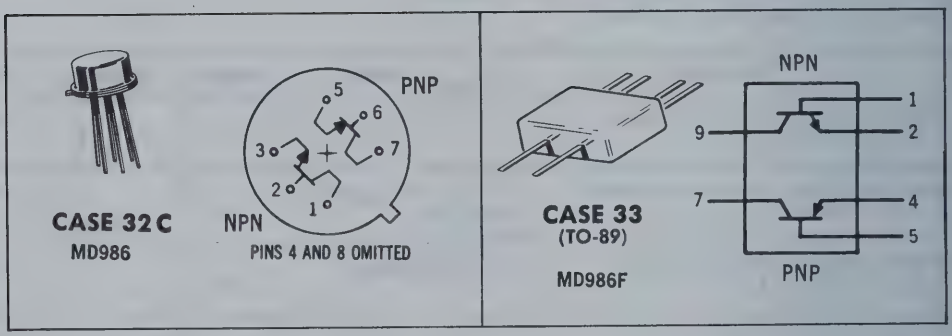
(T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
Collector-Base Breakdown Voltage (I_C = -10 μAdc, I_E = 0)	BV_{CBO}	40	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = -10 mAdc, I_B = 0)	BV_{CEO}*	20	---	Vdc
Emitter-Base Breakdown Voltage (I_E = -10 μAdc, I_C = 0)	BV_{EBO}	5	---	Vdc
Collector Cutoff Current (V_{CB} = -20 Vdc, I_E = 0) (V_{CB} = -20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	--- ---	.025 30	μAdc
Collector-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc) (I_C = -50 mAdc, I_B = -5 mAdc)	$V_{CE(sat)}$	--- ---	0.3 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc)	$V_{BE(sat)}$	---	0.9	Vdc
DC Forward Current Transfer Ratio (I_C = -10 mAdc, V_{CE} = -10 Vdc)	h_{FE}	25	---	---
Output Capacitance (V_{CB} = -10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	---	4	pF
Small-Signal Forward Current Transfer Ratio (I_C = -20 mAdc, V_{CE} = -20 Vdc, f = 100 MHz)	h_{fe}	2.5	---	---
Current-Gain–Bandwidth Product (I_C = -20 mAdc, V_{CE} = -20 Vdc)	f_T	250	---	MHz

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

MD986, F (SILICON)

NPN-PNP silicon annular Star complementary pair dual transistors for high-speed switching circuits and DC to UHF amplifier applications.



Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	40		Vdc
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	200		mAdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ $T_A = 25°C$	P_D			
Flat Package		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
Metal Can		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C

ELECTRICAL CHARACTERISTICS (each side)

(T_A = 25°C unless otherwise noted)

Test Conditions and Limits are given in magnitudes only. Care must be taken to insure the application of proper polarities for the NPN or PNP transistor, respectively.

Characteristics	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	.025	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		—	30	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.3	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)		—	0.5	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
DC Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	4	pF
Current-Gain — Bandwidth Product (V_{CE} = 20 Vdc, I_C = 20 mAdc) TO-5 Package	f_T	200	—	MHz
(V_{CE} = 10 Vdc, I_C = 20 mAdc) Flat Package		200	—	

*Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2%

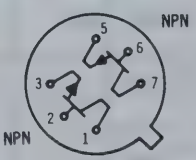
MD1120, F (SILICON)
MD1121, F
MD1122, F

NPN silicon annular Star dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.

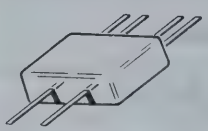


CASE 32 C

MD1120
thru
MD1122

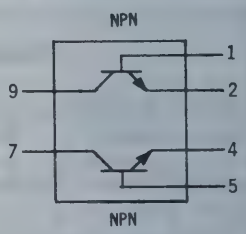


PINS 4 AND 8 OMITTED



CASE 33
(TO-89)

MD1120F
thru
MD1122F



Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
D.C. Collector Current	I_C	500		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to + 200		°C
Flat Package	P_D	One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C		250	350	mW
(Derate above 25°C)		1.5	2.0	mW/°C
Total Device Dissipation @ T_A = 25°C Metal Can	P_D	500	600	mW
(Derate above 25°C)		2.9	3.4	mW/°C

ELECTRICAL CHARACTERISTICS (each side)

(T_A = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc)		BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc)		BV_{CEO}*	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)		BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc)		I_{CBO}	—	0.010	μAdc
(V_{CB} = 50 Vdc, T_A = 150°C)			—	10	
Emitter Cutoff Current (V_{EB} = 3 Vdc)		I_{EBO}	—	10	nAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		V_{CE} (sat)	—	0.1	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		V_{BE} (sat)	—	0.85	Vdc
DC Forward Current Transfer Ratio		h_{FE}			—
(I_C = 10 μAdc, V_{CE} = 10 Vdc)	MD1121, MD1122†		20	100	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	All Types		30	120	
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	All Types		40	160	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	All Types		50	200	
DC Current Gain Ratio **		h_{FE1}/h_{FE2}**			—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD1120†		0.8	1.0	
	MD1121, MD1122†		0.9	1.0	
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	MD1122†		0.9	1.0	
Base Voltage Differential		$\lvert V_{BE1}-V_{BE2} \rvert$			mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD1120, MD1121†		—	10	
	MD1122†		—	5	
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	MD1122†		—	5	
Base Voltage Differential Change (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = -55°C to + 125°C)	MD1121, MD1122†	$\frac{\Delta (V_{BE1}-V_{BE2})}{\Delta T_A}$	—	10	μV/°C
Collector Output Capacitance (V_{CB} = 10 Vdc, f = 100 kHz)		C_{ob}	—	8	pF
Small-Signal Forward Current Transfer Ratio		h_{fe}			—
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz) TO-5 Package			2.5	—	
(I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) Flat Package			2.0	—	
Current-Gain-Bandwidth Product		f_T			MHz
(V_{CE} = 20 Vdc, I_C = 20 mAdc) TO-5 Package			250	—	
(V_{CE} = 10 Vdc, I_C = 20 mAdc) Flat Package			200	—	

* Pulse Test: Pulse Width ≤ 300 μs. Duty Cycle ≤ 2%

** The lowest h_{FE} reading is taken as h_{FE1} for this ratio

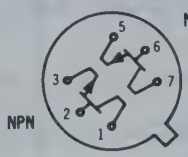
† Applies to corresponding Flat Package device type also

MD1126 (SILICON)
MD1127

NPN silicon annular dual transistors for high-speed switching applications.



CASE 32 C



Pins 4 and 8 omitted

Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	200		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		
		One Side	Both Sides	
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	400 2.3	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.75 4.3	1.5 8.6	Watt mW/°C

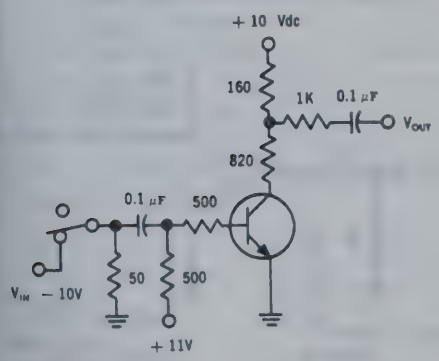
ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_B = 0)		BV_{CEO}*	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)		BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	0.025	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)			-	15	
ON CHARACTERISTICS					
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}*	30	-	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	MD1126	$V_{CE(sat)}$	-	0.40	Vdc
	MD1127		-	0.25	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	0.7	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	6.0	pF
Charge-Storage Time Constant (I_C = I_{B1} = I_{B2} = 10 mAdc)	MD1126	τ_S	-	40	ns
(I_C = I_{B1} = I_{B2} = 20 mAdc)	MD1127		-	25	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

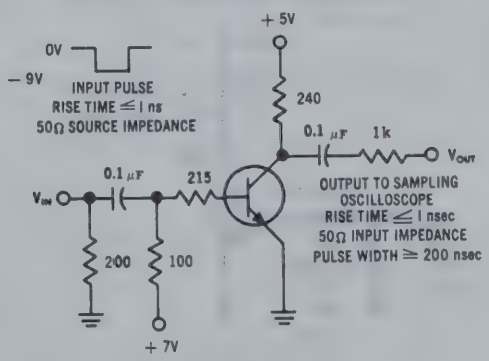
CHARGE STORAGE TIME CONSTANT TEST CIRCUIT

MD1126



CHARGE STORAGE TIME CONSTANT TEST CIRCUIT

MD1127

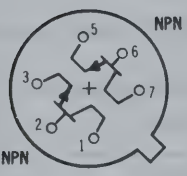


MD1128 (SILICON)

NPN silicon annular dual transistors for high-speed switching applications.



CASE 32C



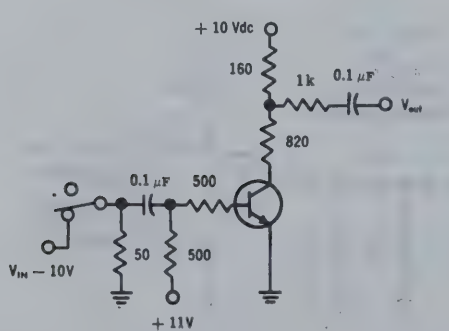
PINS 4 AND 8 OMITTED

Pin Connections Bottom View
All Leads Electrically Isolated from Case

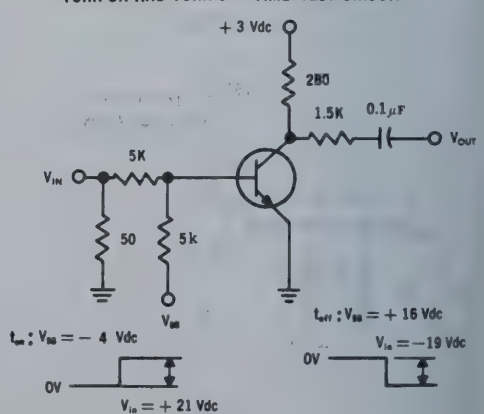
MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	200		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	400 2.3	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.75 4.3	1.5 8.6	Watt mW/°C

CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



TURN-ON AND TURN-OFF TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	I_{CES}	-	10	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = +150°C)	I_{CBO}	- -	0.025 30	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	-	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	- -	0.3 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	4.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{on}	-	20	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{off}	-	35	ns
Charge-Storage Time Constant (I_C = I_{B1} = I_{B2} = 10 mAdc)	τ_S	-	30	ns

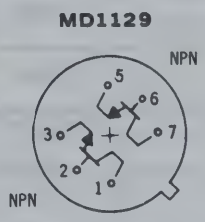
*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MD1129, F (SILICON)

NPN silicon annular dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.

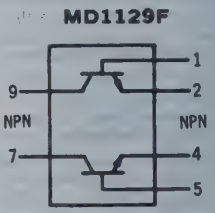


CASE 32C
MD1129





CASE 33
(TO-89)
MD1129F



Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current (Limited by P_D)	I_C	200		mAdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Flat Package Total Device Dissipation Derate above 25°C T_A = 25°C	P_D	250 1.5	350 2	mW mW/°C
TO-5 Package Total Device Dissipation Derate above 25°C T_A = 25°C	P_D	500 2.9	600 3.4	mW mW/°C

ELECTRICAL CHARACTERISTICS (each side)

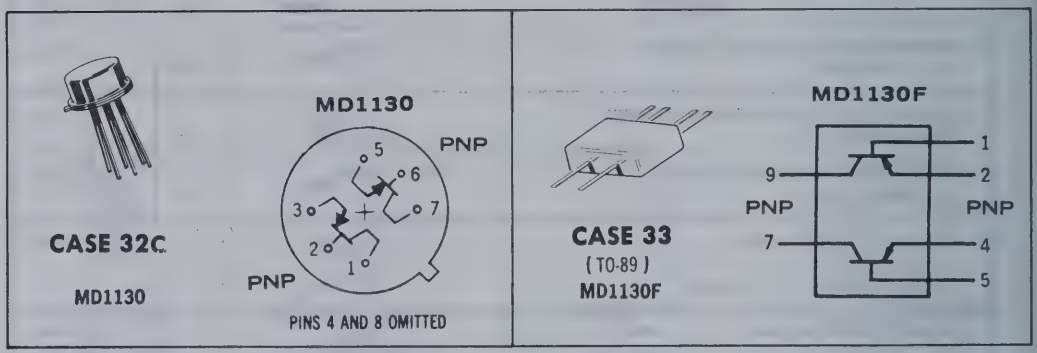
(T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc)	BV_{CEO}*	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)	BV_{EBO}	5	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc) (V_{CB} = 50 Vdc, T_A = 150°C)	I_{CBO}	- -	.010 10	μAdc
Emitter Cutoff Current (V_{EB} = 3 Vdc)	I_{EBO}	-	10	nAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	-	0.1	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	-	0.85	Vdc
DC Forward Current Transfer Ratio (I_C = 10 μAdc, V_{CE} = 10 Vdc) (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 60 100 100 100	 - 300 - -	-
DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1 mAdc, V_{CE} = 10 Vdc)	h_{FE1}/h_{FE2}**	 0.9 0.9	 1.0 1.0	-
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1 mAdc, V_{CE} = 10 Vdc)	$\lvert V_{BE1}-V_{BE2}\rvert$	 - -	 5 5	mVdc
Base Voltage Differential Change (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = -55°C to +125°C)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	-	10	μV/°C
Collector Output Capacitance (V_{CB} = 10 Vdc, f = 100 kHz)	C_{ob}	-	8	pF
Current-Gain–Bandwidth Product (V_{CE} = 10 Vdc, I_C = 20 mAdc)	f_T	200	-	MHz

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%
**The lowest h_{FE} reading is taken as h_{FE1} for this ratio

MD1130, F (SILICON)

PNP silicon annular dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.



Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current (Limited by P_D)	I_C	200		mAdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Flat Package Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 250 1.5	 350 2	 mW mW/°C
Metal Can Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	 500 2.9	 600 3.4	 mW mW/°C

ELECTRICAL CHARACTERISTICS (each side)

(T_A = 25°C unless otherwise noted)

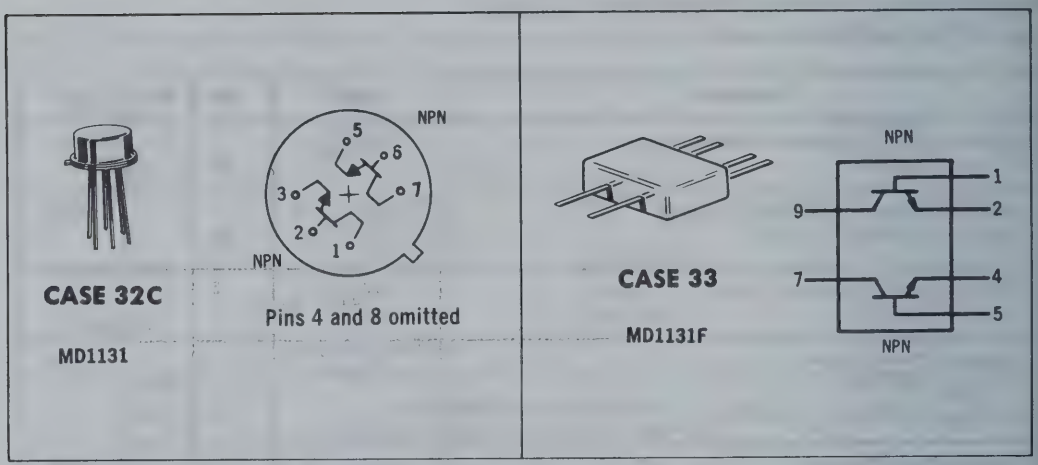
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = -10 μAdc)	BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = -10 mAdc)	BV_{CEO}*	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = -10 μAdc)	BV_{EBO}	5	-	Vdc
Collector Cutoff Current (V_{CB} = -50 Vdc)	I_{CBO}	-	.010	μAdc
(V_{CB} = -50 Vdc, T_A = 150°C)		-	10	
Emitter Cutoff Current (V_{EB} = -3 Vdc)	I_{EBO}	-	10	nAdc
Collector-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
DC Forward Current Transfer Ratio	h_{FE}			-
(I_C = -10 μAdc, V_{CE} = -10 Vdc)		60	-	
(I_C = -100 μAdc, V_{CE} = -10 Vdc)		100	300	
(I_C = -1 mAdc, V_{CE} = -10 Vdc)		100	-	
(I_C = -10 mAdc, V_{CE} = -10 Vdc)		100	-	
DC Current Gain Ratio**	h_{FE1}/h_{FE2}**			-
(I_C = -100 μAdc, V_{CE} = -10 Vdc)		0.9	1.0	
(I_C = -1 mAdc, V_{CE} = -10 Vdc)		0.9	1.0	
Base Voltage Differential	$\lvert V_{BE1}-V_{BE2}\rvert$			mVdc
(I_C = -100 μAdc, V_{CE} = -10 Vdc)		-	5	
(I_C = -1 mAdc, V_{CE} = -10 Vdc)		-	5	
Base Voltage Differential Change (I_C = -100 μAdc, V_{CE} = -10 Vdc, T_A = -55°C to +125°C)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	-	10	μV/°C
Collector Output Capacitance (V_{CB} = -10 Vdc, F = 100 kHz)	C_{ob}	-	4	pF
Current-Gain – Bandwidth Product (V_{CE} = -10 Vdc, I_C = -20 mAdc)	f_T	200	-	MHz

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

** The lowest h_{FE} reading is taken as h_{FE1} for this ratio

MD1131, F (SILICON)

NPN silicon annular dual transistors for high-frequency oscillator and amplifier applications.



Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	30		Vdc
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	50		mAdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can		300	400	mW
Derate above 25°C		1.7	2.3	mW/°C
Flat Package		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C

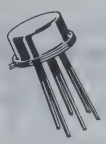
ELECTRICAL CHARACTERISTICS (each side)

(T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
Collector-Base Breakdown Voltage (I_C = 1 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 3 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	.010	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = +150°C)		-	1.0	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
DC Forward Current Transfer Ratio (I_C = 1 mAdc, V_{CE} = 5 Vdc)	h_{FE}	50	-	-
Output Capacitance (V_{CB} = 10 Vdc, f = 140 kHz)	C_{ob}	-	1.7	pF
(V_{CB} = 0 Vdc, f = 140 kHz)		-	3.0	
Input Capacitance (V_{BE} = 0.5 Vdc, f = 140 kHz)	C_{ib}	-	2.0	pF
Small-Signal Forward Current Transfer Ratio (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	6.0	-	-

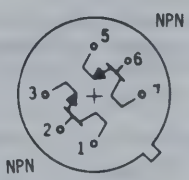
MD1132, F (SILICON)

NPN silicon annular dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.

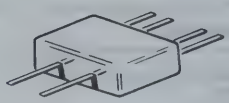


CASE 32C

MD1132

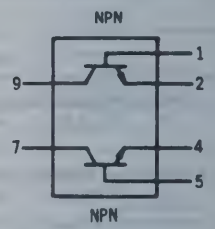


PINS 4 AND 8 OMITTED



CASE 33

MD1132F



Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	30		Vdc
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	50		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can MD1132		300	400	mW
Derating Factor Above 25°C		1.7	2.3	mW/°C
Flat Package: MD1132F		250	350	mW
Derating Factor Above 25°C		1.5	2.0	mW/°C

ELECTRICAL CHARACTERISTICS (each side)

(T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 1 μAdc)	BV_{CBO}	30	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 3 mAdc)	BV_{CEO}	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)	BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc) (V_{CB} = 15 Vdc, T_A = 150°C)	I_{CBO}	— —	.010 1.0	μAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
DC Forward Current Transfer Ratio (I_C = 1 mAdc, V_{CE} = 5 Vdc)	h_{FE}	50	—	—
DC Current Gain Ratio* (I_C = 1 mAdc, V_{CE} = 5 Vdc)	h_{FE1}/h_{FE2}*	0.9	1.0	—
Base Voltage Differential (I_C = 1 mAdc, V_{CE} = 5 Vdc)	$\lvert V_{BE1}-V_{BE2} \rvert$	—	5	mVdc
Base Voltage Differential Change (I_C = 1 mAdc, V_{CE} = 5 Vdc, T_A = -55 to +25°C) (I_C = 1 mAdc, V_{CE} = 5 Vdc, T_A = +25 to +125°C)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	— —	10 10	μV/°C
Collector Output Capacitance (V_{CB} = 10 Vdc, f = 140 kHz) (V_{CB} = 0 Vdc, f = 140 kHz)	C_{ob}	— —	1.7 3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, f = 140 kHz)	C_{ib}	—	2.0	pF
Small Signal Forward Current Transfer Ratio (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	6.0	—	—

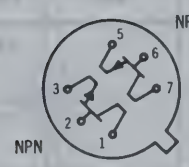
*The lowest h_{FE} reading is taken as h_{FE1} for this ratio

MD1134 (SILICON)

NPN silicon annular dual transistor for high-speed switching applications.



CASE 32C



Pin Connections Bottom View
All Leads Electrically Isolated from Case
PINS 4 AND 8 OMITTED

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Peak*	I_C*	500		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C

* 10 μs Pulse.

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	0.4 30	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	50 20 20	- - -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.70	0.85	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	500	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	4.0	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	4.0	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MD2218, MD2218A (SILICON)
MD2218F, MD2218AF
MQ2218

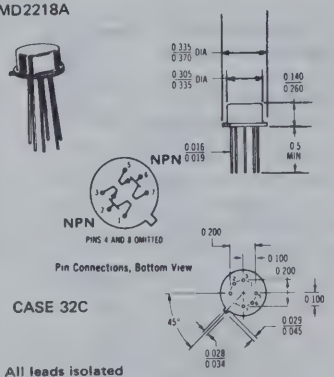
DUAL AND QUAD NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-speed switching circuits, dc to VHF amplifier applications and complementary circuitry with the PNP MD2904, MD2904A, MD2904F, MD2904AF and MQ2904.

- DC Current Gain Specified from 0.1 to 300 mAdc
- High Current-Gain–Bandwidth Product – f_T = 200 MHz (Min) @ I_C = 20 mAdc
- Each Transistor Similar to the 2N2218

NPN SILICON TRANSISTORS

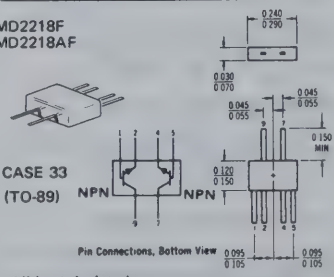
MD2218
MD2218A



CASE 32C

All leads isolated from case

MD2218F
MD2218AF

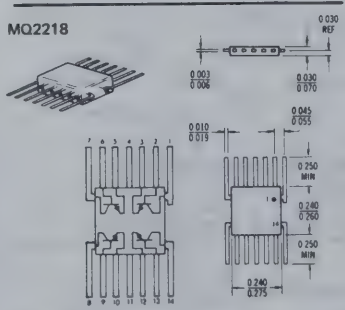


CASE 33
(TO-89)

All leads isolated from case

Lead 1 identified by square impression on underside of case

MQ2218



CASE 83
(TO-86)

Lead 1 identified by color dot or by elbow on lead

14 LEAD FLAT PACKAGE

All leads isolated from case

MAXIMUM RATINGS (Each Transistor)

Rating	Symbol	MD2218 MD2218F MQ2218	MD2218A MD2218AF	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CB}	60	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	Vdc
Collector Current	I_C	600		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
MD2218, MD2218A		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
MD2218F, MD2218AF		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MD2218, MD2218A		1.6	3.0	Watts
Derate above 25°C		9.1	17.2	mW/°C
MD2218F, MD2218AF		800	900	mW
Derate above 25°C		4.6	5.2	mW/°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D			
MQ2218		400	500	mW
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MQ2218		0.65	3.5	Watts
Derate above 25°C		3.71	14.8	mW/°C

Devices mounted on a printed circuit board in the vertical position shielded from air movement.

ELECTRICAL CHARACTERISTICS (Each Transistor) (T_A = 25°C unless otherwise noted)

Characteristics apply to corresponding flat package, and quad type number.

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MD2218	BV_{CEO}*	30	–	Vdc
	MD2218A		40	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MD2218	BV_{CBO}	60	–	Vdc
	MD2218A		75	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MD2218	BV_{EBO}	5.0	–	Vdc
	MD2218A		6.0	–	
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MD2218	I_{CEX}	–	0.020	μAdc
	MD2218A		–	0.015	
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MD2218	I_{BL}	–	0.03	μAdc
	MD2218A				
ON CHARACTERISTICS					
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)		h_{FE}*	20	–	–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)			25	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			35	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)			40	120	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)			20	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MD2218		20	–	
	MD2218A		25	–	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	MD2218	$V_{CE(sat)}$*	–	0.4	Vdc
	MD2218A		–	0.3	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD2218		–	1.2	
	MD2218A		–	0.9	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	MD2218	$V_{BE(sat)}$*	0.6	1.3	Vdc
	MD2218A		0.6	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD2218		–	2.0	
	MD2218A		–	1.8	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	MD2218	C_{ib}	–	30	pF
	MD2218A		–	25	
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 30 Vdc, $V_{EB(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	MD2218	t_d	–	20	ns
	MD2218A		–	15	
Rise Time	MD2218	t_r	–	40	ns
	MD2218A		–	30	
Storage Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	MD2218	t_s	–	280	ns
	MD2218A		–	250	
Fall Time	MD2218	t_f	–	70	ns
	MD2218A		–	60	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

For more detailed information pertaining to the electrical characteristics curves, see the 2N2218 data sheet.

MD2219, MD2219A (SILICON)
MD2219F, MD2219AF
MQ2219A

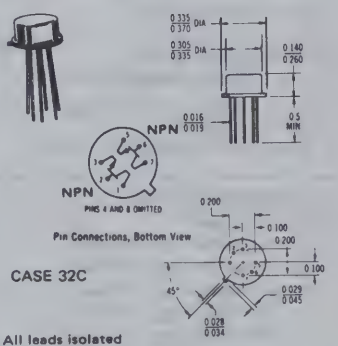
DUAL AND QUAD NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-speed switching circuits, dc to VHF amplifier applications and complementary circuitry with the PNP MD2905, MD2905A, MD2905F, MD2905AF, and MQ2905A.

- DC Current Gain Specified from 0.1 to 300 mAdc
- High Current-Gain–Bandwidth Product – f_T = 200 MHz (Min) @ I_C = 20 mAdc
- Each Transistor Similar to the 2N2219

NPN SILICON TRANSISTORS

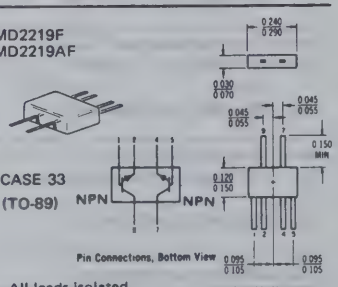
MD2219
MD2219A



CASE 32C

All leads isolated from case

MD2219F
MD2219AF

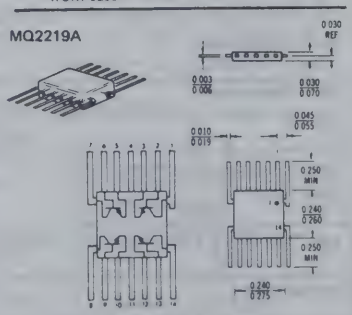


CASE 33
(TO-89)

All leads isolated from case

Lead 1 identified by square impression on underside of case

MQ2219A



CASE 83
(TO-86)

Lead 1 identified by color dot or by elbow on lead

14 LEAD FLAT PACKAGE

All leads isolated from case

†MAXIMUM RATINGS (Each Transistor)

Rating	Symbol	MD2219 MD2219F	MD2219A MD2219AF MQ2219A	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Collector-Base Voltage	V_{CB}	60	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	Vdc
Collector Current	I_C	600		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
MD2219, MD2219A		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
MD2219F, MD2219AF		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MD2219, MD2219A		1.6	3.0	Watts
Derate above 25°C		9.1	17.2	mW/°C
MD2219F, MD2219AF		800	900	mW
Derate above 25°C		4.6	5.2	mW/°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D			
MQ2219A		400	500	mW
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MQ2219A		0.65	3.5	Watts
Derate above 25°C		3.71	14.8	mW/°C

†Devices mounted on a printed circuit board in the vertical position shielded from air movement.

ELECTRICAL CHARACTERISTICS (Each Transistors) (T_A = 25°C unless otherwise noted)

Characteristics apply to corresponding flat package, and quad type number.

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MD2219	BV_{CEO}*	30	–	Vdc
	MD2219A		40	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MD2219	BV_{CBO}	60	–	Vdc
	MD2219A		75	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MD2219	BV_{EBO}	5.0	–	Vdc
	MD2219A		6.0	–	
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MD2219	I_{CEX}	–	0.020	μAdc
	MD2219A		–	0.015	
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	MD2219	I_{BL}	–	0.03	μAdc
	MD2219A				
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)			35	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)			50	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			75	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)			100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)			50	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)			30	–	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	MD2219	$V_{CE(sat)}$*	–	0.4	Vdc
	MD2219A		–	0.3	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD2219		–	1.2	
	MD2219A		–	0.9	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	MD2219	$V_{BE(sat)}$*	0.6	1.3	Vdc
	MD2219A		0.6	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	MD2219		–	2.0	
	MD2219A		–	1.8	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	MD2219	C_{ib}	–	30	pF
	MD2219A		–	25	
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 30 Vdc, $V_{EB(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	MD2219	t_d	–	20	ns
	MD2219A		–	15	
Rise Time	MD2219	t_r	–	40	ns
	MD2219A		–	30	
Storage Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	MD2219	t_s	–	280	ns
	MD2219A		–	250	
Fall Time	MD2219	t_f	–	70	ns
	MD2219A		–	60	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

For more detailed information pertaining to the electrical characteristics, see the 2N2219 data sheet.

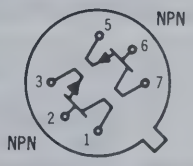
MD2369, F (SILICON)
MD2369A, F
MD2369B, F

Dual NPN silicon annular transistors designed for high-speed, logic switching and space saving considerations. Matched pairs are available for differential amplifier applications.

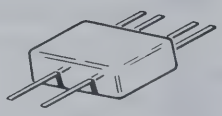


CASE 32C

MD2369
MD2369A
MD2369B

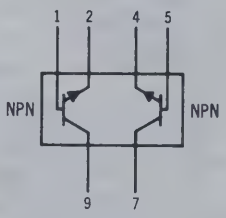


PINS 4 AND 8 OMITTED



CASE 33
(TO-89)

MD2369F
MD2369AF
MD2369BF



Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current (10 μs Pulse)	I_C	500		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can Derate above 25°C		500 2.9	600 3.4	mW mW/°C
Flat Package Derate above 25°C		250 1.5	350 2.0	mW mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage * (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	15	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	—	0.03	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = +150°C)			—	30	
ON CHARACTERISTICS					
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}*	40	140	—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)			20	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	0.7	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	500	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	—	4	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 140 MHz)		C_{ib}	—	4	pF
Charge Storage Time Constant (Figure 3)		t_s	—	13	ns
Turn-On Time (Figure 1)		t_{on}	—	15	ns
Turn-Off Time (Figure 2)		t_{off}	—	20	ns
MATCHING CHARACTERISTICS					
DC Current Gain Ratio** (I_C = 3 mAdc, V_{CE} = 1 Vdc)	MD2369A, MD2369AF	h_{FE1}/h_{FE2}	0.9	1.0	—
	MD2369B, MD2369BF		0.8	1.0	
Base Voltage Differential (I_C = 3 mAdc, V_{CE} = 1 Vdc)	MD2369A, MD2369AF	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5	mVdc
	MD2369B, MD2369BF		—	10	
Base Voltage Differential Gradient (I_C = 3 mAdc, V_{CE} = 1 Vdc, T_A = -55 to +125°C)	MD2369A, MD2369AF	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C
	MD2369B, MD2369BF		—	20	

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%
**The lowest h_{FE} reading is taken as h_{FE1} for this test.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — t_{on} CIRCUIT — 10 mA

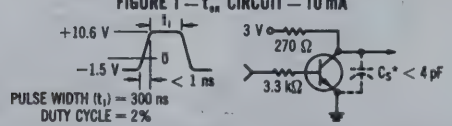


FIGURE 2 — t_{off} CIRCUIT — 10 mA

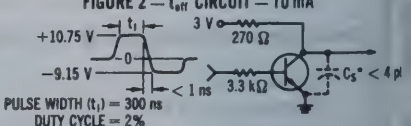
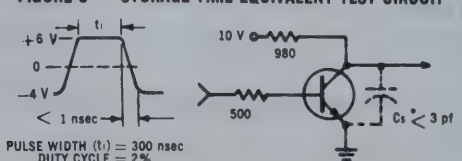


FIGURE 3 — STORAGE TIME EQUIVALENT TEST CIRCUIT



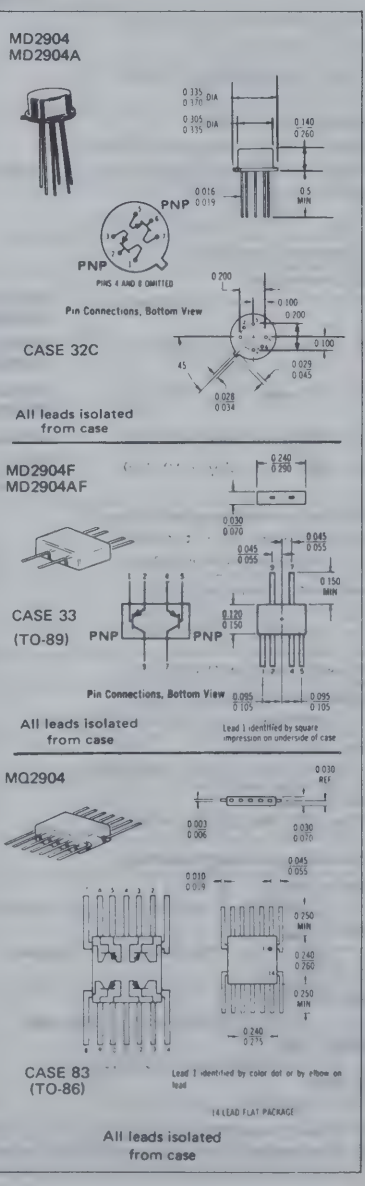
MD2904, MD2904A (SILICON)
MD2904F, MD2904AF
MQ2904

DUAL AND QUAD PNP SILICON
ANNULAR TRANSISTORS

. . . designed for high-speed switching circuits, dc to VHF amplifier applications and complementary circuitry with the NPN MD2218, MD2218A, MD2218F, MD2218AF, and MQ2218.

- DC Current Gain Specified — 0.1 to 500 mAdc
- High Current-Gain—Bandwidth Product — f_T = 200 MHz (Min) @ I_C = 50 mAdc
- Each Transistor Similar to the 2N2904

PNP SILICON
TRANSISTORS



†MAXIMUM RATINGS (Each Transistor)

Rating	Symbol	MD2904 MD2904F MQ2904	MD2904A MD2904AF	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	600		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
MD2904, MD2904A		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
MD2904F, MD2904AF		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MD2904, MD2904A		1.6	3.0	Watts
Derate above 25°C		9.1	17.2	mW/°C
MD2904F, MD2904AF		800	900	mW
Derate above 25°C		4.6	5.2	mW/°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D			
MQ2904		400	500	mW
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MQ2904		0.65	3.5	Watts
Derate above 25°C		3.71	14.8	mW/°C

Devices mounted on a printed circuit board in the vertical position shielded from air movement.

ELECTRICAL CHARACTERISTICS (Each Transistor) (T_A = 25°C unless otherwise noted)

Characteristics apply to corresponding flat package, and quad type number.

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MD2904	BV_{CEO}*	40	–	Vdc
	MD2904A		60	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 3.0 Vdc)		I_{CEX}	–	0.020	μAdc
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 3.0 Vdc, T_A = 150°C)			–	30	
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 3.0 Vdc)		I_{BL}	–	0.030	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD2904	h_{FE}*	20	–	–
	MD2904A		40	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD2904		25	–	
	MD2904A		40	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD2904		35	–	
	MD2904A		40	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	All Types		40	120	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MD2904		20	–	
	MD2904A		40	–	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$*	–	0.4	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			–	1.6	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$*	–	1.3	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			–	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	30	pF
SWITCHING CHARACTERISTICS					
Turn-On-Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	–	45	ns
Delay Time		t_d	–	12	ns
Rise Time		t_r	–	35	ns
Turn-Off-Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	–	130	ns
Storage Time		t_s	–	100	ns
Fall Time		t_f	–	40	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

For more detailed information pertaining to the electrical characteristic curves, see the 2N2904 data sheet.

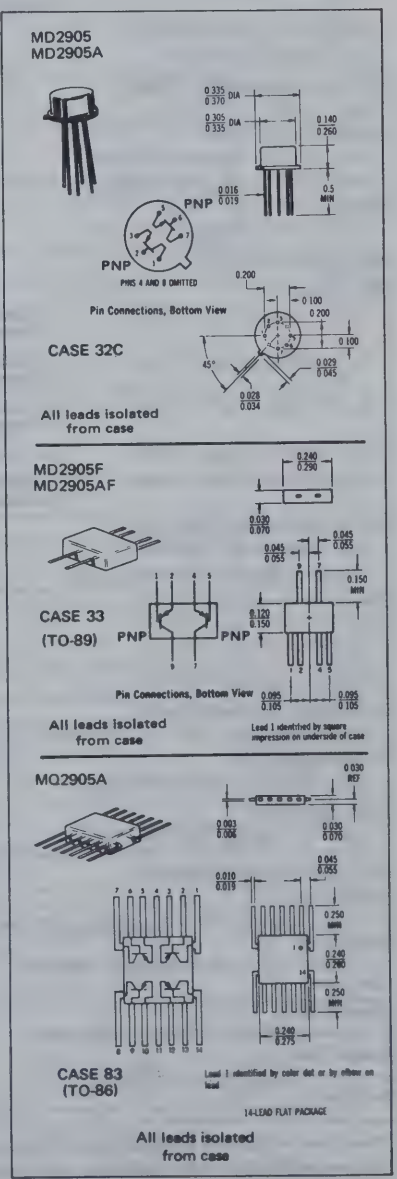
MD2905, MD2905A (SILICON)
MD2905F, MD2905AF
MQ2905A

DUAL AND QUAD PNP SILICON ANNULAR TRANSISTORS

. . . designed for high-speed switching circuits, dc to VHF amplifier applications and complementary circuitry with the NPN MD2219, MD2219A, MD2219F, MD2219AF, and MQ2219A.

- DC Current Gain Specified — 0.1 to 500 mAdc
- High Current-Gain–Bandwidth Product — f_T = 200 MHz (Min) @ I_C = 50 mAdc
- Each Transistor Similar to the 2N2905

PNP SILICON TRANSISTORS



†MAXIMUM RATINGS (Each Transistor)

Rating	Symbol	MD2905 MD2905F	MD2905A MD2905AF MQ2905A	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	600		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
	P_D	One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C				
MD2905, MD2905A		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
MD2905F, MD2905AF		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MD2905, MD2905A		1.6	3.0	Watts
Derate above 25°C		9.1	17.2	mW/°C
MD2905F, MD2905AF		800	900	mW
Derate above 25°C		4.6	5.2	mW/°C
	P_D	One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C				
MQ2905A		400	500	mW
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MQ2905A		0.65	3.5	Watts
Derate above 25°C		3.71	14.8	mW/°C

†Devices mounted on a printed circuit board in the vertical position shielded from air movement.

ELECTRICAL CHARACTERISTICS (Each Transistor) (T_A = 25°C unless otherwise noted)

Characteristics apply to corresponding flat package, and quad type number.

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MD2905	BV_{CEO}*	40	–	Vdc
	MD2905A		60	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 3.0 Vdc)			–	0.020	
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 3.0 Vdc, T_A = 150°C)			–	30	
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 3.0 Vdc)		I_{BL}	–	0.030	μAdc
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD2905		35	–	
	MD2905A		75	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD2905		50	–	
	MD2905A		100	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD2905		75	–	
	MD2905A		100	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	All Types		100	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MD2905		30	–	
	MD2905A		50	–	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	1.6	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			–	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			–	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	30	pF
SWITCHING CHARACTERISTICS					
Turn-On-Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_{on}	–	45	ns
Delay Time		t_d	–	12	ns
Rise Time		t_r	–	35	ns
Turn-Off-Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_{off}	–	130	ns
Storage Time		t_s	–	100	ns
Fall Time		t_f	–	40	ns

*Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

For more detailed information pertaining to the electrical characteristic curves, see the 2N2905 data sheet.

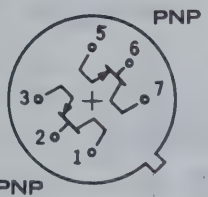
MD3133, F (SILICON)
MD3134, F

Dual PNP silicon annular transistors designed for high-speed switching circuits and DC to VHF amplifier applications.

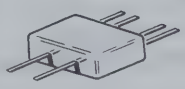


CASE 32C

MD3133
MD3134

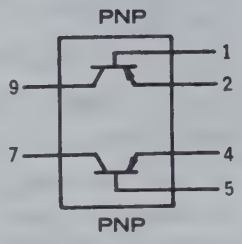


PINS 4 AND 8 OMITTED



CASE 33
(TO-89)

MD3133F
MD3134F



Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

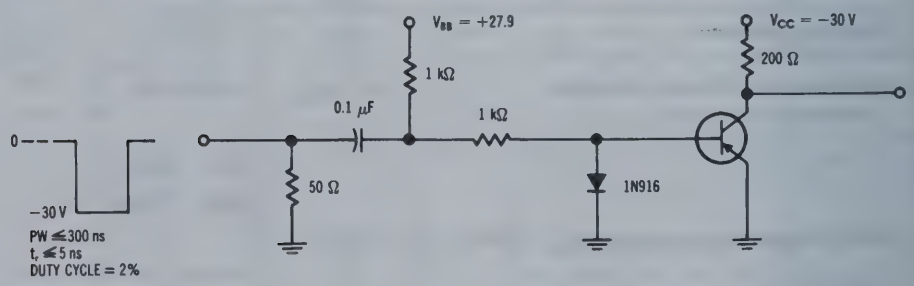
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	35		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	4		Vdc
Collector Current	I_C	600		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
TO-89 Flat Package		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	35	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4	—	Vdc
Collector-Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 0.5 Vdc)	I_{CEX}	—	0.1	μAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 20, T_A = 150°C)	I_{CBO}	— —	0.05 30	μAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 0.5 Vdc)	I_{BL}	—	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 1 mAdc, V_{CE} = 10 Vdc) MD3133, MD3133F MD3134, MD3134F (I_C = 150 mAdc, V_{CE} = 10 Vdc) MD3133, MD3133F MD3134, MD3134F	h_{FE}*	25 50 40 100	— — 120 300	—
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$*	—	0.6	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$*	—	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	10	pF
Input Capacitance (V_{BE} = 2 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	40	pF
Turn-On Time, Figure 1 (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc	t_{on}	—	75	ns
Turn-Off Time, Figure 1 (V_{CC} = 30 Vdc, I_C = 150 mAdc I_{B1} = I_{B2} = 15 mAdc)	t_{off}	—	150	ns

*Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT



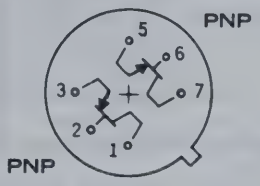
MD3250, A, F, AF (SILICON)
MD3251, A, F, AF

Dual PNP silicon annular transistors, especially designed for low-level, differential amplifier applications.

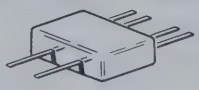


CASE 32C

MD3250, A
MD3251, A

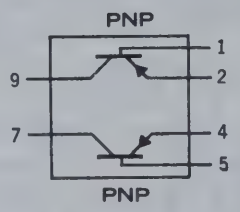


PINS 4 AND 8 OMITTED



CASE 33
(TO-89)

MD3250F, AF
MD3251F, AF



Pin Connections Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	50		Vdc
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
DC Collector Current	I_C	50		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Metal Can		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
Flat Pack		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
Metal Can		1.2	2.0	mW
Derate above 25°C		6.85	11.42	mW/°C

MD3250, A, F, AF and MD3251, A, F, AF (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

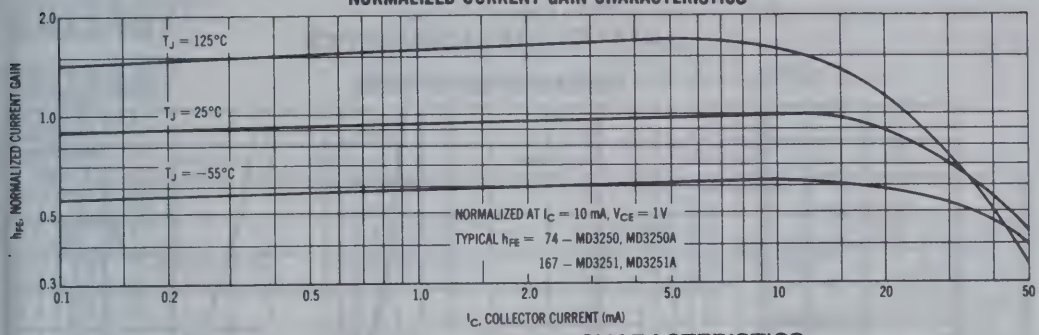
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	50	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40		—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	0.01	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			—	—	10	
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Forward Current Transfer Ratio* (I_C = 10 μAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A	h_{FE}*	25	—	—	—
	MD3251, MD3251A		50	—	—	
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		50	—	150	
	MD3251, MD3251A		100	—	300	
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	MD3250, MD3250A		25	—	—	
	MD3251, MD3251A		50	—	—	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		50	—	150	
	MD3251, MD3251A		100	—	300	
(I_C = 10 mAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		50	—	—	
	MD3251, MD3251A		100	—	—	
(I_C = 50 mAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		15	—	—	
	MD3251, MD3251A		30	—	—	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$*	—	—	0.25	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)			—	—	0.50	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$*	0.6	—	0.9	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)			—	—	1.2	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MD3250, MD3250A	f_T	200	—	—	MHz
	MD3251, MD3251A		250	—	—	
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	—	6	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	—	8	pF
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	MD3250, MD3250A	h_{fe}	50	—	200	—
	MD3251, MD3251A		100	—	400	
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	MD3250, MD3250A	h_{re}	—	—	10	X10-4
	MD3251, MD3251A		—	—	20	
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	MD3250, MD3250A	h_{ie}	1	—	6	kohms
	MD3251, MD3251A		2	—	12	
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	MD3250, MD3250A	h_{oe}	4	—	40	μmhos
	MD3251, MD3251A		10	—	60	
Wide Band Noise Figure (I_C = 100 μA, V_{CE} = 10 V, R_g = 3 kohm, Noise Bandwidth 10 cps to 15.7 kHz)	MD3250, MD3250A	NF	—	—	4	dB
	MD3251, MD3251A		—	—	3	
MATCHING CHARACTERISTICS (Types MD3250A and MD3251A only)						
DC Current Gain Ratio** (I_C = 100 μAdc and 1 mAdc, V_{CE} = 5 Vdc)	MD3250A, MD3251A	h_{FE1}/h_{FE2}**	0.9	—	1.0	—
Base Voltage Differential (I_C = 10 μA, to 10 mA, V_{CE} = 5 Vdc)	MD3250A, MD3251A	$\lvert V_{BE1}-V_{BE2}\rvert$	—	—	5	mVdc
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	MD3250A, MD3251A		—	—	3	
Base Voltage Differential Change (I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +25°C)	MD3250A, MD3251A	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	—	—	10	mV/°C
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = 25 to 125°C)	MD3250A, MD3251A		—	—	10	

*Pulse Test ≤ 300 μs, duty cycle ≤ 2%

** The lowest h_{FE} reading is taken as h_{FE1} for this ratio

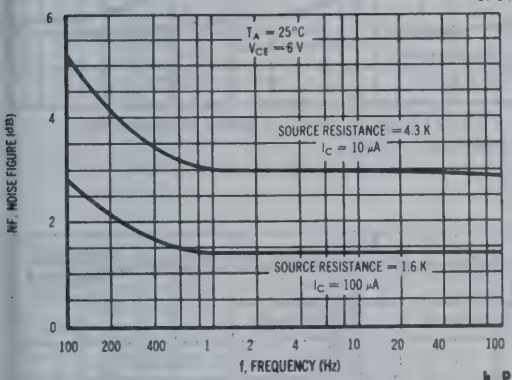
MD3250, A, F, AF and MD3251, A, F, AF (continued)

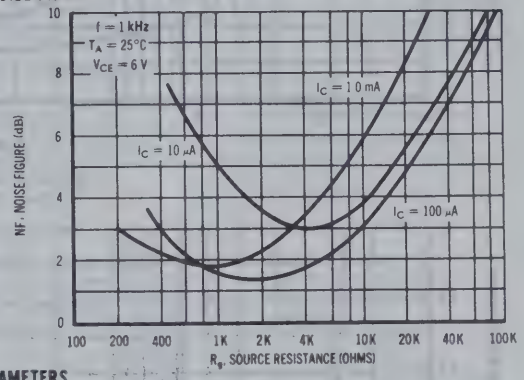
NORMALIZED CURRENT GAIN CHARACTERISTICS



AUDIO SMALL SIGNAL CHARACTERISTICS

SPOT NOISE FIGURE

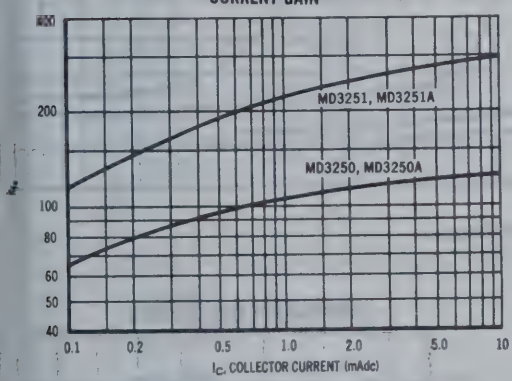




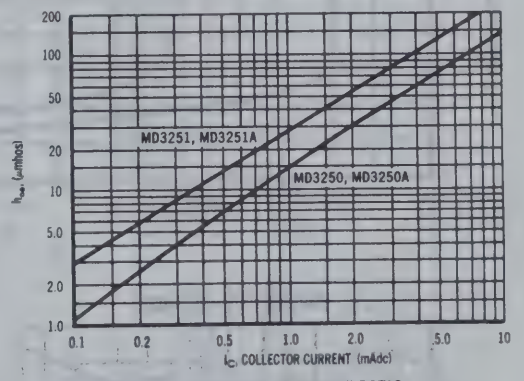
h PARAMETERS

V_{CE} = 10 Vdc, f = 1 kHz, T_A = 25°C

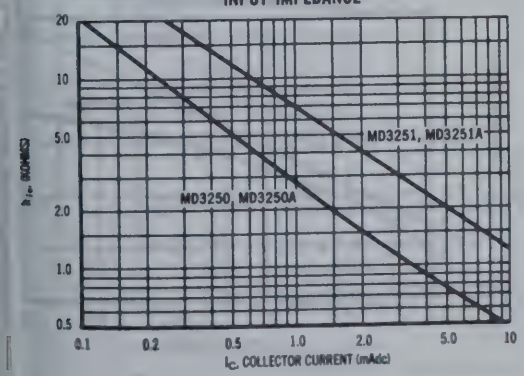
CURRENT GAIN



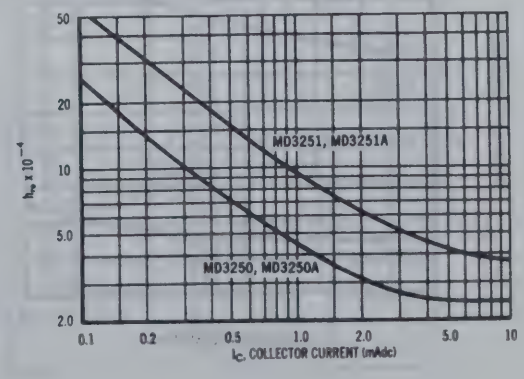
OUTPUT ADMITTANCE



INPUT IMPEDANCE

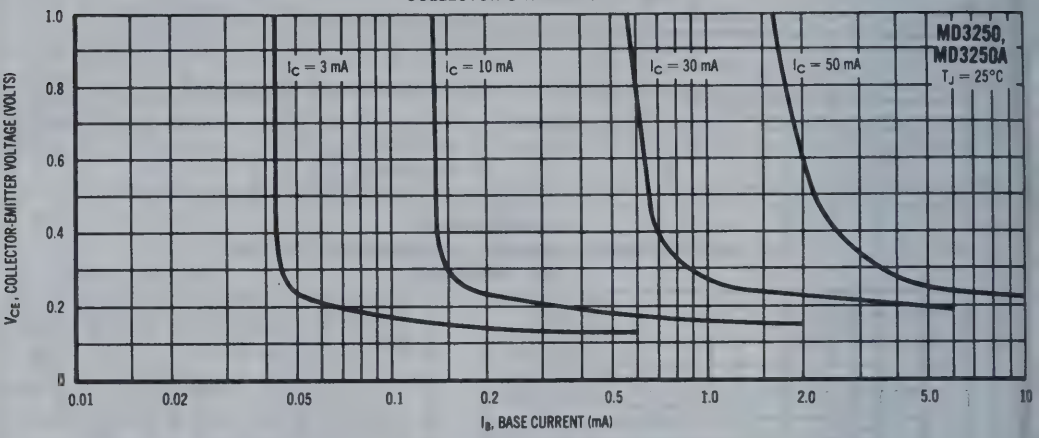


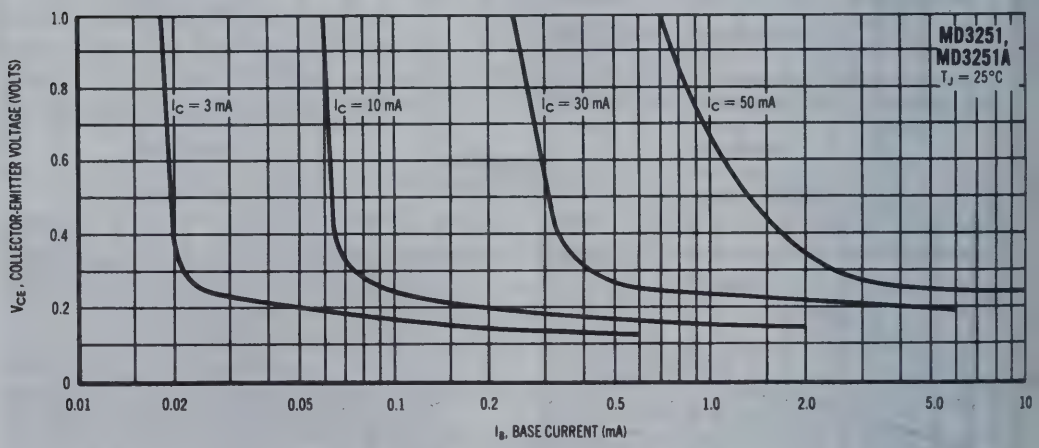
VOLTAGE FEEDBACK RATIO



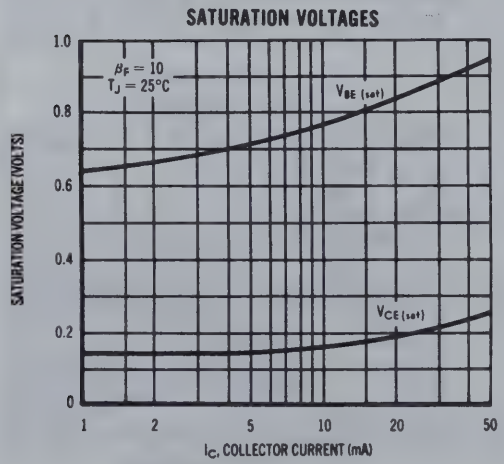
STATIC CHARACTERISTICS

COLLECTOR SATURATION REGION

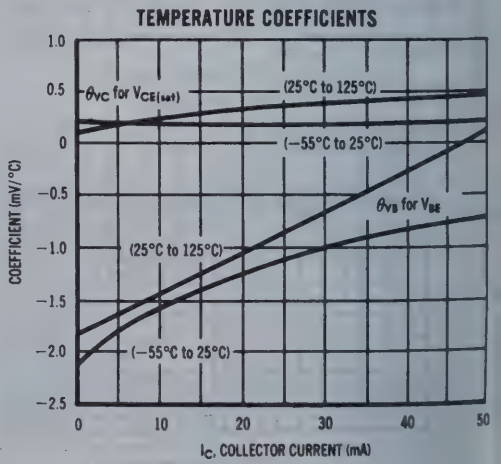




SATURATION VOLTAGES



TEMPERATURE COEFFICIENTS



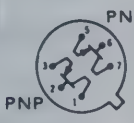
MD3467 (SILICON)
MD3467F
MQ3467

Dual and quad PNP silicon annular transistors designed for medium-current, high-speed switching and driver applications where space reduction is required.

MD3467



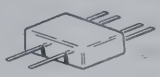
CASE 32C



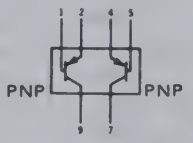
Pins 4 and 8 omitted

Pin connections, bottom view

MD3467F



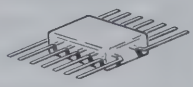
CASE 33
(TO-89)



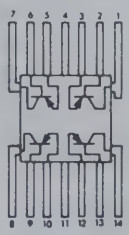
Pin connections, bottom view

Lead 1 identified by square impression on underside of case.

MQ3467



CASE 83
(TO-86)



Lead 1 identified by color dot or by elbow on lead.

All leads isolated from case

MAXIMUM RATINGS (each transistor)

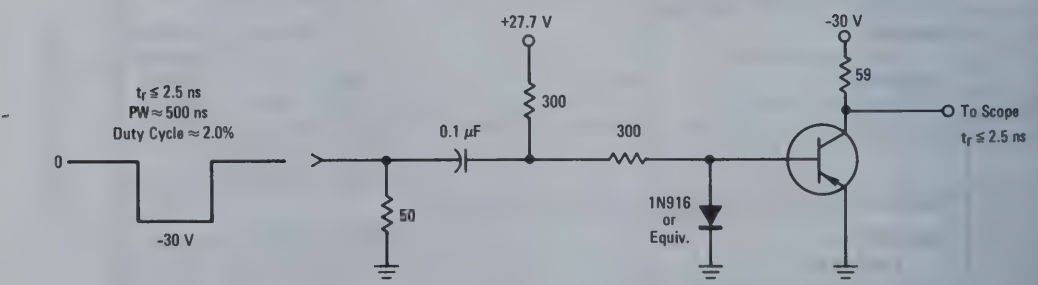
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	1.0		Adc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
MD3467		500	600	mW
Derate above 25°C		2.86	3.43	mW/°C
MD3467F		250	350	mW
Derate above 25°C		1.43	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MD3467		1.0	2.0	Watts
Derate above 25°C		5.7	11.4	mW/°C
MD3467F		1.25	2.5	Watts
Derate above 25°C		7.15	14.3	mW/°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MQ3467		400	500	
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MQ3467		1.25	5.0	
Derate above 25°C		7.15	28.6	mW °C

ELECTRICAL CHARACTERISTICS (each transistor) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	40		-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40		-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0		-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	30	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	30	100	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}*	20	40	-	-
Collector-Emitter Saturation Voltage* (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$*	-	0.35	0.5	Vdc
Base-Emitter Saturation Voltage* (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$*	-	0.9	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain —Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	250	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	11	20	pF
Collector-Emitter Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	-	60	80	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_d	-	7.0	10	ns
Rise Time		t_r	-	15	30	ns
Storage Time	(I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_s		30	80	ns
Fall Time		t_f	-	16	30	ns

*Pulse Test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



MD3725 (SILICON)
MD3725F
MQ3725

MD3725



CASE 32C



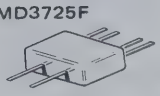
PINS 4 AND 8 OMITTED

Pin Connections, Bottom View

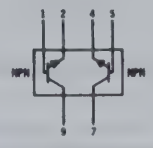
All leads isolated from case

Dual and quad NPN silicon annular transistors designed for medium-current, high-speed switching and driver applications where space reduction is required.

MD3725F



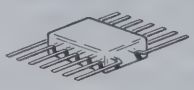
CASE 33
(TO-89)



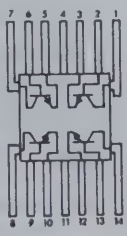
Pin Connections, Bottom View

Lead 1 identified by square impression or dot on underside of case
All leads isolated from case

MQ3725



CASE 83
(TO-86)



Lead 1 identified by color dot or by elbow on lead.
All leads electrically isolated from package.

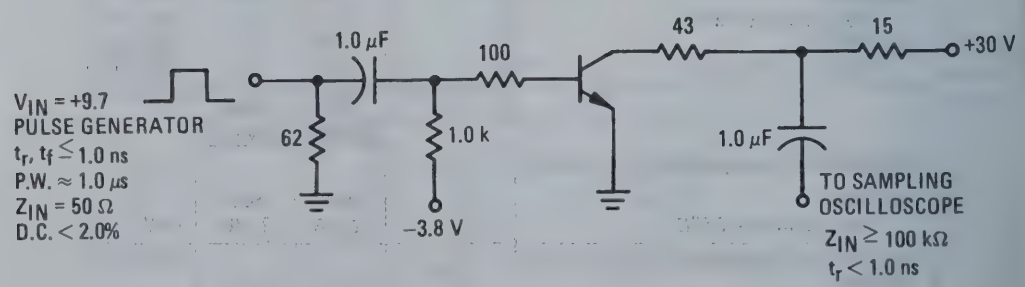
MAXIMUM RATINGS (each transistor)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	65		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current - Continuous	I_C	1.0		Adc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
MD3725		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
MD3725F		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MD3725		1.0	2.0	Watts
Derate above 25°C		5.7	11.4	mW/°C
MD3725F		1.25	2.5	Watts
Derate above 25°C		7.1	14.3	mW/°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MQ3725		400	500	
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MQ3725		1.25	5.0	
Derate above 25°C		7.15	28.6	mW/°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	65	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	- -	1.7 120	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	50 30	150 -	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	- -	0.26 0.52	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	- 0.85	0.86 1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	-	55	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (Figure 1) (I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	-	45	ns
Turn-Off Time (Figure 1) (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	-	75	ns

FIGURE 1



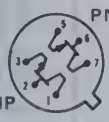
MD3762 (SILICON)
MD3762F
MQ3762

Dual and quad PNP silicon annular transistors designed for high-current, high-speed switching and driver applications where space reduction is required.

MD3762



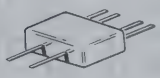
CASE 32C



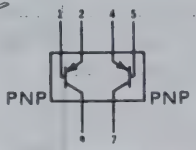
Pins 4 and 8 omitted

Pin connections, bottom view

MD3762F



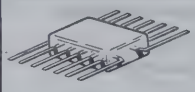
CASE 33
(TO-89)



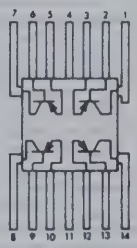
Pin connections, bottom view

Lead 1 identified by square impression on underside of case.

MQ3762



CASE 83
(TO-86)



Lead 1 identified by color dot or by elbow on lead.

All leads isolated from case

MAXIMUM RATINGS (each transistor)

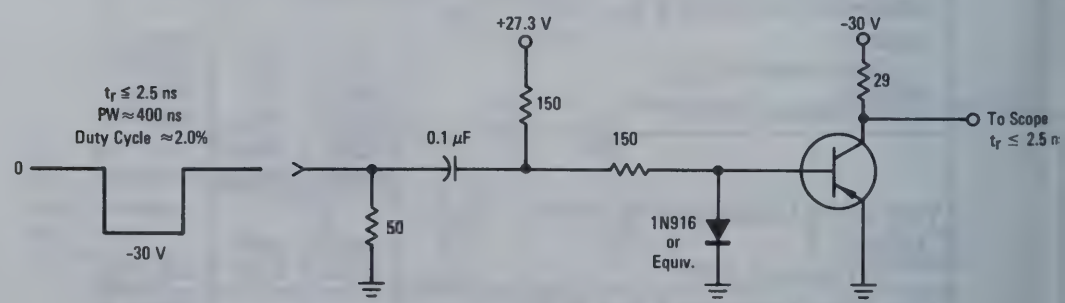
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	1.5		Adc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
MD3762		500	600	mW
Derate above 25°C		2.86	3.43	mW/°C
MD3762F		250	350	mW
Derate above 25°C		1.43	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
MD3762		1.0	2.0	Watts
Derate above 25°C		5.7	11.4	mW/°C
MD3762F		1.25	2.5	Watts
Derate above 25°C		7.15	14.3	mW/°C
		One Device	Four Devices	
Total Device Dissipation @ T_A = 25°C	P_D			mW
MQ3762		400	500	
Derate above 25°C		2.28	2.86	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			Watts
MQ3762		1.25	5.0	
Derate above 25°C		7.15	28.6	mW/°C

ELECTRICAL CHARACTERISTICS (each transistor) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	40		-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40		-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0		-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	30	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	30	100	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}*	20	40	-	-
Collector-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$*	-	0.7	1.0	Vdc
Base-Emitter Saturation Voltage* (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$*	-	1.1	1.4	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	150	250	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	11	20	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	-	60	80	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = 1.0 Adc, I_{B1} = 0.1 Adc)	t_d	-	7.0	10	ns
Rise Time		t_r	-	15	30	ns
Storage Time	(I_C = 1.0 Adc, I_{B1} = I_{B2} = 0.1 Adc)	t_s	-	30	80	ns
Fall Time		t_f	-	16	30	ns

*Pulse test: Pulse Width ≈ 300 μs, Duty Cycle ≈ 2.0%

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT

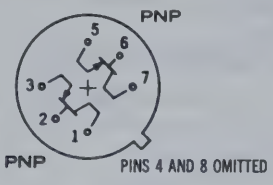


MD4957 (SILICON)



CASE 32C

Dual PNP silicon annular 450-MHz amplifier designed for high-gain, low-noise amplifier, oscillator, and mixer applications.



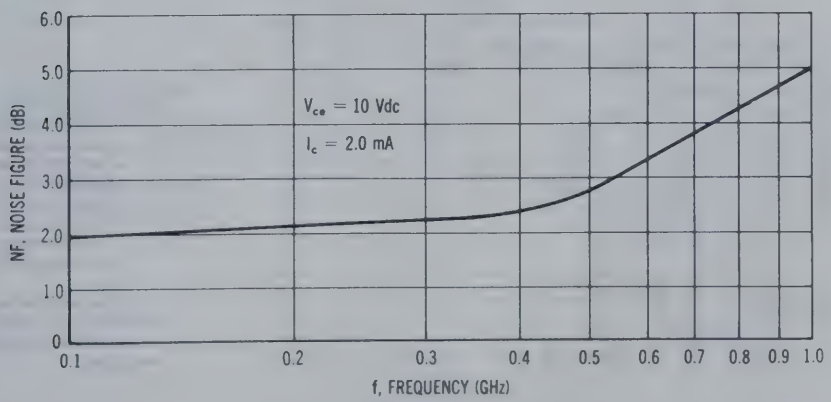
Pin Connections, Bottom View

All leads electrically isolated from case

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current	I_C	30		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D	200	400	mW
Derate above 25°C		1.15	2.3	mW/°C

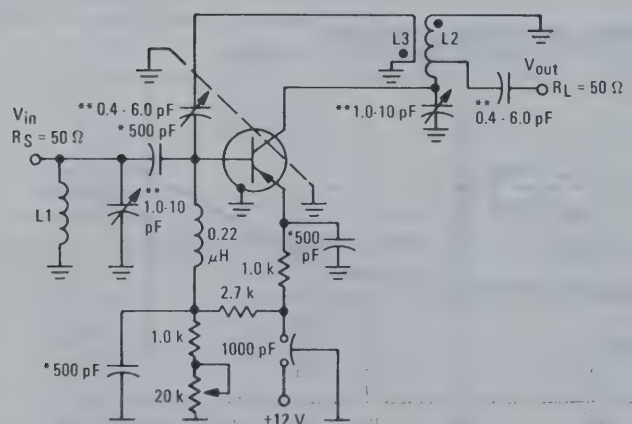
TYPICAL NOISE FIGURE vs. FREQUENCY



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	-	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	-	150	-
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	1000	1500	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	0.4	0.8	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	-	200	-
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	$r_b'C_c$	-	4.0	8.0	ps
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz) Figure 1	NF	-	2.6	-	dB
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 GHz)		-	5.0	-	
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz)	G_{pe}	-	18	-	dB
(V_{CE} = 10 Vdc, I_C = 2.0 mAdc, R_S = 50 ohms, f = 1.0 GHz)		-	13	-	

FIGURE 1 — NOISE FIGURE AND POWER GAIN TEST CIRCUIT



* Button type capacitors
** Variable air piston type capacitors

1. L1 - silver plated brass bar, 1.0 in. lg by 0.25 in od.
2. L2 - silver plated brass bar, 1.5 in. lg by 0.25 in od. Tap is 0.25 in. from collector
3. L3 - ½ turn of AWG No. 16 wire 0.25 in. from and parallel to L2.
4. The noise source is a hot-cold body (All type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

COMMON EMITTER Y PARAMETER VARIATIONS

Y PARAMETERS VS FREQUENCY

V_{CE} = 10 Vdc

I_C = 2.0 mA

FIGURE 2 — INPUT ADMITTANCE

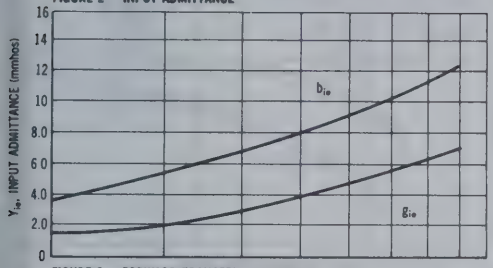


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

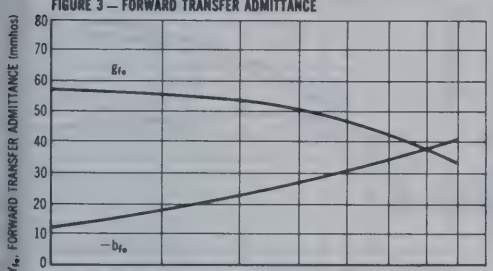


FIGURE 4 — OUTPUT ADMITTANCE

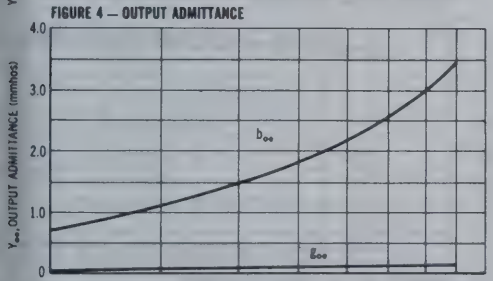
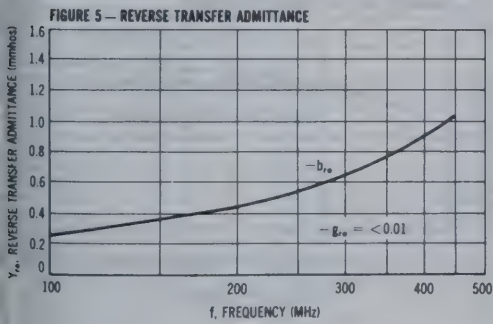


FIGURE 5 — REVERSE TRANSFER ADMITTANCE



Y PARAMETERS VS CURRENT

V_{CE} = 10 Vdc ——— V_{CE} = 15 Vdc — — —

f = 450 MHz

FIGURE 6 — INPUT ADMITTANCE

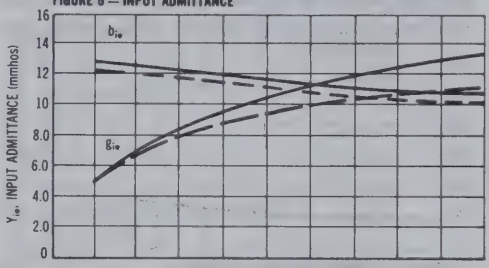


FIGURE 7 — FORWARD TRANSFER ADMITTANCE

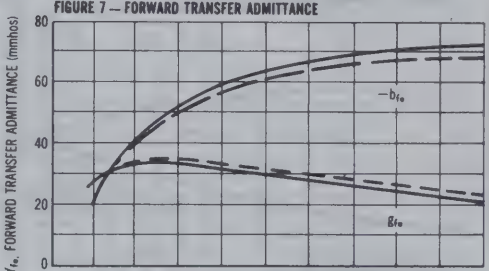


FIGURE 8 — OUTPUT ADMITTANCE

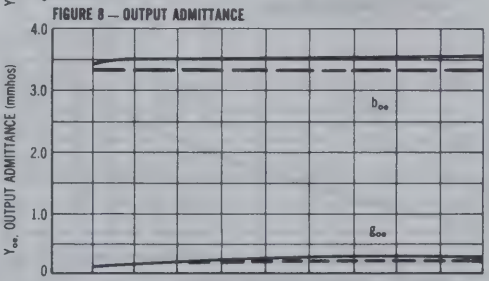
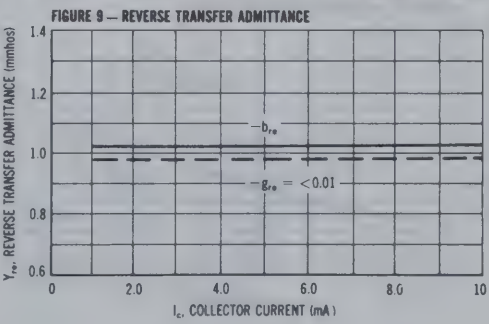


FIGURE 9 — REVERSE TRANSFER ADMITTANCE



COMMON BASE Y PARAMETER VARIATIONS

Y PARAMETERS versus FREQUENCY

V_{CB}= 10 Vdc

I_C = 2.0 mA

FIGURE 10 — INPUT ADMITTANCE

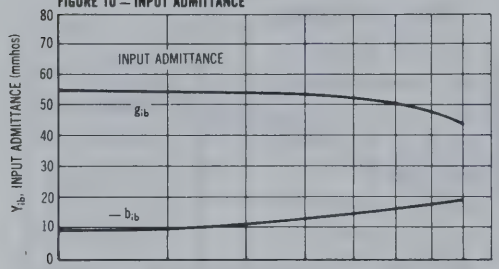


FIGURE 11 — FORWARD TRANSFER ADMITTANCE

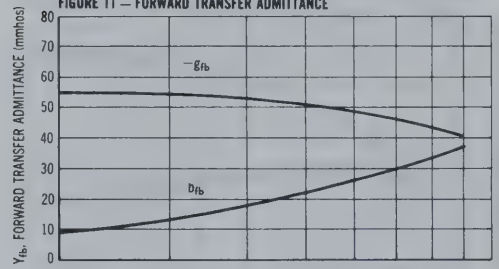


FIGURE 12 — OUTPUT ADMITTANCE

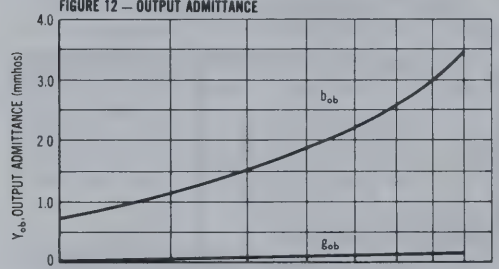
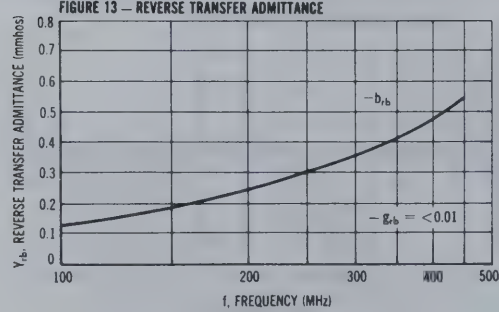


FIGURE 13 — REVERSE TRANSFER ADMITTANCE



Y PARAMETERS versus CURRENT

V_{CB}= 10 Vdc —— V_{CB}= 15 Vdc — — —

f = 450 MHz

FIGURE 14 — INPUT ADMITTANCE

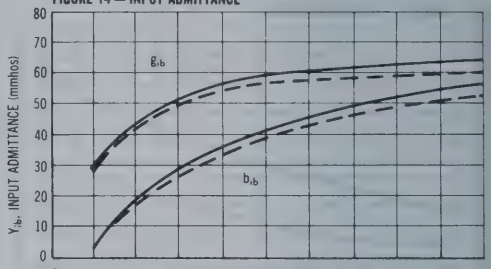


FIGURE 15 — FORWARD TRANSFER ADMITTANCE

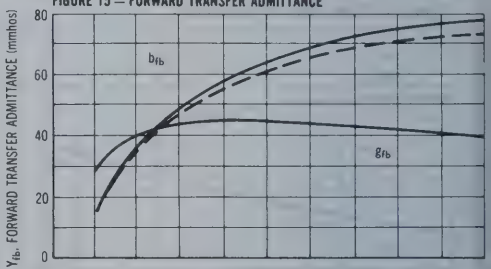


FIGURE 16 — OUTPUT ADMITTANCE

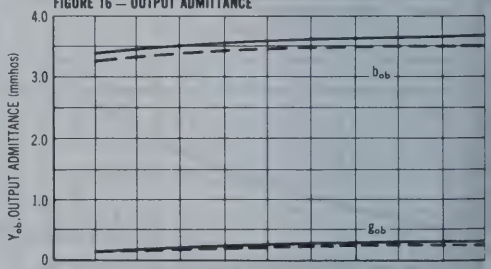
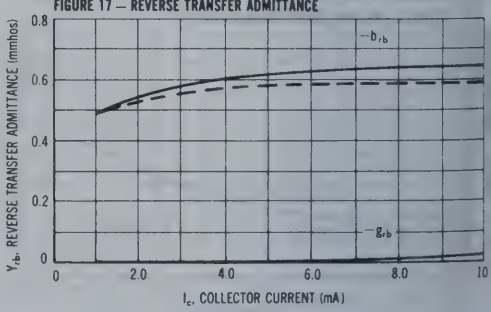


FIGURE 17 — REVERSE TRANSFER ADMITTANCE

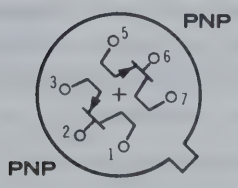


MD5000, A, B (SILICON)



CASE 32C

Dual PNP silicon annular transistors designed for ultra-high frequency oscillator and amplifier applications and for differential-amplifier applications requiring a matched pair of transistors with a high degree of parameter uniformity under varying environmental conditions.



PINS 4 AND 8 OMITTED

Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Base Voltage	V_{CB}	20		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A=25°C	P_D	300	400	mW
Derate above 25°C		1.7	2.3	mW/°C

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 3 mAdc, I_B = 0)		BV_{CEO}	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	20	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	—	0.010	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)			—	—	1.0	
ON CHARACTERISTICS						
DC Current Gain (I_C = 3 mAdc, V_{CE} = 1 Vdc)		h_{FE}	20	50	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	—	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	—	—	1.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	600	900	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	—	—	1.7	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	—	—	2.0	pF
Noise Figure (I_C = 1 mAdc, V_{CE} = 6 Vdc, f = 60 MHz, R_S = 400 ohms)		NF	—	3.0	6.0	dB
FUNCTIONAL TEST						
Amplifier Power Gain (I_C = 6 mAdc, V_{CB} = 12 Vdc, R_G = R_L = 50 ohms, f = 200 MHz)		G_{pe}	15	20	—	dB
MATCHING CHARACTERISTICS						
DC Current Gain Ratio* (I_C = 4 mAdc, V_{CE} = 10 Vdc)	MD5000	h_{FE1}/h_{FE2}*	—	0.7	—	—
	MD5000A		0.9	—	1.0	
	MD5000B		0.8	—	1.0	
Base Voltage Differential (I_C = 4 mAdc, V_{CE} = 10 Vdc)	MD5000	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5	—	mVdc
	MD5000A		—	—	5	
	MD5000B		—	—	10	
Base Voltage Differential Change (I_C = 4 mAdc, V_{CE} = 10 Vdc, T_A = -55 to +125°C)	MD5000	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	—	μV/°C
	MD5000A		—	—	10	
	MD5000B		—	—	20	

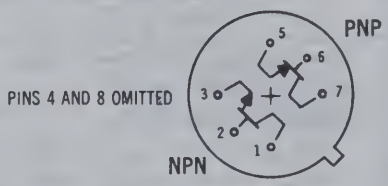
*The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

MD6001 (SILICON)
MD6002



CASE 32 C

Silicon annular complementary-pair dual transistor is designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.



PIN CONNECTIONS
(BOTTOM VIEW)

MAXIMUM RATINGS (each side) ($T_A = 25°C$ unless otherwise specified)

Test Conditions and Limits are given in magnitudes only. Care must be taken to insure the application of proper polarities for the NPN or PNP transistor, respectively.

Rating	Symbol	Value		Unit
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
DC Collector Current (Limited by P_D)	I_C	300		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation @ $T_A = 25°C$	P_D	500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
Total Device Dissipation @ $T_C = 25°C$	P_D	1.2	2.0	W
Derate above 25°C		6.83	11.43	mW/°C

NPN SATURATED SWITCHING TIME TEST CIRCUITS

For PNP Switching Tests, reverse diodes, voltage polarities, and input pulses.

FIGURE 1 — NPN TURN-ON TIME

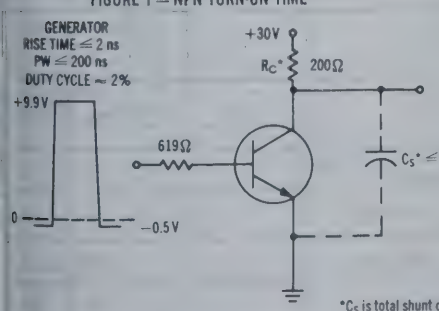
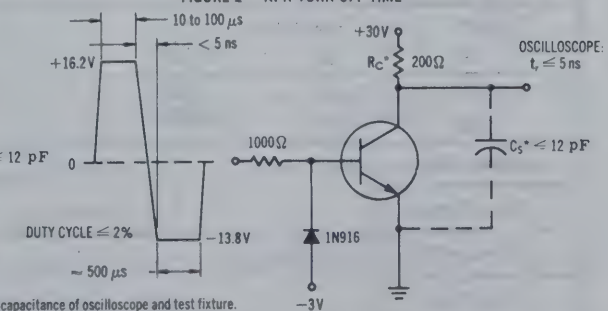


FIGURE 2 — NPN TURN-OFF TIME



*C_S is total shunt capacitance of oscilloscope and test fixture.
R_C includes oscilloscope resistance.

MD6001, MD6002 (continued)

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)			BV_{CEO}*	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, V_{EB} = 3 Vdc)			I_{CEX}	—	0.02	μAdc
(V_{CE} = 50 Vdc, V_{EB} = 3 Vdc, T_A = 150°C)				—	30	
Base Cutoff Current (V_{CE} = 50 Vdc, V_{EB} = 3 Vdc)			I_{BL}	—	0.03	μAdc
ON CHARACTERISTICS						
DC Current Gain*			h_{FE}*			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)		MD6001		20	—	
		MD6002		35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		MD6001		25	—	
		MD6002		50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		MD6001		35	—	
		MD6002		75	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		MD6001		40	120	
		MD6002		100	300	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)		MD6001		20	—	
		MD6002		50	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)		MD6001		20	—	
		MD6002		30	—	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)			$V_{BE(sat)}$*	—	1.3	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)				—	2.0	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)			$V_{CE(sat)}$*	—	0.4	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)				—	1.4	
DYNAMIC CHARACTERISTICS						
Gain - Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)			f_T	—	200	MHz
Collector Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			C_{ob}	—	8	pF
Collector Input Capacitance (V_{BE} = 2 Vdc, I_C = 0, f = 100 kHz)			C_{ib}	—	30	pF
Delay Time	See Figure 1	V_{CC} = 30 V, $V_{BE(off)}$ = 0.5 V	t_d	—	20	ns
Rise Time		I_C = 150 mA, I_{B1} = 15 mA	t_r	—	40	ns
Storage Time	See Figure 2	V_{CC} = 30 V, I_C = 150 mA	t_s	—	280	ns
Fall Time		I_{B1} = I_{B2} = 15 mA	t_f	—	70	ns

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

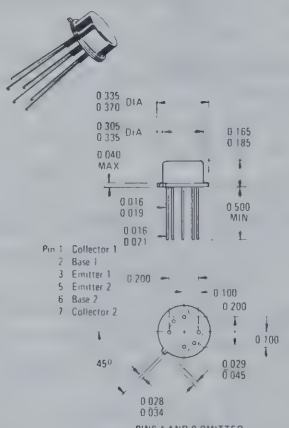
MD6003 (SILICON)
MD6003F

SILICON ANNULAR COMPLEMENTARY DUAL TRANSISTORS

. . . designed for DC to VHF amplifier applications and complementary circuitry.

- Contains One NPN and One PNP Transistor Having Identical Specifications
- NPN Transistor Similar to the 2N2218 or 2N2219
  PNP Transistor Similar to the 2N2904 or 2N2905
- DC Current Gain Specified – 0.1 mAdc to 300 mAdc
- High Current Gain – Bandwidth Product –
  f_T = 200 MHz (Min) @ I_C = 50 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc

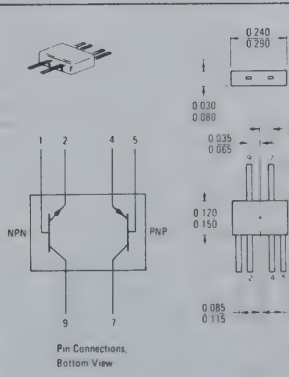
NPN-PNP COMPLEMENTARY DUAL SILICON TRANSISTORS



MD6003
Case 654-04
(Formerly Case 32-02)

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	300		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
Can Package		500	600	mW
Derate above 25°C		2.87	3.43	mW/°C
TO-89 Flat Package		250	350	mW
Derate above 25°C		1.43	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
Can Package		1.2	2.0	Watts
Derate above 25°C		6.86	11.43	mW/°C



Lead 1 identified by square impression on underside of case
All Leads Electrically Isolated from Case

MD6003F
CASE 33 A-02
TO-89

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (1)	h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		40	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		70	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)		30	–	
Collector-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.4	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	8.0	pF
Input Capacitance (V_{EB} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	30	pF

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

MD6100 (SILICON)

Dual NPN-PNP complementary-pair silicon annular transistor designed for complementary circuits where low-level, low-noise amplification is required.





PINS 4 AND 8 OMITTED

Pin Connections, Bottom View

CASE 32 C

MAXIMUM RATINGS (each side)

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current-Continuous	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.83	2.0 11.43	Watts mW/°C

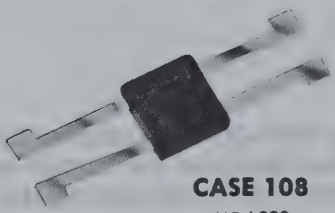
ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.010 10	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 μAdc, V_{CE} = 5 Vdc) (I_C = 100 μAdc, V_{CE} = 5 Vdc) (I_C = 500 μAdc, V_{CE} = 5 Vdc) (I_C = 1 mAdc, V_{CE} = 5 Vdc) (I_C = 10 mAdc, V_{CE} = 5 Vdc)	h_{FE}*	50 100 150 150 125	— — — — —	—
Collector-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$*	— —	0.2 0.25	Vdc
Base-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc) (I_C = 1 mAdc, I_B = 0.1 mAdc)	$V_{BE(sat)}$*	— —	0.7 0.8	Vdc
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5 Vdc)	$V_{BE(on)}$	—	0.7	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5 Vdc, f = 30 MHz)	f_T	30	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	4	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	8	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3k ohms, Noise Bandwidth = 10 Hz to 15 kHz)	NF	—	4	dB

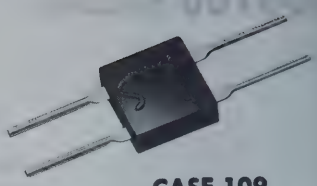
*Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%

SILICON
MINIATURE DIODE ASSEMBLIES

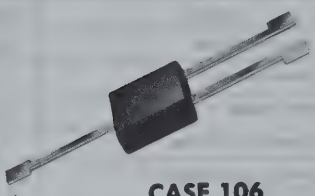
MDA920 series
MDA930 series
MDA940 series
MDA950 series



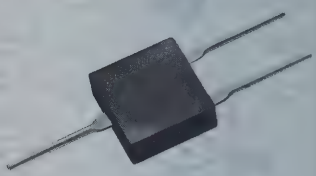
CASE 108
MDA920



CASE 109
MDA920A



CASE 106
MDA930
MDA940
MDA950



CASE 107
MDA930A
MDA940A
MDA950A

Miniature Integral Diode Assemblies (MIDA)are low-current rectifier circuit configurations designed with a high output-current/size ratio for applications where space is at a premium. MIDA packages are available with flat ribbon leads and with round leads. For round leads, add suffix "A" to type number. Example, MDA920A-1.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Value	Unit
Maximum Forward Voltage Drop per Cell (I_F = 500 mA Continuous)	V_F	1.2	Vdc
Maximum Reverse Current* (Figure 2) (V_R = Rated V_{RM}) 25°C 100°C	I_R*	60 600	μAdc

*2 cells in parallel - MDA920 series
1 cell - MDA930, MDA940, and MDA950 series

MECHANICAL CHARACTERISTICS

CASE: Transfer molded plastic encapsulation.

FINISH: All external surfaces are corrosion-resistant, terminals are readily solderable.

POLARITY: Embossed symbol on 4-lead devices.
Terminal designation by color dots on 3-lead devices:
AC input — yellow
+DC output — red
—DC output — white

MOUNTING POSITION: Any.

WEIGHT (approx.): 0.4 gram.

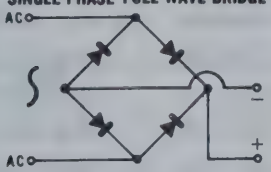
MINIATURE DIODE ASSEMBLIES (continued)

ABSOLUTE MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

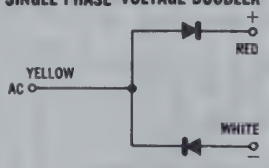
	MOTOROLA TYPE NO.	DEVICE MARKING LETTER SYMBOLS	PEAK REVERSE VOLTAGE PER CELL (DC or RECURRENT) V_{RM} Volts	SINE WAVE RMS INPUT VOLTAGE (LINE to LINE) V_{in} Volts	DC OUTPUT VOLTAGE Res. Load V_{out} Volts	DC OUTPUT VOLTAGE Cap. Load V_{out} Volts	DC OUTPUT CURRENT @ 75°C AMBIENT I_{out} Amp	PEAK FULL WAVE ONE CYCLE SURGE CURRENT NON-REPETITIVE (SINUSOIDAL 60 cps) $I_{FM(surge)}$ Amp	PEAK FULL WAVE REPETITIVE FORWARD CURRENT (NONSINUSOIDAL 60 cps) $I_{FM(rep)}$ Amp
	MDA920-1	BA	25	18	15	25			
	-2	BB	50	35	30	50			
	-3	BC	100	70	62	100			
A	-4	BD	200	140	124	200	1.0	32.0	5.0
	-5	BE	300	210	185	300			
	-6	BF	400	280	250	400			
	-7	BG	600	420	380	600			
	MDA930-1	DA	25	9	—	25			
	-2	DB	50	18	—	50			
	-3	DC	100	35	—	100			
B	-4	DD	200	70	—	200	0.5	32.0	5.0
	-5	DE	300	105	—	300			
	-6	DF	400	140	—	400			
	-7	DG	600	210	—	600			
	MDA940-1	CA	25	9	8	13			
	-2	CB	50	18	15	25			
	-3	CC	100	35	30	50			
C	-4	CD	200	70	62	100	1.0	32.0	5.0
	-5	CE	300	105	92	150			
	-6	CF	400	140	125	200			
	-7	CG	600	210	190	300			
	MDA950-1	CJ	25	9	8	13			
	-2	CK	50	18	15	25			
	-3	CL	100	35	30	50			
D	-4	CM	200	70	62	100	1.0	32.0	5.0
	-5	CN	300	105	92	150			
	-6	CP	400	140	125	200			
	-7	CR	600	210	190	300			

SCHEMATIC DIAGRAM

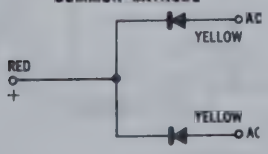
A — SINGLE PHASE FULL WAVE BRIDGE



B — SINGLE PHASE VOLTAGE DOUBLER



C — SINGLE PHASE CENTER TAP COMMON CATHODE



D — SINGLE PHASE CENTER TAP COMMON ANODE

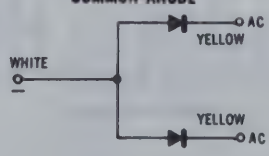


FIGURE 1 — TYPICAL FORWARD CHARACTERISTICS

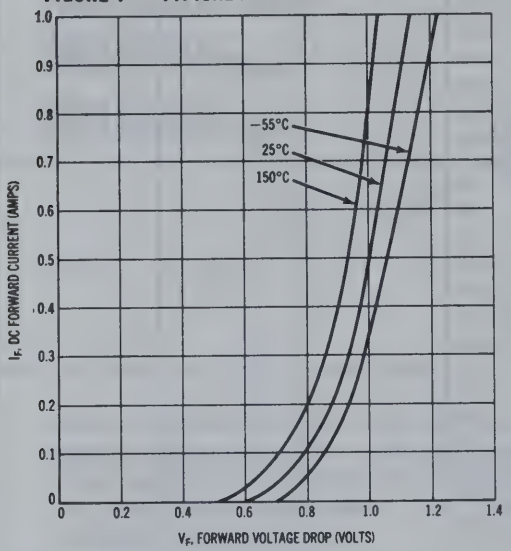


FIGURE 2 — TYPICAL REVERSE CHARACTERISTICS

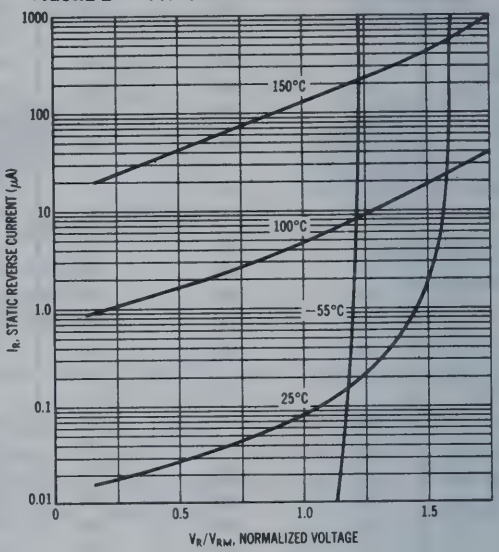


FIGURE 3 — MAX ALLOWABLE SURGE CURRENT

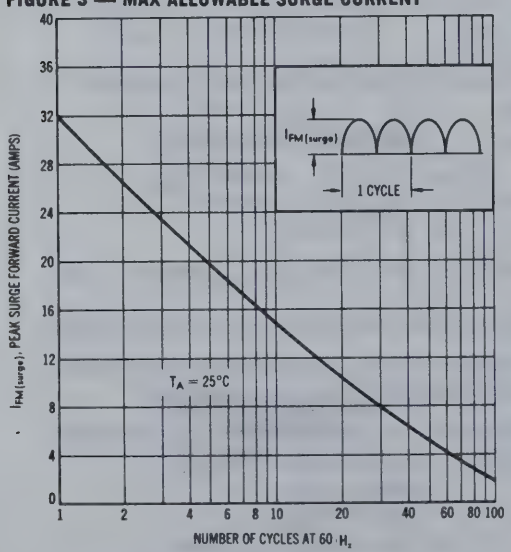
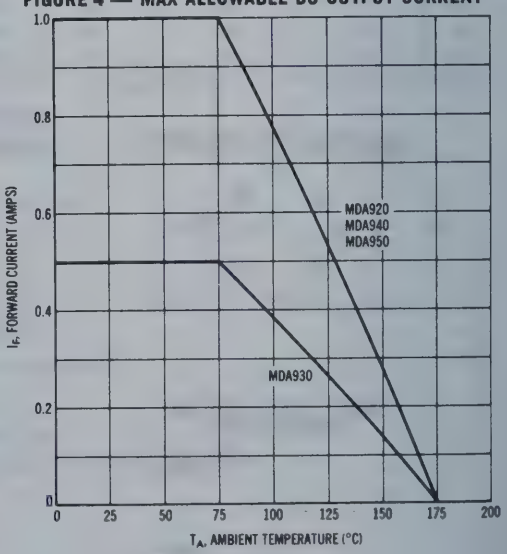


FIGURE 4 — MAX ALLOWABLE DC OUTPUT CURRENT



SILICON
MOLDED ASSEMBLY RECTIFIER BRIDGES

Single-Phase Full-Wave Bridge

MDA942 SERIES (1.5 AMPS DC)
MDA952 SERIES (6.0 AMPS DC)
MDA962 SERIES (10.0 AMPS DC)
MDA972 SERIES (16.0 AMPS DC)
MDA1491 SERIES (1.5 AMPS DC)
MDA1591 SERIES (4.0 AMPS DC)

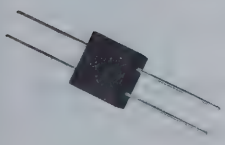
Three-Phase Full-Wave Bridge
MDA1505 SERIES (8.0 AMPS DC)



MDA952
CASE 113



MDA962
CASE 115



MDA942
CASE 110



MDA942A
CASE 111



MDA972
CASE 116



MDA1505
CASE 114



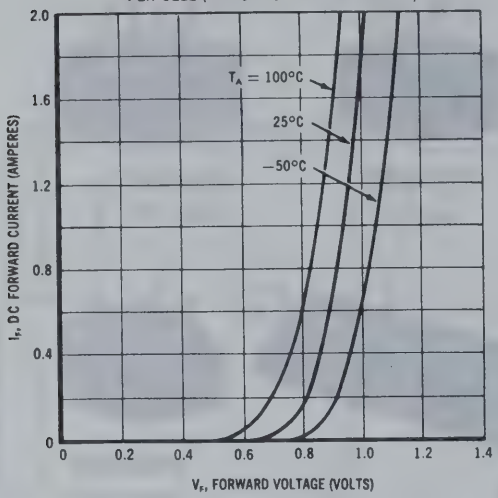
MDA1491
MDA1591
CASE 112

Molded assembly rectifier bridges are individual hermetically sealed rectifiers interconnected and encapsulated in molded assemblies for use as single-phase and three-phase full-wave bridge configurations, with output current from 1.5 to 16 amps, peak reverse voltage from 50 to 600 volts.

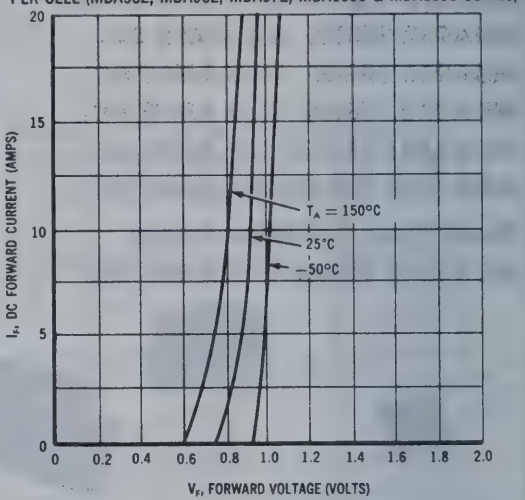
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Value	Unit
Maximum Forward Voltage Drop per Cell		V_F		Vdc
(I_F = 0.75 Adc)	MDA942 series		1.1	
(I_F = 3.0 Adc)	MDA952 series		1.0	
(I_F = 5.0 Adc)	MDA962 series		1.0	
(I_F = 5.0 Adc)	MDA972 series		1.0	
(I_F = 0.75 Adc)	MDA1491 series		1.1	
(I_F = 4.0 Adc)	MDA1505 series		1.0	
(I_F = 2.0 Adc)	MDA1591 series		1.0	
Maximum Reverse Current per Cell		I_R		mAdc
(V_R = Rated V_{RM})	MDA942 series		0.01	
	MDA952 series		1.0	
	MDA962 series		1.0	
	MDA972 series		1.0	
	MDA1491 series		0.01	
	MDA1505 series		1.0	
	MDA1591 series		1.0	

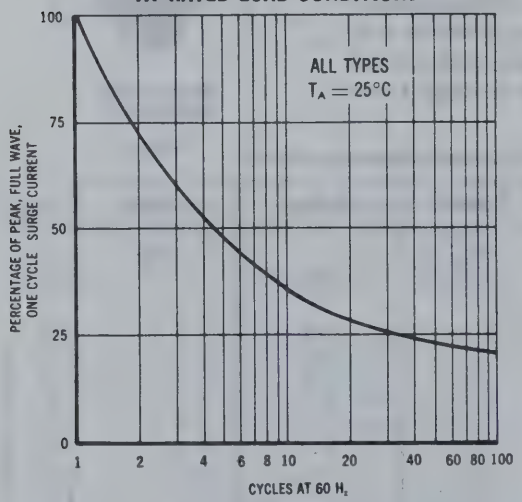
TYPICAL FORWARD CHARACTERISTICS
PER CELL (MDA942 & MDA1491 SERIES)



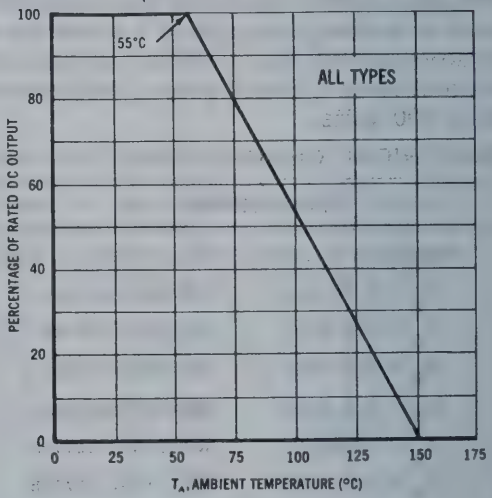
TYPICAL FORWARD CHARACTERISTICS
PER CELL (MDA952, MDA962, MDA972, MDA1505 & MDA1591 SERIES)



MAXIMUM ALLOWABLE FULL WAVE SURGE CURRENT AT RATED LOAD CONDITIONS



MAXIMUM ALLOWABLE DC OUTPUT
(RESISTIVE OR INDUCTIVE LOAD)



MECHANICAL CHARACTERISTICS

CASE: Molded plastic encapsulation, hermetically sealed individual rectifier cells.

FINISH: All external surfaces are corrosion-resistant, terminals are readily solderable.

POLARITY: Terminal designation by color dots:
AC input — yellow
+DC output — red
−DC output — not marked

MOUNTING POSITION: Any

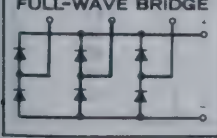
WEIGHT (approx.):
MDA942, MDA942A — 3.8 grams
MDA952 — 35 grams
MDA962, MDA1505 — 92 grams
MDA972 — 340 grams
MDA1491 — 33 grams
MDA1591 — 39 grams

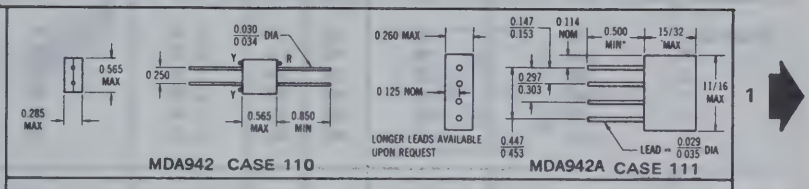
RECTIFIER BRIDGES (continued)

SINGLE-PHASE FULL-WAVE BRIDGE

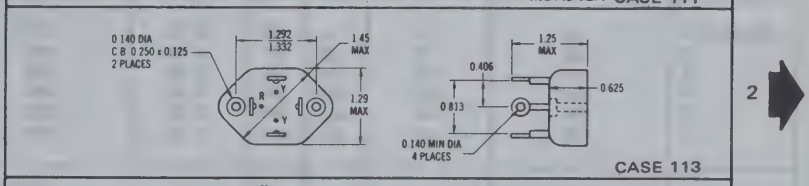


THREE-PHASE FULL-WAVE BRIDGE

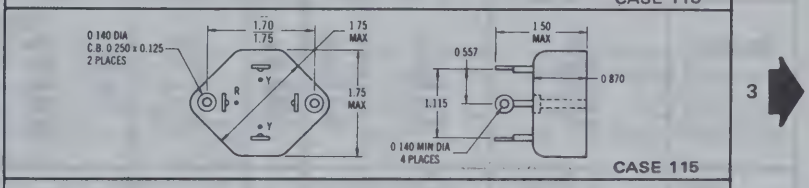




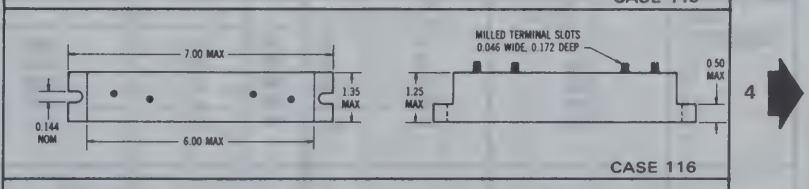
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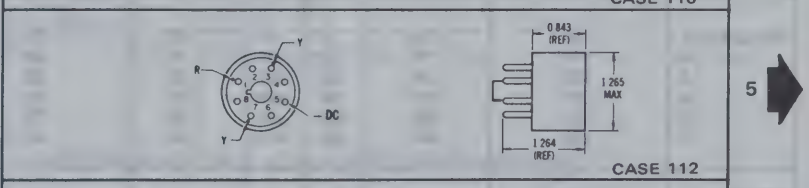
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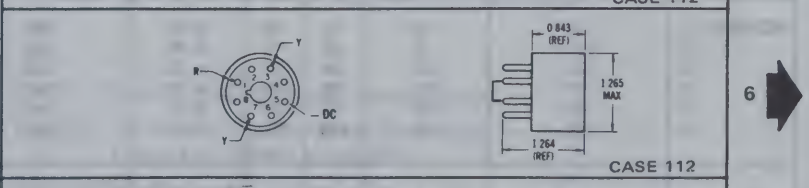
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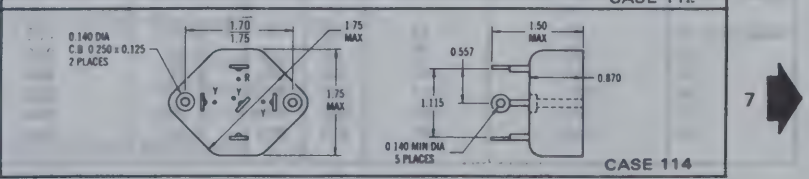
4



5



6



7

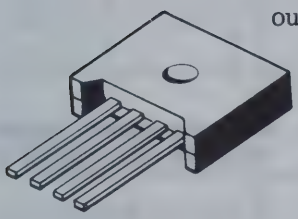
MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

	TYPE NO.	PEAK REVERSE VOLTAGE PER CELL (DC or RECURRENT) Volts	SINE WAVE RMS INPUT VOLTAGE (LINE to LINE) Volts	DC OUTPUT VOLTAGE		DC OUTPUT CURRENT @ 55°C AMBIENT Amps	PEAK FULL WAVE ONE CYCLE SURGE CURRENT (60 Hz) Amps	PEAK FULL WAVE RECURRENT FORWARD CURRENT (60 Hz) Amps
				Res. Load Volts	Cap. Load Volts			
1	MDA942-1	50	35	30	50	1.50	25	6.0
	-2	100	70	62	100	1.50	25	6.0
	-3	200	140	124	200	1.50	25	6.0
	-4	300	210	185	300	1.50	25	6.0
	-5	400	280	250	400	1.50	25	6.0
	-6	600	420	380	600	1.50	25	6.0
2	MDA952-1	50	35	30	50	6.00	150	35
	-2	100	70	62	100	6.00	150	35
	-3	200	140	124	200	6.00	150	35
	-4	300	210	185	300	6.00	150	35
	-5	400	280	250	400	6.00	150	35
	-6	600	420	380	600	6.00	150	35
3	MDA962-1	50	35	30	50	10.0	250	60
	-2	100	70	62	100	10.0	250	60
	-3	200	140	124	200	10.0	250	60
	-4	300	210	185	300	10.0	250	60
	-5	400	280	250	400	10.0	250	60
4	MDA972-1	50	35	30	50	16.0	250	60
	-2	100	70	62	100	16.0	250	60
	-3	200	140	124	200	16.0	250	60
	-4	300	210	185	300	16.0	250	60
	-5	400	280	250	400	16.0	250	60
5	MDA1491-1	50	35	30	50	1.50	25	6.0
	-2	100	70	62	100	1.50	25	6.0
	-3	200	140	124	200	1.50	25	6.0
	-4	300	210	185	300	1.50	25	6.0
	-5	400	280	250	400	1.50	25	6.0
	-6	600	420	380	600	1.50	25	6.0
6	MDA1591 -1	50	35	30	50	4.00	100	25
	-2	100	70	62	100	4.00	100	25
	-3	200	140	124	200	4.00	100	25
	-4	300	210	185	300	4.00	100	25
	-5	400	280	250	400	4.00	100	25
	-6	600	420	380	600	4.00	100	25
7	MDA1505 -1	50	35	47	50	8.00	200	45
	-2	100	70	95	100	8.00	200	45
	-3	200	140	190	200	8.00	200	45
	-4	300	210	285	300	8.00	200	45
	-5	400	280	380	400	8.00	200	45
	-6	600	420	570	600	8.00	200	45

Maximum Operating and Storage Temperature: -65°C to +150°C (All Types)

MDA960 series (SILICON)
(2.5 Adc)
MDA970 series
(4.0 Adc)

Miniature integral diode assemblies diffused silicon dice interconnected and transfer molded into rectifier circuit assemblies for use in applications where high output-current size ratio is of prime importance.



CASE 117



MAXIMUM RATINGS

Type No.	Peak Reverse Voltage Per Cell (DC or Recurrent) $V_{RM(rep)}$ Volts	Sine Wave RMS Input Voltage (Line to Line) V_R Volts	DC Output Voltage		DC Output Current @ 55°C Ambient I_o Amps (1)	Peak Full Wave One Cycle Surge Current (60 Hz) $I_{FM(surge)}$ Amps (2)	Peak Full-Wave Repetitive Forward Current (Nonsinusoidal 60 Hz) $I_{FM(rep)}$ Amps
			Res. Load Volts	Cap. Load Volts			
MDA960 -1	50	35	30	50	2.5	100	15
-2	100	70	62	100	2.5	100	15
-3	200	140	124	200	2.5	100	15
MDA970 -1	50	35	30	50	4.0	150	25
-2	100	70	62	100	4.0	150	25
-3	200	140	124	200	4.0	150	25

(1) See Fig. 2 (2) See Fig. 4 Maximum Operating and Storage Temperature: -65°C to +150°C (All Types)

MECHANICAL CHARACTERISTICS

CASE: Transfer-molded plastic encapsulation.

FINISH: All external surfaces are corrosion-resistant. Leads are readily solderable.

POLARITY: Embossed symbols

AC input = ~
+DC output = +
-DC output = -

MOUNTING POSITION: Any

WEIGHT (approx.): 7.5 grams

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Value	Unit
Maximum Forward Voltage Drop per Cell (I_F = 1.25 Adc) MDA960 (I_F = 2.0 Adc) MDA970	V_F	1.0	Vdc
Maximum Reverse Current per Cell (V_R = Rated V_{RM})	I_R	1.0	mA

FIGURE 1 — TYPICAL FORWARD VOLTAGE CHARACTERISTICS (PER CELL)

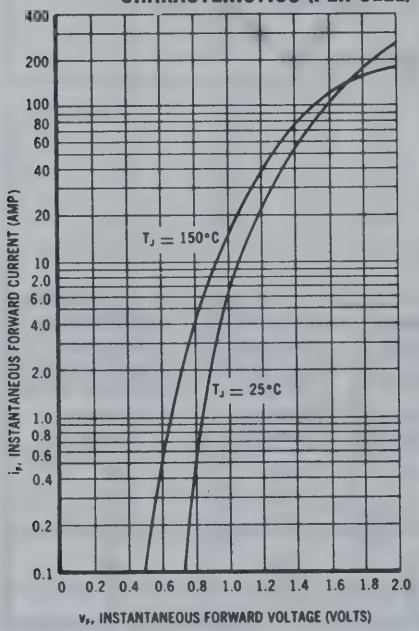


FIGURE 2 — MAXIMUM CURRENT RATING (RESISTIVE OR INDUCTIVE LOAD)

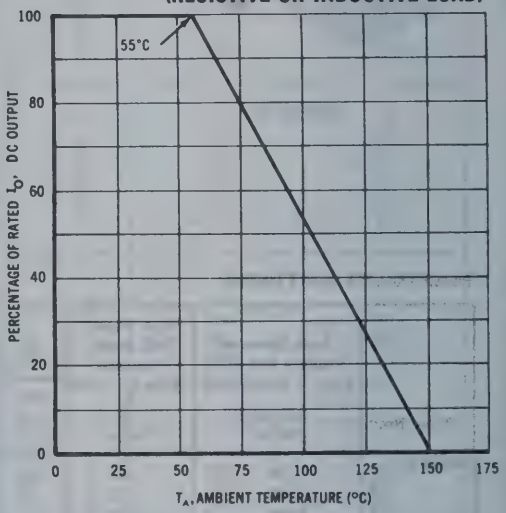


FIGURE 3 — TYPICAL RECTIFICATION EFFICIENCY

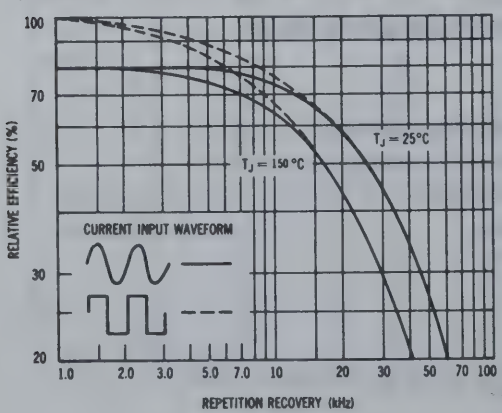
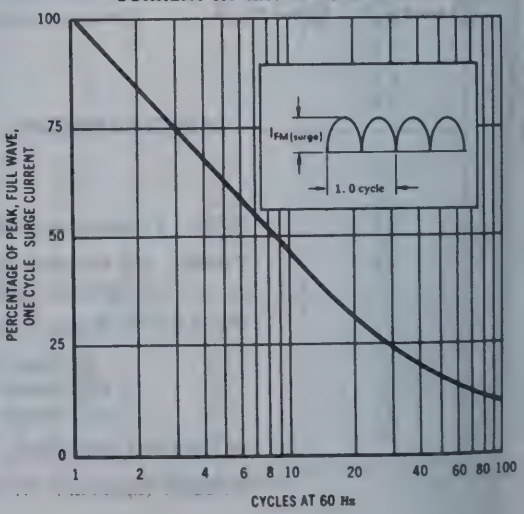


FIGURE 4 — MAXIMUM ALLOWABLE FULL-WAVE SURGE CURRENT AT RATED LOAD CONDITIONS



MDA980-1 thru MDA980-6 (SILICON)
MDA990-1 thru MDA990-6



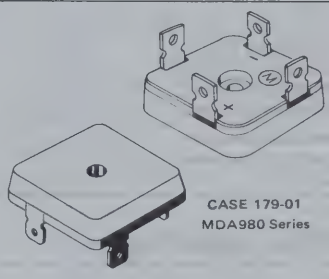
SINGLE-PHASE
FULL-WAVE BRIDGE

12 and 27 AMPERES
50 thru 600 VOLTS

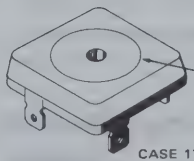
MINIATURE INTEGRAL DIODE ASSEMBLIES

. . . passivated, diffused silicon dice interconnected and transfer molded into voidless hybrid rectifier circuit assemblies. The MDA990 series incorporates an electrically insulated aluminum disc for improved heat dissipation when mounted directly on a metal chassis or heat sink.

- Large surge capability – 300 A (For 1/2 cycle)
- Efficient Thermal Management Provides Maximum Power Handling in Minimum Space



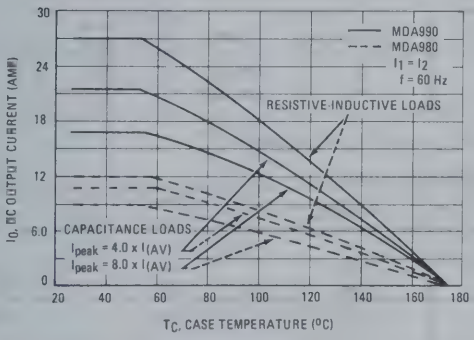
CASE 179-01
MDA980 Series



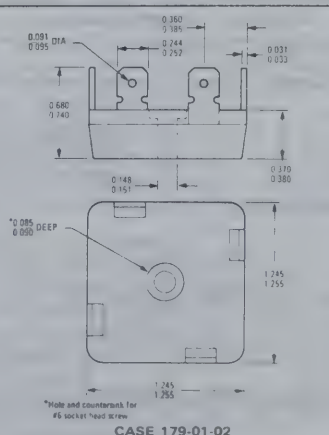
CASE 179-02
MDA 990 Series

MAXIMUM CIRCUIT RATINGS

FIGURE 1 – CURRENT DERATING **



**Case temperature is measured at the interface of the bottom of the case and heat sink.



CASE 179-01-02

MECHANICAL CHARACTERISTICS

CASE: Transfer-molded plastic encapsulation.

POLARITY: Terminal-designation embossed on case
+DC output
-DC output
AC not marked

MOUNTING POSITION: Bolt down-highest heat transfer efficiency accomplished through the surface opposite the terminals.

WEIGHT: MDA980 – 21 grams (approx)
MDA990 – 22.5 grams (approx)

TERMINALS: Suitable for fast-on connections, readily solderable connections, corrosion resistant.

MOUNTING TORQUE: 20 in. lb. Max

MAXIMUM RATINGS

Rating (Per Leg)	Symbol	-1	-2	-3	-4	-5	-6	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$	50	100	200	300	400	600	Volts
DC Blocking Voltage	V_R	50	100	200	300	400	600	Volts
DC Output Voltage Resistive Load Capacitive Load	 Vdc Vdc	 30 50	 62 100	 124 200	 185 300	 250 400	 380 600	 Volts Volts
Sine Wave RMS Input Voltage (Line to Line)	V_r	35	70	140	210	280	420	Volts
DC Output Current @ T_C = +55°C MDA980 MDA990	I_O I_O	12 27						Amp Amp
Peak Full Wave One Cycle Surge Current (60 Hz Non-Repetitive, @ Rated Conditions), Figure 4	I_{FM} (surge)	300 (for 1/2 Cycle)						Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175						°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Type	Value Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	MDA980 MDA990	18 7.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Value Max	Unit
Maximum Forward Voltage Drop (Per Leg) MDA980 – I_F = 6.0 Adc MDA990 – I_F = 13.5 Adc	 V_F V_F	 1.0 1.0	 Vdc Vdc
Maximum Reverse Current (Across ac terminals) MDA980 and MDA990 @ Rated V_{RM}	I_R	0.5	mAdc

FIGURE 2 – CURRENT VERSUS AMBIENT TEMPERATURE

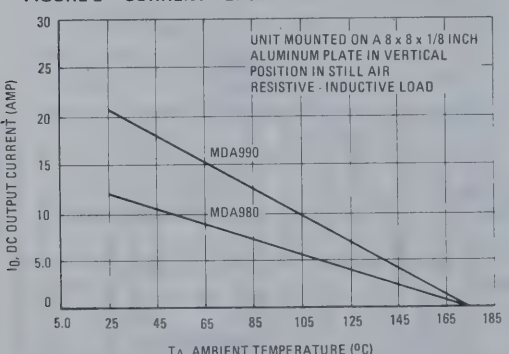


FIGURE 3 – MAXIMUM SURGE CAPABILITY

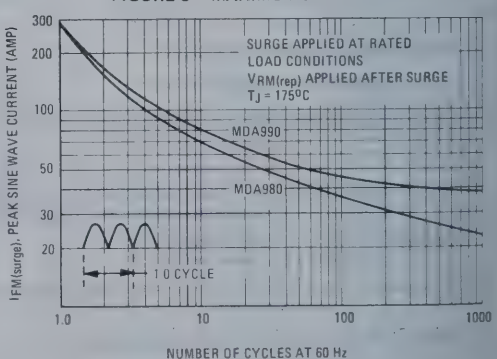


FIGURE 4 – TYPICAL THERMAL RESPONSE

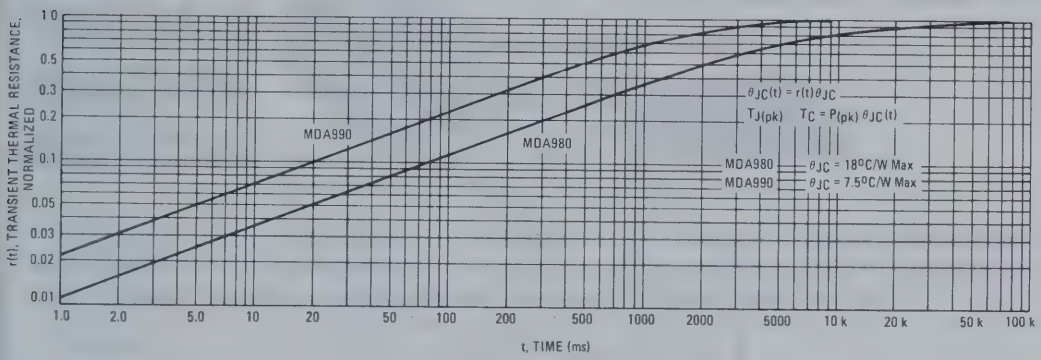


FIGURE 5 – NORMALIZED EFFECTIVE THERMAL RESISTANCE

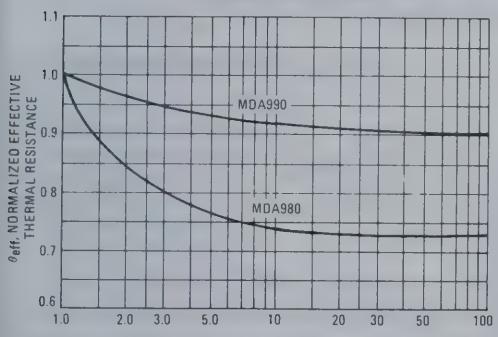
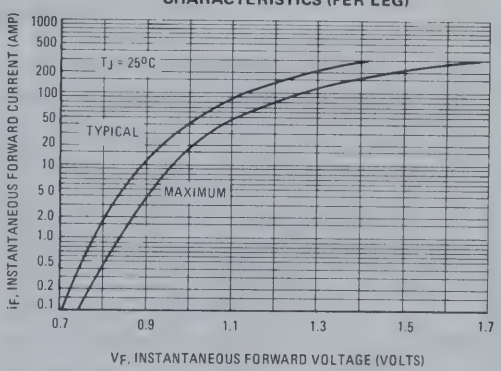


FIGURE 6 – FORWARD VOLTAGE CHARACTERISTICS (PER LEG)



Application of "Effective Thermal Resistance"

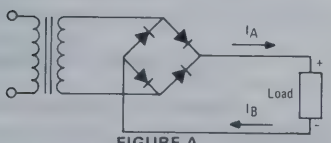


FIGURE A

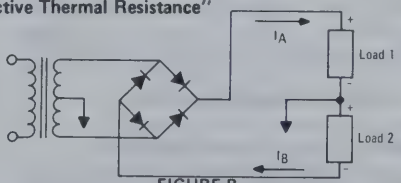


FIGURE B

There are two basic circuit configurations in which the bridge rectifier can be used. The standard bridge circuit of Figure A has one load with currents I_A and I_B equal. This is the configuration used for the information presented in Figure 3 (maximum surge capability), and in Figure 1 and 2 (current derating, resistive, inductive and capacitive loads). The circuit of Figure B utilizes a center-tapped transformer with two loads and current I_A is not necessarily equal to I_B. (Please note: I_A and I_B are the average currents, not the instantaneous currents). Due to the thermal coupling between the rectifier legs within the bridge, the effective thermal resistance of a rectifier leg will vary as the ratio of I_A to I_B is changed. Figure 5 shows normalized effective thermal resistance versus I_1/I_2, where I_1 is the larger of the two currents I_A and I_B.

By using Figure 5 and Figure 1, the capability of the bridge can be determined for conditions other than $I_1 = I_2$ (or $I_A = I_B$) using the relationship:

$$T_C' = T_{J(Max)} \quad (1-\theta_{eff}) + \theta_{eff}\, T_C$$

where $T_{J(Max)}$ = maximum operating junction, temperature
θ_{eff} = normalized effective thermal resistance as shown in Figure 5.

T_C = Case temperature determined from Figure 1 and the value of I_1,
T_C' = true allowable case temperature for the particular I_1 and I_1/I_2 ratio.

For example: using an MDA980 device to determine the allowable case temperature for $I_A = 9.0$ A and $I_B = 3.0$ A (resistive load). Then

$I_1/I_2 = 9/3 = 3.0$
$\theta_{eff} = 0.8$ as shown in Figure 5
From Figure 1, $I_A = I_1 = 9.0$ A,
Therefore: $T_C = 93^oC$.
$T_C' = 175\ (1-0.8) + (0.8)\ (93)$
$T_C' = 35 + 74$
$T_C' = 109^oC$

Thus the allowable case temperature has been increased from 93^oC for $I_1 = I_2 = 9.0$ A to 109^oC for $I_1 = 9.0$ A, $I_2 = 3.0$ A.

TYPICAL DYNAMIC CHARACTERISTICS (PER LEG)

FIGURE 7 – FORWARD VOLTAGE TEMPERATURE COEFFICIENTS

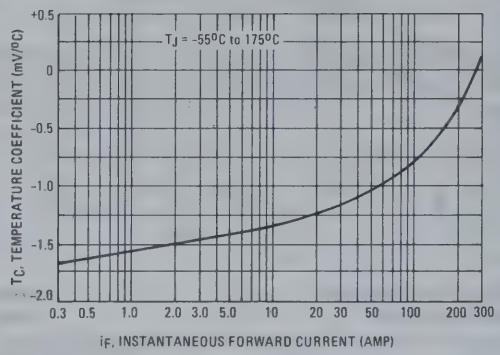


FIGURE 8 – REVERSE RECOVERY TIME

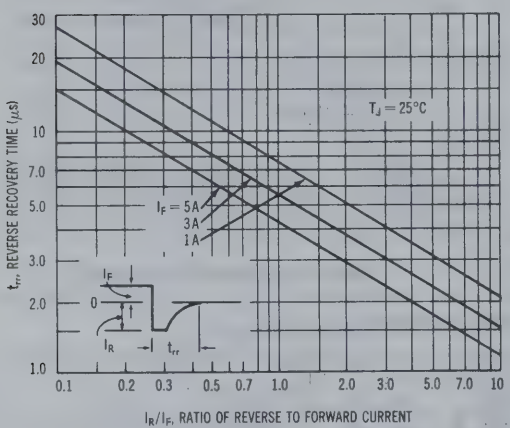


FIGURE 9 – FORWARD RECOVERY TIME

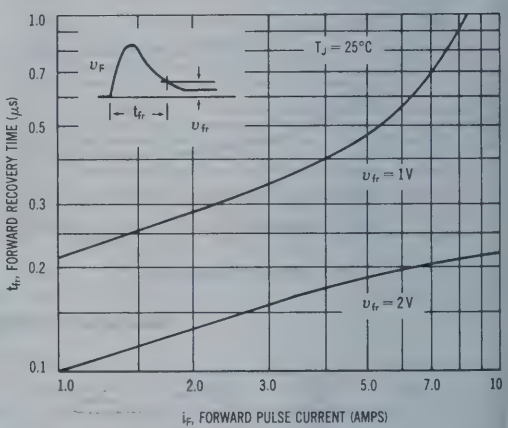


FIGURE 10 – RECTIFICATION EFFICIENCY

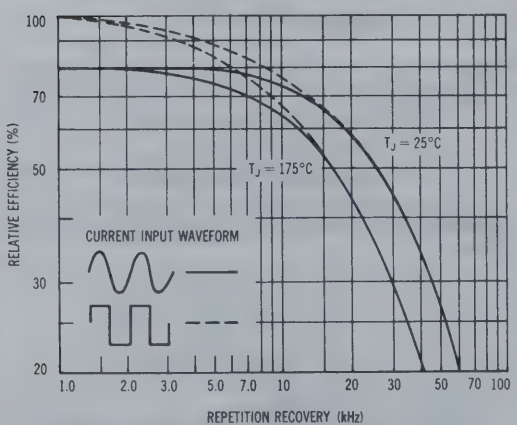
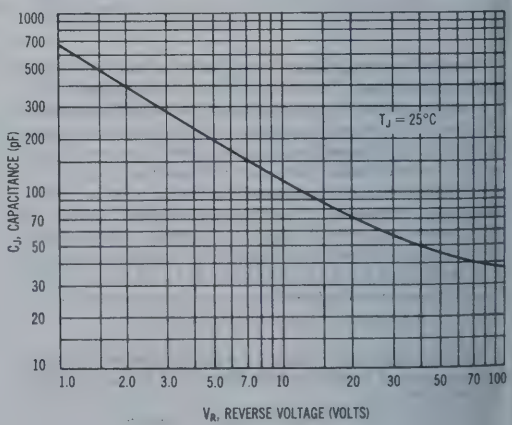


FIGURE 11 – JUNCTION CAPACITANCE

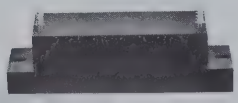


HIGH VOLTAGE SILICON RECTIFIER MOLDED ASSEMBLIES

MDA1330H
MDA1331H
MDA1332H
MDA1333H



I_O — to 2.5 A
$V_{RM(rep)}$ = 5000 and 10,000 VOLTS



Compensated series-connected rectifier cells for high-voltage, single-phase, half-wave circuit applications. Each cell in the series string is shunted by a high-voltage capacitor and resistor for equal voltage distribution.

NOTES:

1. MDA1330H and MDA1331H, add suffix "C" for common cathode, "U" for common anode, "D" for voltage doubler.
2. MDA1332H and MDA1333H, reverse polarity available by adding suffix "R".

MAXIMUM RATINGS

Rating	Symbol	MDA1330H	MDA1331H	MDA1332H	MDA1333H	Units
Peak Repetitive Reverse Voltage ① (Rated Current, Over Operating Temperature Range)	$V_{RM(rep)}$	5,000	10,000	5,000	10,000	Volts
RMS Reverse Voltage (Rated Current Over the Complete Operating Temperature Range)	V_r	3,500	7,000	3,500	7,000	Volts
DC Blocking Voltage ② (Over Operating Temperature Range)	V_R	3,000	6,000	3,000	6,000	Volts
Average Half Wave Rectified Forward Current (Resistive Load, 180° Conduction Angle, 60cps, Free Convection Cooling) T_A = 40°C	I_O	1.0	1.0	2.5	2.5	Amps
T_A = 100°C		0.3	0.3	0.5	0.5	
Peak 1 Cycle Surge Current (T_A = 40°C, Superimposed on Rated Current at Rated Voltage)	$I_{FM(surge)}$	25	25	250	250	Amps
Operating Frequency Range	DC to 400					cps
Operating and Storage Temperature Range	-55 to +110					°C

① $V_{RM(rep)}$ ratings of 5,000 or 10,000 volts peak are both the maximum repetitive and non-repetitive ratings. Where voltage transient suppression is employed, these assemblies can be reliably operated at the maximum ratings.

② The DC Blocking Voltage rating (V_R), is established by the continuous power dissipation ratings of the shunting resistors and is not a function of the series rectifiers.

ELECTRICAL CHARACTERISTICS

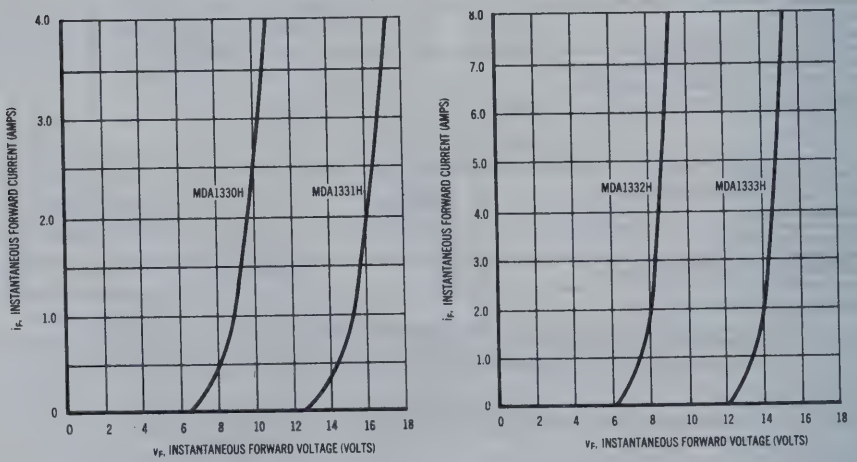
Rating	Symbol	MDA1330H	MDA1331H	MDA1332H	MDA1333H	Units
Maximum Full-Cycle Average Forward Voltage Drop (Half-Wave, Resistive Load, Rated Current and Voltage, T_A=40°C)	$V_{F(AV)}$	5.0	10.0	5.0	10.0	Volts
Maximum Full-Cycle Average Reverse Current (Half-Wave, Resistive Load, Rated Current and Voltage, T_A=40°C)	$I_{R(AV)}$	0.2	0.2	3.0	3.0	mA

Note: Ambient temperatures are measured at the cold air source point i.e. immediately below the rectifier legs under convection cooling and on the cool air side with forced air cooling.

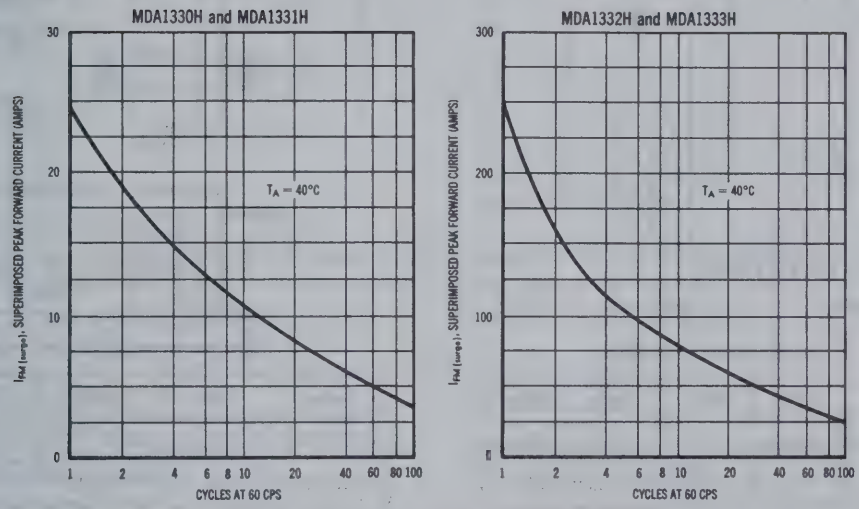
ELECTRICAL DESIGN NOTES

1. For single-phase, full-wave circuits using "Series 1300" stacks, multiply the current ratings given for the half-wave by two.
2. For three-phase, full-wave and half-wave circuits, multiply given current ratings for single-phase, half-wave by two and one half.
3. For capacitive loads, sufficient surge and capacitor inrush current protection must be employed. Recurrent peak currents up to six times the single-phase average output-current ratings can be safely sustained when the average value of these peaks are held at or below the rated average output. Non-repetitive peak currents must be held to the maximum surge ratings.

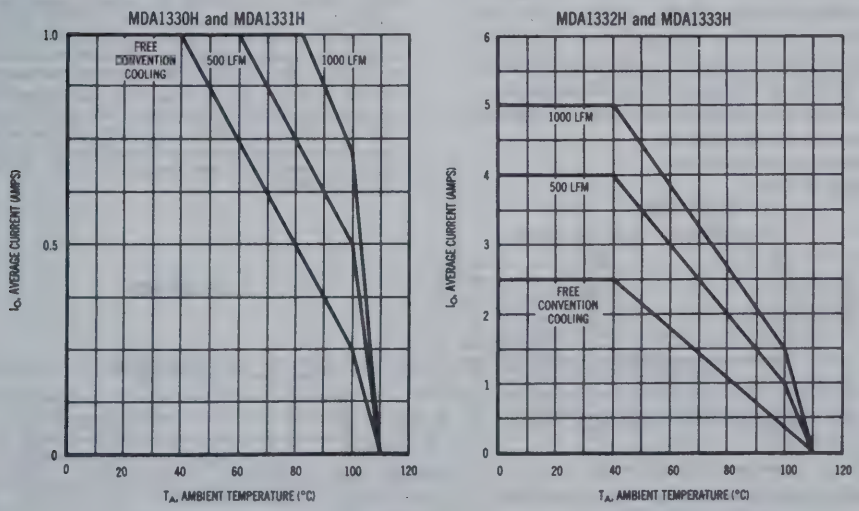
TYPICAL FORWARD CHARACTERISTICS
($T_J = 25°C$)



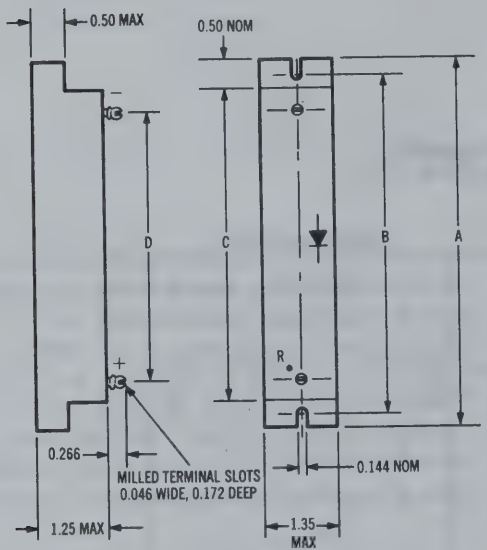
MAXIMUM SURGE CURRENT
RATED CONDITIONS



MAXIMUM AVERAGE HALF-WAVE RECTIFIED CURRENT
(RESISTIVE OR INDUCTIVE LOAD, 180° CONDUCTION ANGLE, 60 CPS)



MECHANICAL DESIGN INFORMATION AND OUTLINE DIMENSIONS FOR THE BASIC MDA1330H AND MDA1331H RECTIFIER LEGS.

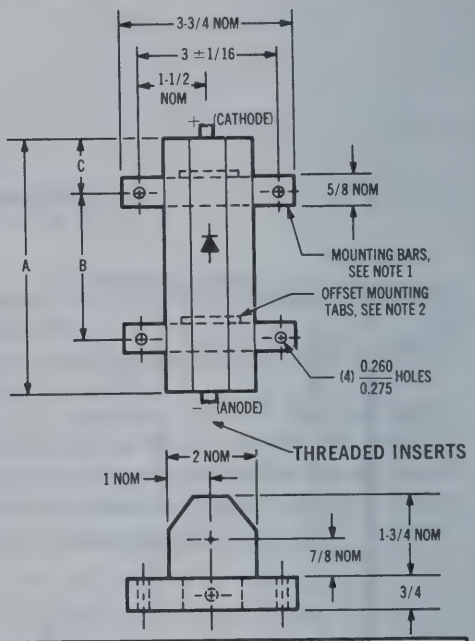


POLARITY DOTS: RED = +DC OUTPUT

Device	A Dim	B Dim	C Dim	D Dim
MDA1330H	4.25max	3.70±0.05	3.25max	3.00nom
MDA1331H	7.00max	6.39±0.05	6.00max	5.25nom

NOTES: These basic rectifier legs are suitable for chassis mounting and connection into multiple leg circuits. Center tapped versions of the MDA1330H and MDA1331H are also available for use in lower voltage, Center tapped and Voltage Doubler applications. The center tapped versions of the MDA1330H and MDA1331H are designated by a different suffix letter as follows: instead of "H" specify
"C" for common cathode, center tap
"U" for common anode, center tap
"D" for voltage doubler.

MECHANICAL DESIGN INFORMATION AND OUTLINE DIMENSIONS FOR THE BASIC MDA1332H AND MDA1333H RECTIFIER LEGS.

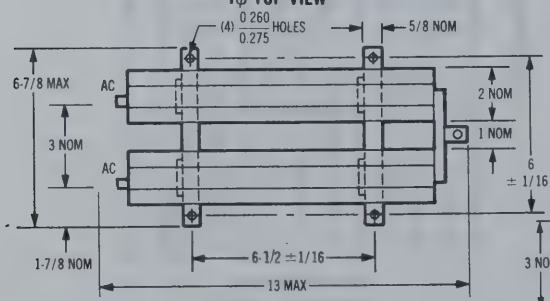


Device	A Dim	B Dim	C Dim
MDA1332H	5-5/8 nom	3-1/4 1/16	1-1/8 nom
MDA1333H	11-1/4 nom	6-1/2±1/16	2-3/8 nom

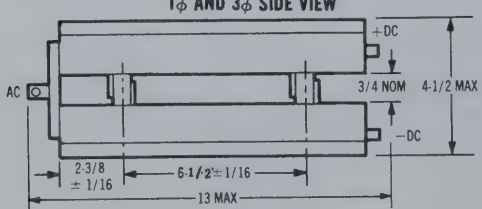
NOTE 1. Insulated mounting bars are supplied with all Series 1300 stacks and the single unit bar is shown above. For multiple leg circuits, mounting bars are available in lengths suitable for 2 or 3 legs mounted side by side. In addition, the mounting arrangement used is also suitable for mounting legs top and bottom on the same bar with stand-offs employed for support of the assembly.

NOTE 2. Offset mounting taps are used to provide more compact multiple leg assemblies. When top & bottom or side by side mounting is employed, reverse polarity legs are often required in some circuits. Legs of reverse polarity to that shown above are designated by an "R" suffix, i.e. MDA1332HR.

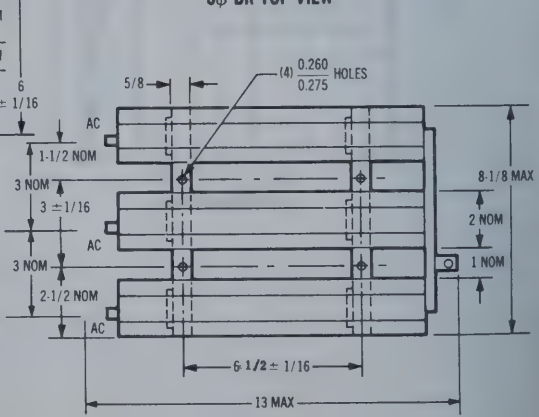
1φ TOP VIEW



1φ AND 3φ SIDE VIEW



3φ BR TOP VIEW



MF3304 (SILICON)



CASE 20
(TO-72)

PNP silicon epitaxial transistor designed for low-level, high-speed switching applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	18	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μA, I_B = 0)	BV_{CBO}	18	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μA, I_B = 0)	BV_{CES}	12	—	—	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 10 mA, I_B = 0)	$V_{CEO(sus)}$*	12	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)	BV_{EBO}	5	—	—	Vdc

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 9 V, I_E = 0)	I_{CBO}	—	—	10	nA
Collector Reverse Current (V_{CE} = 6 V, V_{EB} = 0)	I_{CES}	—	—	10	nA
(V_{CE} = 6 V, V_{EB} = 0, 150°C)		—	—	10	μA
Collector-Emitter Saturation Voltage (I_C = 1.0 mA, I_B = 0.1 mA)	$V_{CE(sat)}$	—	—	0.15	Vdc
(I_C = 10 mA, I_B = 1.0 mA)		—	—	0.16	
(I_C = 10 mA, I_B = 1.0 mA, 125°C)		—	—	0.23	
(I_C = 50 mA, I_B = 5.0 mA)		—	—	0.50	
Base-Emitter Saturation Voltage (I_C = 1.0 mA, I_B = 0.1 mA)	$V_{BE(sat)}$	0.7	—	0.8	Vdc
(I_C = 10 mA, I_B = 1.0 mA)		0.8	—	0.9	
(I_C = 50 mA, I_B = 5.0 mA)		—	—	1.2	
DC Current Gain (I_C = 1.0 mA, V_{CE} = -0.3 V)	h_{FE}	20	—	—	
(I_C = 10 mA, V_{CE} = -0.3 V)		30	—	120	
(I_C = 10 mA, V_{CE} = -0.3 V, -55°C)		15	—	—	
(I_C = 50 mA, V_{CE} = -1.0 V)		20	—	—	
High-Frequency Current Gain (I_C = 10 mA, V_{CE} = -5.0 V, f = 100 MHz)	h_{fe}	6.0	—	—	—
Output Capacitance** (V_{CB} = -5.0 V, I_E = 0, f = 140 kHz)	C_{ob}**	—	—	2.5	pF
Emitter Transition Capacitance (V_{EB} = -0.5 V, I_C = 0, f = 140 kHz)	C_{TE}	—	—	2.5	pF
Collector-Base Time Constant (V_{CB} = 10 V, I_C = 10 mA, f = 31.8 MHz)	$r_b'C_c$	—	—	40	ps
Charge Storage Time ($I_C \approx I_{B1} \approx I_{B2} \approx$ -10 mA)	t_s	—	—	30	ns
Turn-On Time ($I_C \approx$ 10 mA, $I_{B1} \approx$ 0.5 mA)	t_{on}	—	—	60	ns
Turn-Off Time ($I_C \approx$ 10 mA, $I_{B1} \approx I_{B2} \approx$ -0.5 mA)	t_{off}	—	—	60	ns

TYPICAL AMPLIFIER PERFORMANCE

Noise Figure (V_{CE} = 10 V, I_C = 2 mA, f = 60 MHz, R_S = 200 ohms)	NF	—	2.7	—	dB
AC Current Gain (V_{CE} = 10 V, I_C = 2 mA, f = 1 kHz)	h_{fe}	—	70	—	—
Current Gain — Bandwidth Product (V_{CE} = 10 V, I_C = 2 mA, f = 100 MHz)	f_T	—	700	—	MHz
Collector-Base Time Constant (V_{CB} = 10 V, I_C = 2 mA)	$r_b'C_c$	—	15	—	ps

**Measured in guarded circuit
*Pulse Conditions: PW ≤ 300 μs, Duty Cycle ≤ 2%

MFE2000 (SILICON)
MFE2001

Silicon N-channel junction field-effect transistor designed for VHF/UHF amplifier applications.



CASE 20 (1)
(TO-72)

Active elements isolated from case

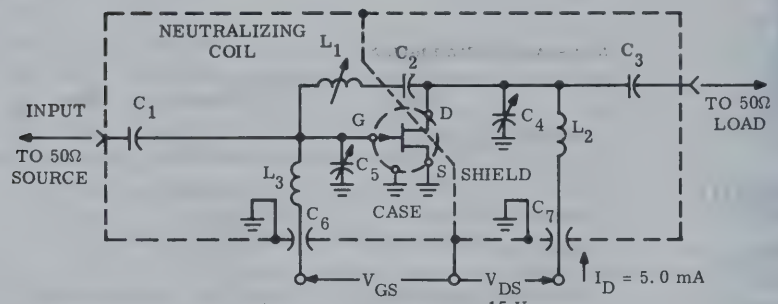
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = -1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	-	-	Vdc
Gate-Source Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)	MFE2000 MFE2001	V_{GS}	0.5 3.0	- -	4.0 7.5	Vdc
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0)		I_{GSS}	-	-	100	pAdc
(V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 150°C)			-	-	200	nAdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	MFE2000 MFE2001	I_{DSS}	4.0 8.0	- -	10 20	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	MFE2000 MFE2001	$\|y_{fs}\|$	2500 4000	- -	6000 8000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	MFE2000 MFE2001	$\|y_{os}\|$	- -	- -	50 75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	-	5.0	pF
Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	-	-	2.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	-	1.0	pF
Small-Signal Power Gain (Figure 1) (V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz)		G_{ps}	18	23	-	dB
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz)			10	14	-	
Noise Figure (Figure 1) (V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 100 MHz, R_G = 1.0 k ohm)		NF	-	1.6	2.0	dB
(V_{DS} = 15 Vdc, I_D = 4.0 mAdc, f = 400 MHz, R_G = 1.0 k ohm)			-	3.3	4.0	

FIGURE 1 — 100 MHz and 400 MHz NEUTRALIZED AMPLIFIER



NOTE:

The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

ADJUST V_{GS} FOR I_D = 5.0 mA
V_{GS} < 0 VOLTS

Reference Designation	VALUE	
	100 MHz	400 MHz
C_1	7.0 pF	1.8 pF
C_2	1000 pF	27 pF
C_3	3.0 pF	1.0 pF
C_4	1-12 pF	0.8-8.0 pF
C_5	1-12 pF	0.8-8.0 pF
C_6	0.0015 μF	0.001 μF
C_7	0.0015 μF	0.001 μF
L_1	3.0 μH*	0.2 μH**
L_2	0.25 μH*	0.03 μH**
L_3	0.14 μH*	0.022 μH**

* L_1 17 turns (approximately - depending on circuit layout), AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L_2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I. D.

L_3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I. D.

** L_1 6 turns approximately -(depending on circuit layout), AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L_2 1 turn, AWG #16 enameled copper wire, 3/8" I. D.

L_3 1/2 turn, AWG #16 enameled copper wire, 1/4" I. D.

MFE2004 (SILICON)
MFE2005
MFE2006

Silicon N-channel depletion mode (Type A) junction field-effect transistors designed for chopper applications.



CASE 22(4)
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

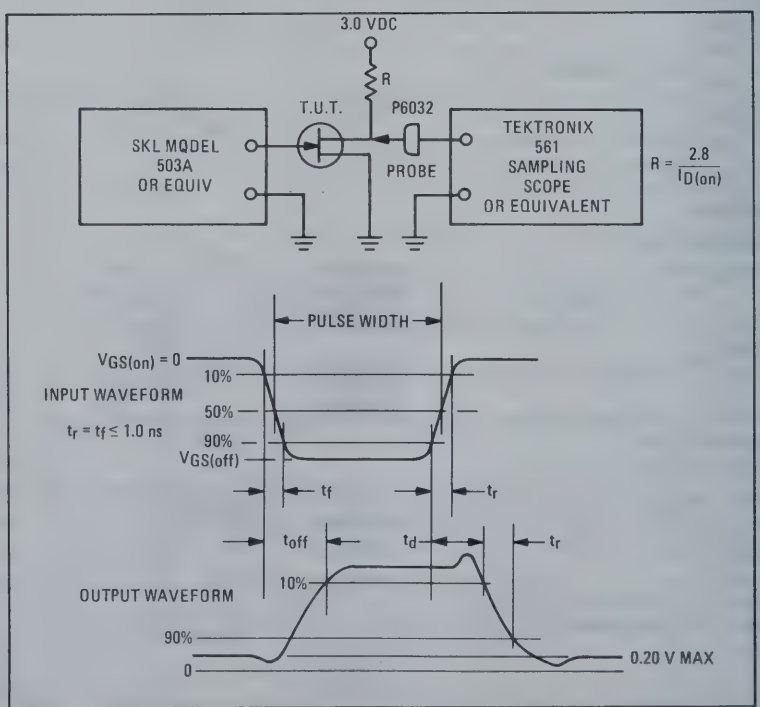
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	-	Vdc
Gate Reverse Current		I_{GSS}			nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0			-	0.2	
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)			-	0.4	μAdc
Drain Cutoff Current		$I_{D(off)}$			nAdc
(V_{DS} = 20 Vdc, V_{GS} = 12 Vdc)			-	0.2	
(V_{DS} = 20 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)			-	0.4	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current*		I_{DSS}*			mAdc
(V_{DS} = 20 Vdc, V_{GS} = 0)	MFE2004		8.0	-	
	MFE2005		15	-	
	MFE2006		30	-	
Gate-Source Voltage		V_{GS}			Vdc
(V_{DS} = 20 Vdc, I_D = 50 μAdc)	MFE2004		1.0	6.0	
	MFE2005		2.0	8.0	
	MFE2006		5.0	10	
Gate-Source Forward Voltage		VGSF			Vdc
(I_G = 1.0 mAdc, V_{DS} = 0)			-	1.0	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 3.0 mAdc, V_{GS} = 0)	MFE2004		-	0.4	
(I_D = 6.0 mAdc, V_{GS} = 0)	MFE2005		-	0.4	
(I_D = 10 mAdc, V_{GS} = 0)	MFE2006		-	0.4	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$			Ohms
(I_D = 1.0 mAdc, V_{GS} = 0)	MFE2004		-	80	
	MFE2005		-	50	
	MFE2006		-	30	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MFE2004	$r_{ds(on)}$	-	80	Ohms
	MFE2005		-	50	
	MFE2006		-	30	
Input Capacitance (V_{DS} = 0, V_{GS} = -12 Vdc, f = 1.0 MHz)		C_{iss}	-	16	pF
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 0, V_{GS} = 6.0 Vdc, f = 1.0 MHz)	MFE2004		-	5.0	
(V_{DS} = 0, V_{GS} = 8.0 Vdc, f = 1.0 MHz)	MFE2005		-	5.0	
(V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)	MFE2006		-	5.0	
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (See Figure 1)		$t_{d(on)}$			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, V_{GS} = 0)	MFE2004		-	20	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, V_{GS} = 0)	MFE2005		-	15	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, V_{GS} = 0)	MFE2006		-	10	
Rise Time (See Figure 1)		t_r			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, V_{GS} = 0)	MFE2004		-	40	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, V_{GS} = 0)	MFE2005		-	20	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, V_{GS} = 0)	MFE2006		-	10	
Turn-Off Time (See Figure 1)		t_{off}			ns
(V_{DD} = 3.0 Vdc, I_D = 3.0 mAdc, $V_{GS(off)}$ = 6.0 Vdc)	MFE2004		-	80	
(V_{DD} = 3.0 Vdc, I_D = 6.0 mAdc, $V_{GS(off)}$ = 8.0 Vdc)	MFE2005		-	60	
(V_{DD} = 3.0 Vdc, I_D = 10 mAdc, $V_{GS(off)}$ = 12 Vdc)	MFE2006		-	40	

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



MFE2007 (SILICON)
MFE2008
MFE2009

Silicon N-channel depletion mode (Type A) junction field-effect transistors designed for chopper applications.

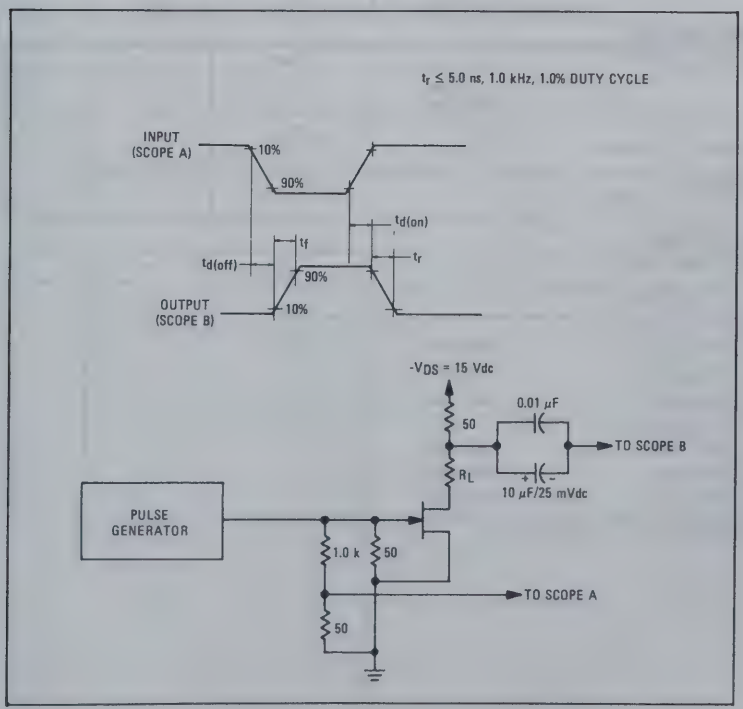


CASE 22 (4)
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T_J	-65 to + 175	°C
Storage Temperature Range	T_{stg}	-65 to + 200	°C

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	-	Vdc
Gate Reverse Current		I_{GSS}			nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0)			-	2.0	
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)			-	4.0	μAdc
Drain Cutoff Current		$I_{D(off)}$			nAdc
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc)			-	2.0	
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)			-	4.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current*		I_{DSS}*			mAdc
(V_{DS} = 20 Vdc, V_{GS} = 0)	MFE2007		8.0	-	
	MFE2008		20	-	
	MFE2009		50	-	
Gate-Source Voltage		V_{GS}			Vdc
(V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	MFE2007		0.5	10	
	MFE2008		1.0	10	
	MFE2009		3.0	10	
Gate-Source Forward Voltage		VGSF			Vdc
(I_G = 1.0 mAdc, V_{DS} = 0)			-	1.0	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 5.0 mAdc, V_{GS} = 0)	MFE2007		-	0.75	
(I_D = 10 mAdc, V_{GS} = 0)	MFE2008		-	0.75	
(I_D = 20 mAdc, V_{GS} = 0)	MFE2009		-	0.75	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$			Ohms
(I_D = 1.0 mAdc, V_{GS} = 0)	MFE2007		-	40	
	MFE2008		-	30	
	MFE2009		-	20	
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MFE2007		-	40	
	MFE2008		-	30	
	MFE2009			20	
Input Capacitance		C_{iss}			pF
(V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)			-	30	
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)			-	15	
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (See Figure 1)		$t_{d(on)}$	-	10	ns
Rise Time (See Figure 1)		t_r	-	6.0	ns
Turn-Off Delay Time (See Figure 1)		$t_{d(off)}$			ns
(V_{DD} = 15 Vdc, I_D = 5.0 mAdc)	MFE2007		-	35	
(V_{DD} = 15 Vdc, I_D = 10 mAdc)	MFE2008		-	20	
(V_{DD} = 15 Vdc, I_D = 20 mAdc)	MFE2009		-	12	
Fall Time (See Figure 1)		t_f			ns
(V_{DD} = 15 Vdc, I_D = 5.0 mAdc)	MFE2007		-	65	
(V_{DD} = 15 Vdc, I_D = 10 mAdc)	MFE2008		-	40	
(V_{DD} = 15 Vdc, I_D = 20 mAdc)	MFE2009		-	25	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

MFE2010 (SILICON)
MFE2011
MFE2012

Silicon N-channel depletion mode (Type A) junction field-effect transistors designed for chopper applications.

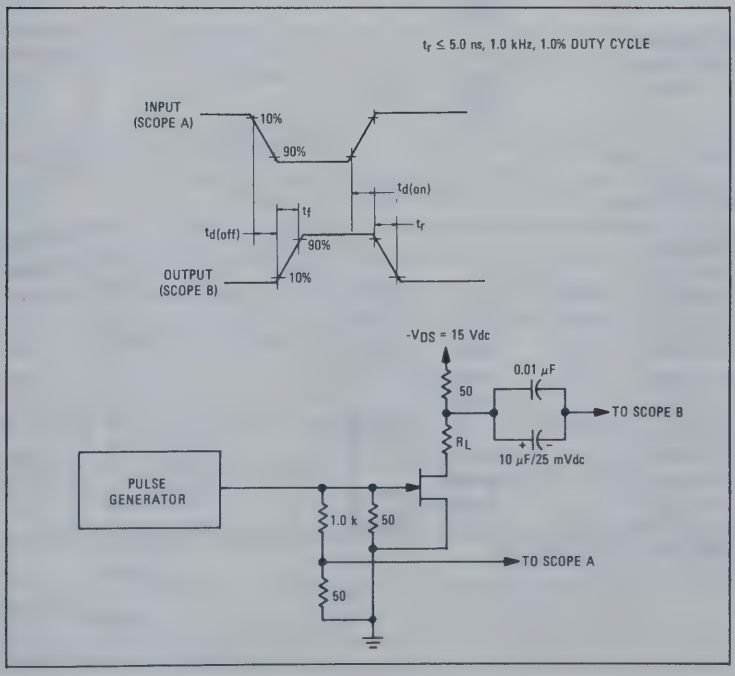


CASE 22 (4)
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25° C	P_D	1.8 10	Watt mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	-	Vdc
Gate Reverse Current		I_{GSS}			nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0)			-	3.0	
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)			-	6.0	μAdc
Drain Cutoff Current		$I_{D(off)}$			nAdc
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc)			-	3.0	
(V_{DS} = 15 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)			-	6.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current* (V_{DS} = 20 Vdc, V_{GS} = 0)	MFE2010	I_{DSS}*	15	-	mAdc
	MFE2011		40	-	
	MFE2012		100	-	
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	MFE2010	V_{GS}	0.5	10	Vdc
	MFE2011		1.0	10	
	MFE2012		3.0	10	
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		VGSF	-	1.0	Vdc
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 8.0 mAdc, V_{GS} = 0)	MFE2010		-	0.75	
(I_D = 15 mAdc, V_{GS} = 0)	MFE2011		-	0.75	
(I_D = 30 mAdc, V_{GS} = 0)	MFE2012		-	0.75	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$			Ohms
(I_D = 1.0 mAdc, V_{GS} = 0)	MFE2010		-	25	
	MFE2011		-	15	
	MFE2012		-	10	
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	MFE2010		-	25	
	MFE2011		-	15	
	MFE2012		-	10	
Input Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)		C_{iss}	-	50	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)		C_{rss}	-	20	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (See Figure 1)		$t_{d(on)}$	-	10	ns
Rise Time (See Figure 1)		t_r	-	6.0	ns
Turn-Off Delay Time (See Figure 1)		$t_{d(off)}$			ns
(V_{DD} = 15 Vdc, I_D = 8.0 mAdc)	MFE2010		-	35	
(V_{DD} = 15 Vdc, I_D = 15 mAdc)	MFE2011		-	20	
(V_{DD} = 15 Vdc, I_D = 30 mAdc)	MFE2012		-	12	
Fall Time (See Figure 1)		t_f			ns
(V_{DD} = 15 Vdc, I_D = 8.0 mAdc)	MFE2010		-	75	
(V_{DD} = 15 Vdc, I_D = 15 mAdc)	MFE2011		-	45	
(V_{DD} = 15 Vdc, I_D = 30 mAdc)	MFE2012		-	25	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

MFE2093 (SILICON)
MFE2094
MFE2095



CASE 20(3)
(TO-72)

Silicon N-channel junction field-effect transistors, designed for low-power audio-amplifier and switching applications. Drain and source interchangeable.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	50	Vdc
Drain Current	I_D	3	mAdc
Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = -10\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	50	-	-	Vdc
Gate Reverse Current ($V_{GS} = -15$ Vdc, $V_{DS} = 0$)		I_{GSS}	-	-	0.1	nAdc
($V_{GS} = -15$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)			-	-	100	
Gate-Source Cutoff Voltage ($I_D = 0.1$ nAdc, $V_{DS} = 15$ Vdc)	MFE2093	$V_{GS(off)}$	-	1.5	2.5	Vdc
	MFE2094		-	3.0	4.5	
	MFE2095		-	4.5	5.5	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	MFE2093	I_{DSS}*	0.1	0.35	0.7	mAdc
	MFE2094		0.4	0.7	1.4	
	MFE2095		1.0	1.5	3.0	
DYNAMIC CHARACTERISTICS						
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 1$ kHz)*	MFE2093	$\lvert y_{fs} \rvert$	250	400	500	μmhos
	MFE2094		350	500	700	
	MFE2095		400	600	800	
($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 100$ MHz)	MFE2093		150	-	-	
	MFE2094		250	-	-	
	MFE2095		300	-	-	
Output Admittance* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 1$ kHz)	MFE2093	$\lvert y_{os} \rvert$*	-	0.5	1.5	μmhos
	MFE2094		-	1.0	3.0	
	MFE2095		-	4.0	10.0	
Drain-Source Resistance ($V_{DS} = 0$, $V_{GS} = 0$)	MFE2093	$r_{ds(on)}$	-	2500	-	Ohms
	MFE2094		-	1600	-	
	MFE2095		-	1300	-	
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 140$ kHz)		C_{iss}	-	4.0	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 140$ kHz)		C_{rss}	-	1.2	2.0	pF

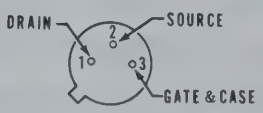
*Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%

MFE2133 (SILICON)



CASE 79 A
(TO-39 with 1½" leads)

N-channel junction silicon field-effect transistor designed for high-level chopper applications.



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate-Drain Current	I_G	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	1.5 10	W mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -1 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	—	—	Vdc
Drain Cutoff Current (V_{DG} = 15 Vdc, I_S = 0)	I_{DGO}	—	—	1.0	nAdc
(V_{DG} = 15 Vdc, I_S = 0, T_A = 150°C)		—	—	1000	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}*	25	—	—	mAdc
Drain Cutoff Current (V_{DS} = 10 Vdc, V_{GS} = -10 Vdc)	$I_{D(off)}$	—	—	1.0	nAdc
(V_{DS} = 10 Vdc, V_{GS} = -10 Vdc, T_A = 150°C)		—	—	1000	
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance* (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 kHz)	y_{fs}*	12000	—	—	μmhos
Drain-Source Resistance (V_{GS} = 0, I_D = 0, f = 1 kHz)	$r_{ds(on)}$	—	40	60	ohms
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	14	20	pF
Reverse Transfer Capacitance (V_{GS} = -10 Vdc, V_{DS} = 0, f = 1 MHz)	C_{rss}	—	3	5	pF

*Pulse Test: Pulse Width $\leq$ 630 ms; Duty Cycle = 10%

FIGURE 1 — DRAIN-SOURCE SATURATION REGION

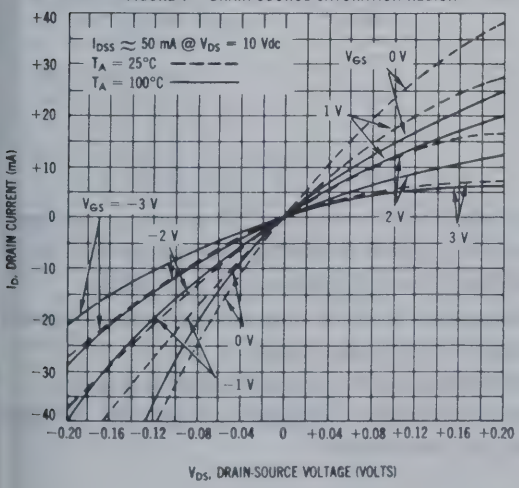
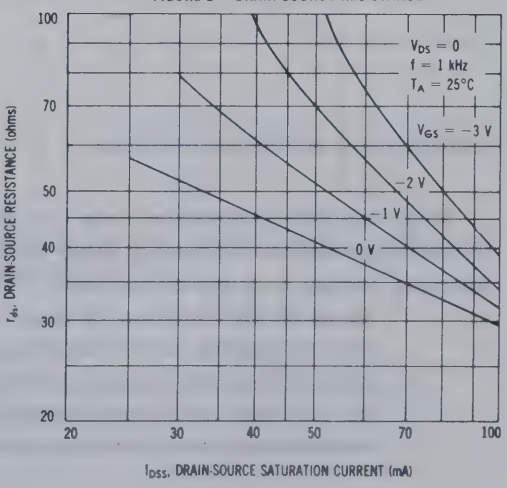


FIGURE 2 — DRAIN-SOURCE RESISTANCE



MFE3001 (SILICON)



CASE 20 (2)
(TO-72)

Silicon N-channel insulated-gate field-effect transistor designed for low-power applications in the audio frequency range.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	20	mAdc
Power Dissipation at $T_A = 25^oC$ Derating Factor above 25^oC	P_D	300 2.0	mW $mW/^oC$
Operating Junction Temperature	T_J	+200	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = -8 V, I_D = 10 μAdc)	BV_{DSX}	20	—	Vdc
Zero-Gate-Voltage Drain Current (V_{GS} = 0 Vdc, V_{DS} = 10 Vdc)	I_{DSS}	0.5	6.0	mAdc
Gate-Source Voltage Cutoff (I_{DS} = 1 μAdc, V_{DS} = 10 Vdc)	$V_{GS(off)}$	—	-8.0	Vdc
ON CHARACTERISTICS				
"On" Drain Current (V_{GS} = 3.5 Vdc, V_{DS} = 10 Vdc)	$I_{D(on)}$	5.0	—	mAdc
Gate-Reverse Current* (V_{GS} = -10 Vdc, V_{DS} = 0)	I_{GSS}*	—	10	pAdc
DYNAMIC CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 kHz)	$\|y_{fs}\|$	700	3500	μmhos
Output Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 kHz)	$\|y_{os}\|$	—	100	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1 MHz)	C_{rss}	—	1.5	pF

*This value of current includes both the FET leakage current as well as the leakage current associated with the test socket and fixture when measured under best attainable conditions.

MFE3002 (SILICON)



Active Elements Isolated From Case

CASE 20(7)
(TO-72)

Silicon N-channel MOS field-effect transistor designed for chopper applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	15	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 10 μAdc)	BV_{DSS}	15	-	Vdc
Gate Leakage Current (V_{GS} = 10 Vdc, V_{DS} = 0)	I_{GSS}	-	100	pAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DS} = 10 Vdc, V_{GS} = 0) (V_{DS} = 10 Vdc, V_{GS} = 0, T_C = 125°C)	I_{DSS}	- -	10 100	nAdc
Gate-Source Threshold Voltage (V_{DS} = 10 Vdc, I_D = 10 μAdc)	$V_{GS(TH)}$	-	3.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source Resistance (V_{GS} = 10 Vdc, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	-	100	Ohms
Drain-Substrate Capacitance ($V_{D(SUB)}$ = 10 Vdc, f = 1.0 MHz)	$C_{d(sub)}$	-	4.0	pF
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	1.0	pF

MFE3003 (SILICON)

Silicon P-channel MOS field-effect transistor designed for chopper applications.



CASE 20 (7)
(TO-72)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	15	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = -10 μAdc)	$V_{(BR)DSS}$	15	-	Vdc
Gate Leakage Current (V_{GS} = ±10 Vdc, V_{DS} = 0)	I_{GSS}	-	100	pAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DS} = -10 Vdc, V_{GS} = 0) (V_{DS} = -10 Vdc, V_{GS} = 0, T_C = 125°C)	I_{DSS}	- -	10 100	nAdc
Gate-Source Threshold Voltage (V_{DS} = -10 Vdc, I_D = -10 μAdc)	$V_{GS(TH)}$	-	4.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source Resistance (V_{GS} = -10 Vdc, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	-	200	Ohms
Drain-Substrate Capacitance ($V_{D(SUB)}$ = -10 Vdc, f = 1.0 MHz)	$C_{d(sub)}$	-	4.0	pF
Input Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	1.0	pF

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

MFE3004 (SILICON)
MFE3005



CASE 20(7)
(TO-72)

Active Elements Isolated From Case

Silicon N-channel MOS field-effect transistors designed for VHF/UHF amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	±30	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = -5.0 Vdc, I_D = 10 μAdc)	BV_{DSX}	20	-	Vdc
Gate-Source Cutoff Voltage (I_D = 10 μAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	-	5.0	Vdc
Gate Reverse Current (V_{GS} = ±15 Vdc, V_{DS} = 0)	I_{GSS}	-	50	pAdc
OFF CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	2.0	10	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)	$\|y_{fs}\|$	2000	-	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	4.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	0.2	pF
Small-Signal Power Gain (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 1.8 k ohms, f = 200 MHz) (Figure 1) MFE3004	G_{ps}	16	-	dB
(V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 650 ohms, f = 400 MHz) (Figure 2) MFE3005		10	-	
Noise Figure (V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 1.8 k ohms, f = 200 MHz) (Figure 1) MFE3004	NF	-	4.5	dB
(V_{DS} = 15 Vdc, I_D = 2.0 mAdc, R_S ≈ 650 ohms, f = 400 MHz) (Figure 2) MFE3005		-	4.5	

FIGURE 1 — 200 MHz TEST CIRCUIT NEUTRALIZED

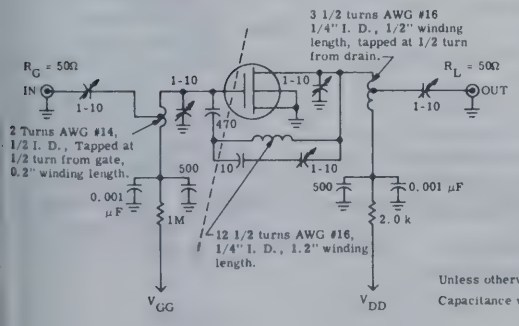
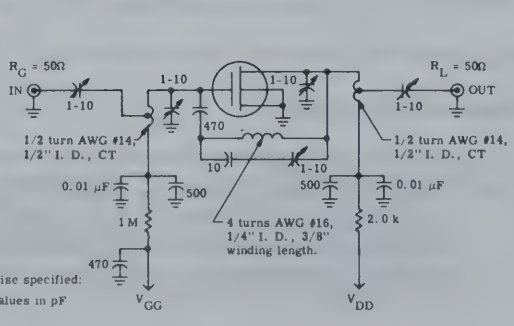


FIGURE 2 — 400 MHz TEST CIRCUIT NEUTRALIZED



MFE3006 (SILICON)
thru
MFE3008

N-CHANNEL DUAL-GATE SILICON-NITRIDE PASSIVATED MOS FIELD-EFFECT TRANSISTORS

. . . depletion mode (Type B) dual gate transistors designed for VHF amplifier and mixer applications. These types are specified as follows:

MFE3006 – RF Amplifier @ 100 MHz
MFE3007 – RF Amplifier @ 200 MHz
MFE3008 – Mixer @ 100 and 200 MHz

- Silicon Nitride Passivation for Excellent Long Term Stability
- High Common-Source Power Gain –
  MFE3006: G_{ps} = 20 dB (Min) @ f = 100 MHz
  MFE3007: G_{ps} = 18 dB (Min) @ f = 200 MHz
- High Common-Source Conversion Gain –
  MFE3008: G_{ps} = 14 dB (Min) @ f = 100 MHz
  G_{ps} = 10 dB (Min) @ f = 200 MHz
- Low Reverse Transfer Capacitance –
  C_{rss} = 0.02 pF (Typ) @ V_{DS} = 15 Vdc

N-CHANNEL

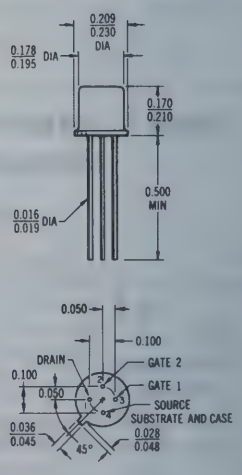
DUAL GATE MOS FIELD-EFFECT TRANSISTORS

TYPE B



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	+25	Vdc
Gate 1 Source Voltage	V_{G1S}	±35	Vdc
Gate 2 Source Voltage	V_{G2S}	±35	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Operating Junction Temperature Range	T_J	–65 to +175	°C
Storage Temperature Range	T_{stg}	–65 to +175	°C



CASE 20 (9)
(TO-72)

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

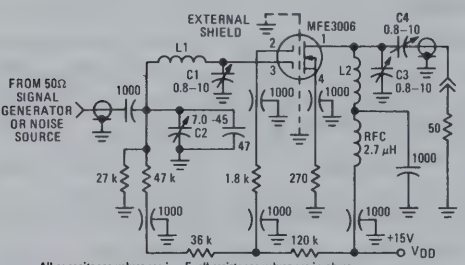
Substrate Connected to Source

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_S = 0, V_{G1} = V_{G2} = -4.0 Vdc)		$V_{(BR)DSX}$	25	–	–	Vdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 200 μAdc)		$V_{G1S(off)}$	–	–	-3.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 200 μAdc)		$V_{G2S(off)}$	–	–	-3.0	Vdc
Gate 1 Reverse Leakage Current		I_{G1SS}				nAdc
(V_{G1S} = -10 Vdc, V_{G2S} = 0, V_{DS} = 0)			–	–	1.0	
(V_{G1S} = -35 Vdc, V_{G2S} = 0, V_{DS} = 0)			–	–	10	
Gate 2 Reverse Leakage Current		I_{G2SS}				nAdc
(V_{G2S} = -10 Vdc, V_{G1S} = 0, V_{DS} = 0)			–	–	1.0	
(V_{G2S} = -35 Vdc, V_{G1S} = 0, V_{DS} = 0)			–	–	10	
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current		I_{DSS}				mAdc
(V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)	MFE3006		2.0	7.0	18	
	MFE3007		5.0	10	20	
	MFE3008		2.0	9.0	20	
SMALL-SIGNAL CHARACTERISTICS						
Forward Transadmittance (Gate 1 to Drain)		Y_{fs}				μmhos
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	MFE3006/8		8000	–	18,000	
	MFE3007		10,000	–	18,000	
Input Capacitance		C_{iss}				pF
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	MFE3006/8		–	4.5	6.0	
	MFE3007		–	4.5	5.5	
Output Capacitance		C_{oss}				pF
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)	MFE3006/8		–	2.5	4.0	
	MFE3007		–	2.5	3.5	
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 MHz)		C_{rss}	–	0.02	–	pF
Common-Source Noise Figure		NF				dB
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, R_S = 1000 Ohms)						
f = 100 MHz, Figure 1	MFE3006		–	2.5	4.0	
f = 200 MHz, Figure 4	MFE3007		–	3.0	4.0	
Common-Source Power Gain		G_{ps}				dB
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc)						
f = 100 MHz, Figure 1	MFE3006		20	25	–	
f = 200 MHz, Figure 4	MFE3007		18	21	–	
Level of Unwanted Signal for 1.0% Cross Modulation (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc)		–	–	100	–	mV
Common-Source Conversion Power Gain		G_{ps}				dB
(V_{DS} = 15 Vdc, V_{G2S} = 0.5 Vdc, Local Oscillator Voltage = 3.0 Vrms)						
Signal Frequency = 100 MHz, Local Oscillator Frequency = 130 MHz, Figure 3	MFE3008		14	17	–	
Signal Frequency = 200 MHz, Local Oscillator Frequency = 230 MHz, Figure 6	MFE3008		10	13	–	

TEST CIRCUITS

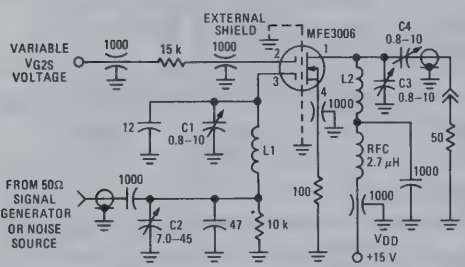
f = 100 MHz

FIGURE 1 – NOISE AND POWER GAIN



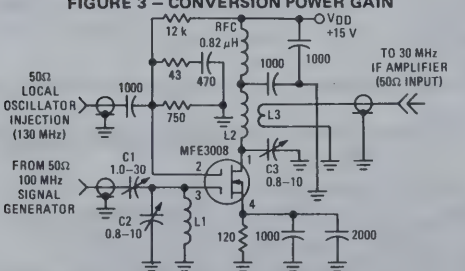
All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Centralab Type 825-G.N. or equivalent
L1: 5 Turns #16 AWG Wire (Internal diameter 5/16", Length 5/8")
L2: 5 Turns #16 AWG Wire (Internal diameter 3/8", Length 5/8")
Adjust C1, C2, C3 and C4 for maximum signal output; C1 and C2 for minimum noise figure, before measuring power gain.
Overall bandwidth = 3.0 MHz @ –3.0 dB
4.5 MHz @ –6.0 dB

FIGURE 2 – GAIN REDUCTION



All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Centralab Type 825-G.N. or equivalent
L1: 5 Turns #16 AWG Wire (Internal diameter 5/16", Length 5/8")
L2: 5 Turns #16 AWG Wire (Internal diameter 3/8", Length 5/8")
Overall bandwidth = 3.0 MHz @ –3.0 dB
4.5 MHz @ –6.0 dB

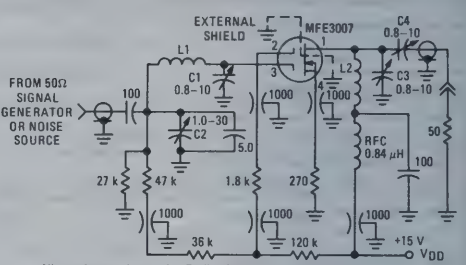
FIGURE 3 – CONVERSION POWER GAIN



All capacitance values are in pF; all resistance values are in ohms.
L1: 6 Turns #16 AWG Wire (Internal diameter 5/16", Length 7/16")
L2: 25 Turns #32 AWG Wire wound on 1/4" O.D. ceramic form
L3: 4 Turns #26 AWG Wire wound on top of and at dc supply end of L2
C1: Johanson Capacitor Type 3908 or equivalent
C2, C3: Johanson Capacitor Type 2950 or equivalent

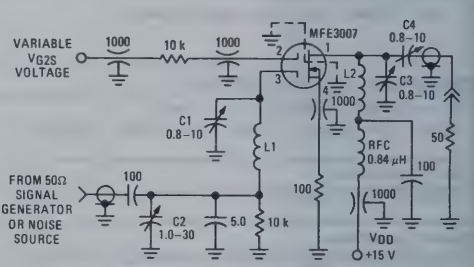
f = 200 MHz

FIGURE 4 – NOISE AND POWER GAIN



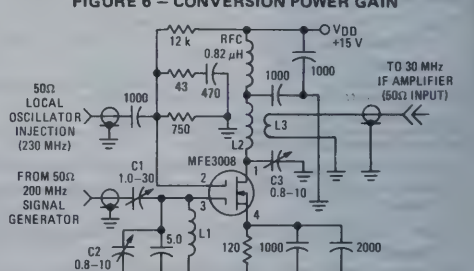
All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Johanson Type 3908 or equivalent
L1: 4 Turns #16 AWG Wire (Internal diameter 1/4", Length 3/4")
L2: 5 Turns #16 AWG Wire (Internal diameter 1/4", Length 3/4")
Adjust C1, C2, C3 and C4 for maximum signal output; C1 and C2 for minimum noise figure, before measuring power gain.
Overall bandwidth = 9.5 MHz @ –3.0 dB
14 MHz @ –6.0 dB

FIGURE 5 – GAIN REDUCTION



All capacitance values are in pF; all resistance values are in ohms.
C1, C3, C4: Johanson Type 2951 or equivalent
C2: Johanson Type 3908 or equivalent
L1: 4 Turns #16 AWG Wire (Internal diameter 1/4", Length 3/4")
L2: 5 Turns #16 AWG Wire (Internal diameter 1/4", Length 3/4")
Overall bandwidth = 9.5 MHz @ –3.0 dB
14 MHz @ –6.0 dB

FIGURE 6 – CONVERSION POWER GAIN



All capacitance values are in pF; all resistance values are in ohms.
L1: 2 Turns #16 AWG Wire (Internal diameter 1/4", Length 1/4")
L2: 25 Turns #32 AWG Wire wound on 1/4" O.D. ceramic form
L3: 4 Turns #26 AWG Wire wound on top of and at dc supply end of L2
C1: Johanson Capacitor Type 3908 or equivalent
C2, C3: Johanson Capacitor Type 2950 or equivalent

CIRCUIT PERFORMANCE

FIGURE 7 – POWER GAIN versus SOURCE RESISTANCE

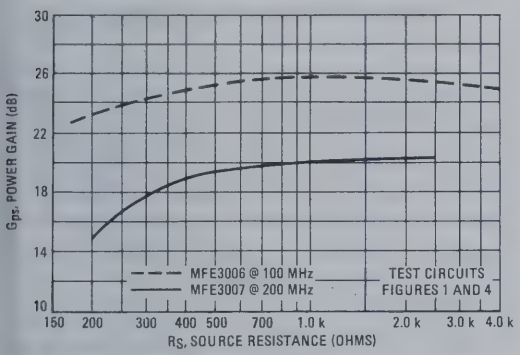


FIGURE 8 – NOISE FIGURE versus SOURCE RESISTANCE

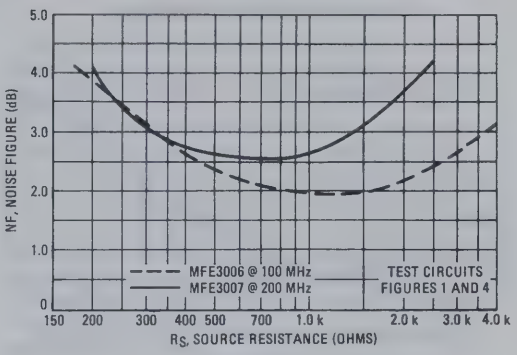


FIGURE 9 – GAIN REDUCTION

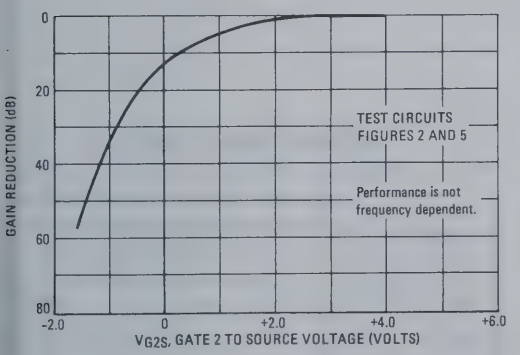


FIGURE 10 – COMMON SOURCE NOISE FIGURE versus GAIN REDUCTION

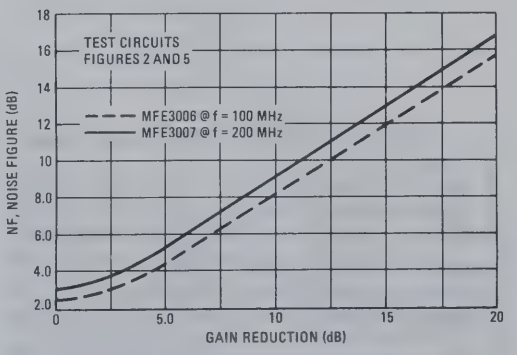


FIGURE 11 – CONVERSION POWER GAIN

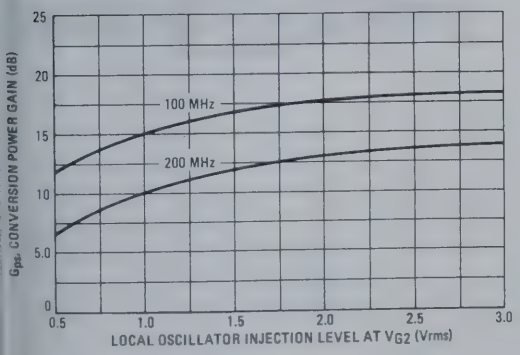
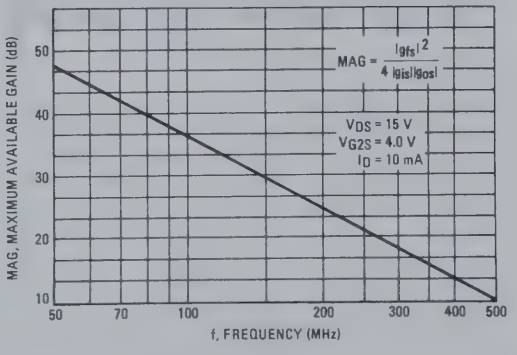


FIGURE 12 – MAXIMUM AVAILABLE POWER GAIN



COMMON-SOURCE ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc)

FIGURE 13 – INPUT ADMITTANCE

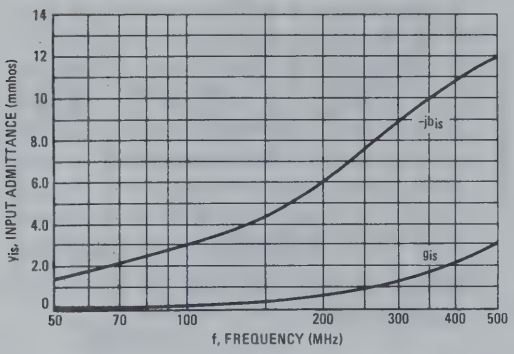


FIGURE 14 – REVERSE TRANSFER ADMITTANCE

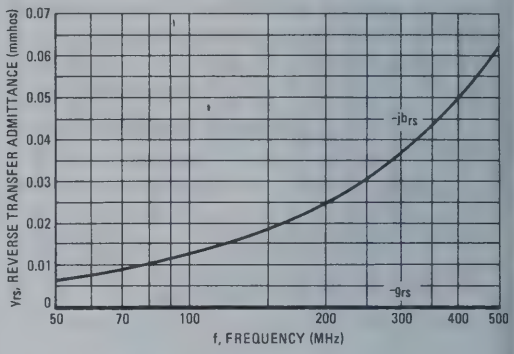


FIGURE 15 – FORWARD TRANSFER ADMITTANCE

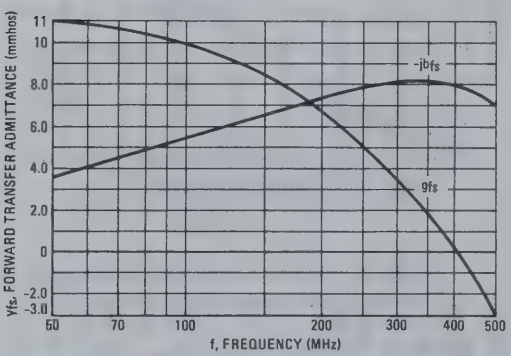
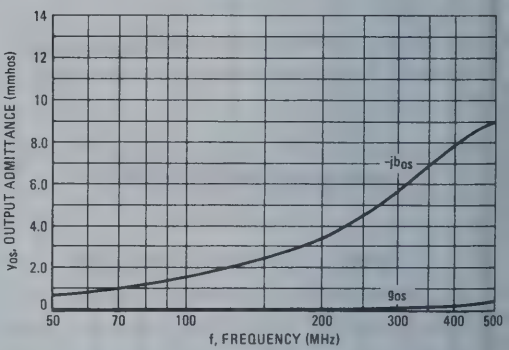


FIGURE 16 – OUTPUT ADMITTANCE



COMMON-SOURCE CIRCUIT DESIGN DATA AS A FUNCTION OF THE STERN "K" FACTOR

(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc)

FIGURE 17 – TRANSDUCER POWER GAIN

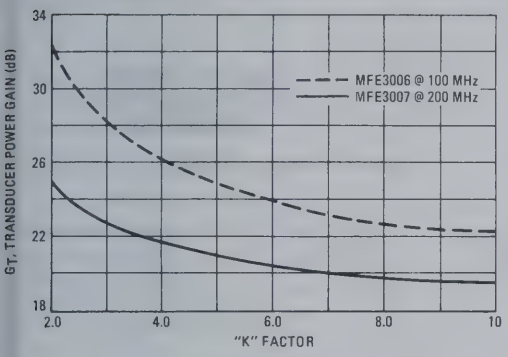


FIGURE 18 – SOURCE ADMITTANCE

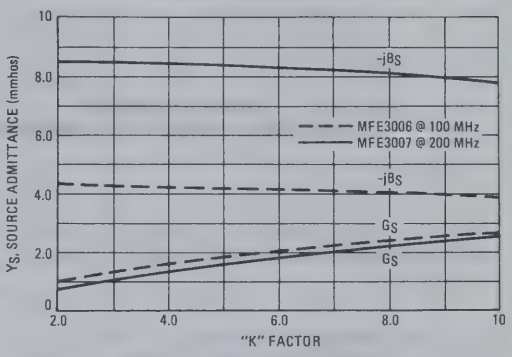
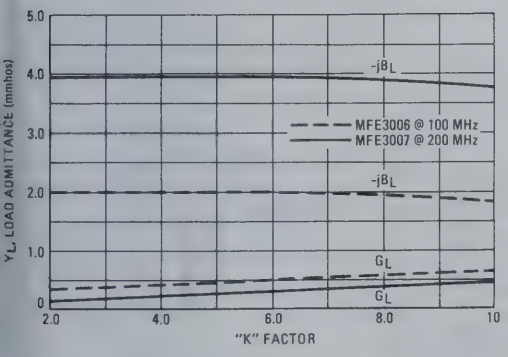


FIGURE 19 – LOAD ADMITTANCE



DESIGN NOTE

Figures 17-19 are included to assist the circuit designer in determining the transducer gain and the proper source and load admittances required for a given stability (Stern "K" factor*).

The Stern "K" factor has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN-215.

As the C_{rss} of the MFE3006-7 is comparable to the distributed capacitance of the circuit where it is used, a feedback capacitance of 0.1 pF has been used throughout these calculations.

*"Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc. I.R.E., March 1967.

MFE3020 (SILICON)
MFE3021

DUAL P-CHANNEL
MOS FIELD-EFFECT TRANSISTORS

Enhancement Mode (Type C) MOS Field-Effect Transistors designed primarily for low-power, chopper or switching applications.

- Low Reverse Gate Current —
  $I_{GSS} \leq 10$ pAdc @ $V_{GS} = -25$ Vdc
- Low Drain-Source "ON" Resistance —
  $r_{ds(on)} = 250$ Ohms (Max) @ $V_{GS} = -15$ Vdc (MFE3021)

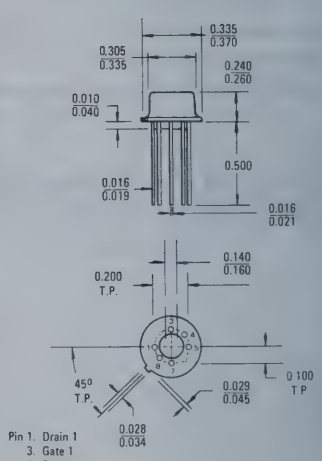
DUAL P-CHANNEL
MOS FIELD-EFFECT
TRANSISTORS

(Type C)



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	+25	Vdc
Forward Gate-Source Voltage	V_{GSF}	-25	Vdc
Drain Current	I_D	200	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.6 4.0	Watt $mW/^oC$
Storage Temperature Range	T_{stg}	-65 to +200	^oC
Operating Junction Temperature Range	T_J	-65 to +175	^oC



Pin 1. Drain 1
3. Gate 1
4. Substrate
5. Gate 2
7. Drain 2
8. Source 1 and 2

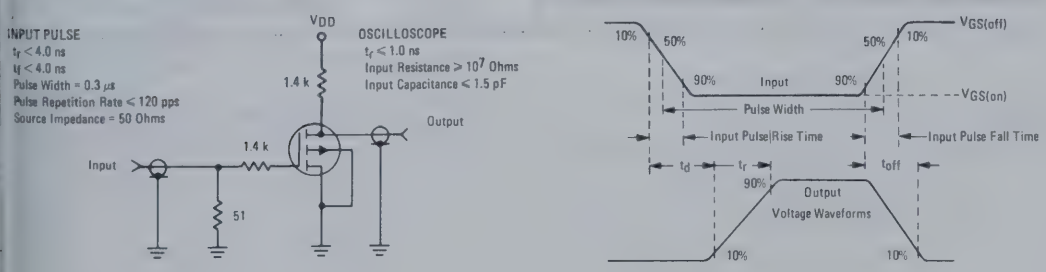
CASE 196
TO-76

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_{GS} = 0)		$V_{(BR)DSS}$	-25	–	Vdc
Source-Drain Breakdown Voltage (I_S = 10 μAdc, V_{GD} = 0)		$V_{(BR)SDS}$	-25	–	Vdc
Zero-Gate Voltage Source Current (V_{SD} = -15 Vdc, V_{GD} = 0)		I_{SDS}	–	10	nAdc
Zero-Gate Voltage Drain Current ① (V_{DS} = -15 Vdc, V_{GS} = 0)		I_{DSS}	–	10	nAdc
Gate Reverse Current (V_{GS} = -25 Vdc, V_{DS} = 0)		I_{GSS}	–	10	pAdc
ON CHARACTERISTICS					
Gate-Source Threshold Voltage (V_{DS} = -15 Vdc, I_D = 10 μAdc)		$V_{GS(th)}$	-2.0	-6.0	Vdc
"ON" Drain Current (V_{DS} = -15 Vdc, V_{GS} = -15 Vdc)		$I_{D(on)}$	10	75	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = -15 Vdc, I_D = 0, f = 1.0 kHz)	MFE3020 MFE3021	$r_{ds(on)}$	– –	500 250	Ohms
Forward Transadmittance ① (V_{DS} = -15 Vdc, V_{GS} = -15 Vdc, f = 1.0 kHz)		$\|Y_{fs}\|$	500	–	μmhos
Input Capacitance (V_{DS} = -15 Vdc, V_{GS} = -15 Vdc, f = 1.0 MHz)		C_{iss}	–	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	1.5	pF
Source-Substrate Capacitance (V_{DU} = -15 Vdc, V_{GS} = 0, I_S = 0, f = 1.0 MHz)		C_{SU}	–	5.0	pF
Drain-Substrate Capacitance (V_{SU} = -15 Vdc, V_{GS} = 0, I_S = 0, f = 1.0 MHz)		C_{DU}	–	5.0	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{DD} = -15 Vdc, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = -15 Vdc, $V_{GS(off)}$ = 0)	t_d	–	20	ns
Rise Time		t_r	–	30	ns
Turn-Off Time		t_{off}	–	50	ns

① Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

FIGURE 1 – SWITCHING TIMES CIRCUIT



MFE4007 (SILICON)
thru
MFE4012



CASE 20 (5)
(TO-72)

P-channel junction field-effect transistors, depletion mode (Type A) designed for general-purpose amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	MFE4007, MFE4008	$V_{GS(off)}$	-	3.0	Vdc
	MFE4009, MFE4010		-	6.0	
	MFE4011, MFE4012		-	8.0	
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	-	2.0	nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)			-	2.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	MFE4007	I_{DSS}	0.5	1.0	mAdc
	MFE4008		0.8	1.6	
	MFE4009		1.5	3.0	
	MFE4010		2.5	5.0	
	MFE4011		4.0	8.0	
	MFE4012		7.0	14	
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 50 μAdc)	MFE4007	V_{GS}	0.3	1.5	Vdc
(V_{DS} = 15 Vdc, I_D = 80 μAdc)	MFE4008		0.4	2.0	
(V_{DS} = 15 Vdc, I_D = 150 μAdc)	MFE4009		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 250 μAdc)	MFE4010		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 400 μAdc)	MFE4011		2.0	6.0	
(V_{DS} = 15 Vdc, I_D = 700 μAdc)	MFE4012		2.0	6.0	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	MFE4007	$\lvert y_{fs} \rvert$	900	2700	μmhos
	MFE4008		1000	3000	
	MFE4009		1500	3500	
	MFE4010		2000	4000	
	MFE4011		2200	4500	
	MFE4012		2500	5000	
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	MFE4007	$Re(y_{fs})$	800	-	μmhos
	MFE4008		900	-	
	MFE4009		1400	-	
	MFE4010		1700	-	
	MFE4011		1900	-	
	MFE4012		2100	-	
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\lvert y_{os} \rvert$	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		C_{iss}	-	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	2.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 1.0 Hz)		NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	-	115	$nV/\sqrt{Hz}$

TRANSFER CHARACTERISTIC CURVES FOR MIN/MAX I_{DSS} LIMITS

FIGURE 1

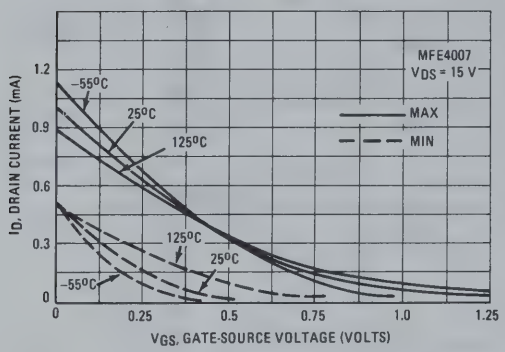


FIGURE 2

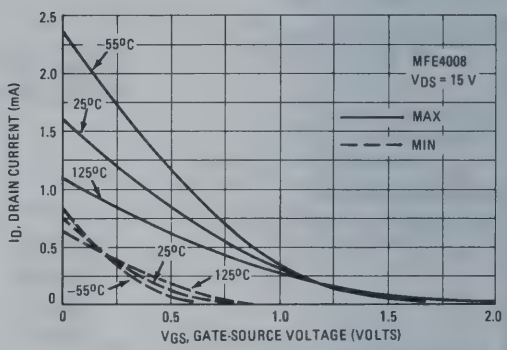


FIGURE 3

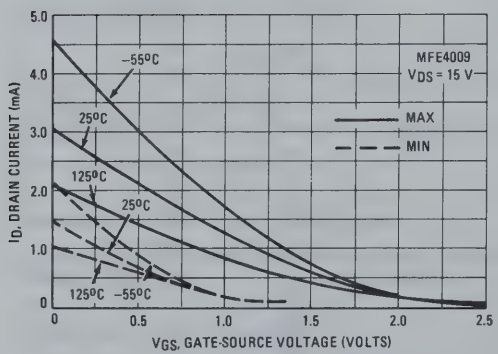


FIGURE 4

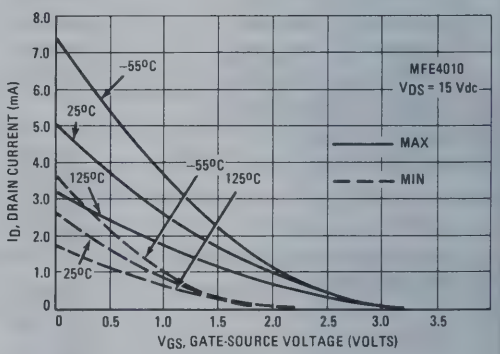


FIGURE 5

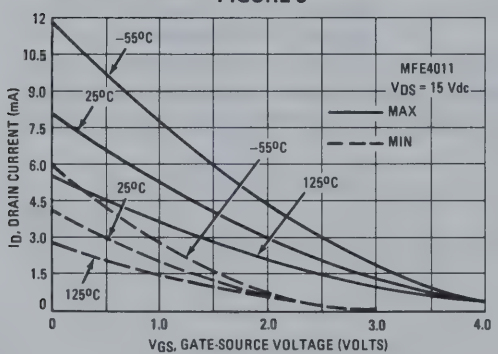
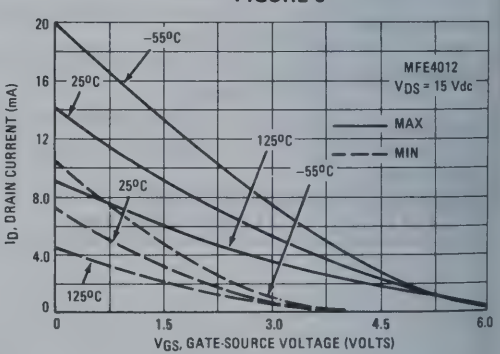


FIGURE 6



TYPICAL AND MINIMUM FORWARD TRANSFER ADMITTANCE

FIGURE 7

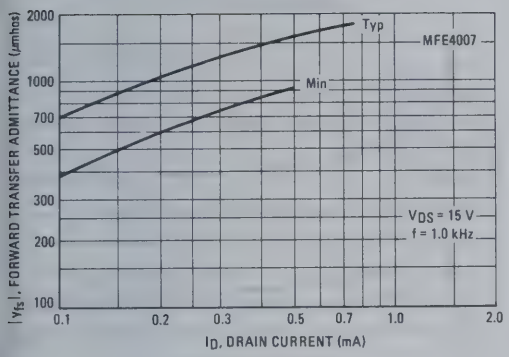


FIGURE 8

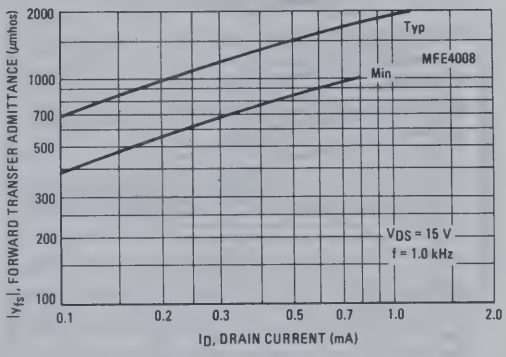


FIGURE 9

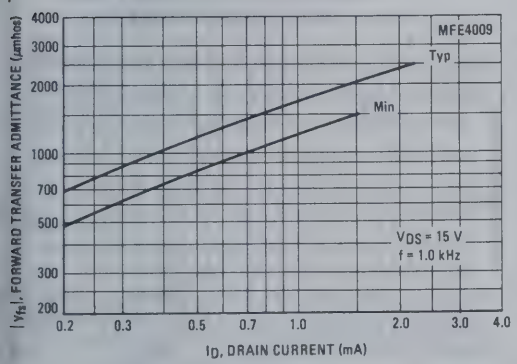


FIGURE 10

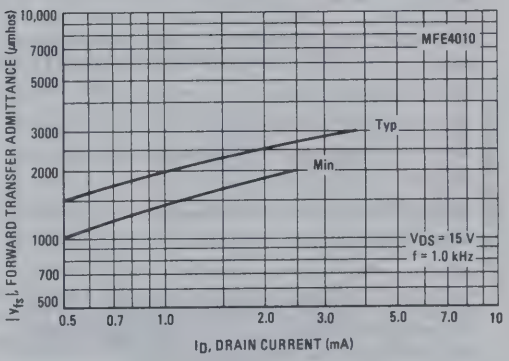


FIGURE 11

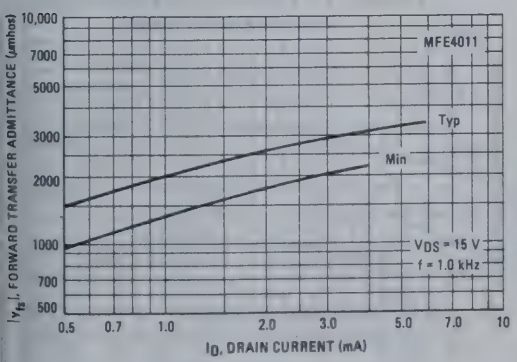
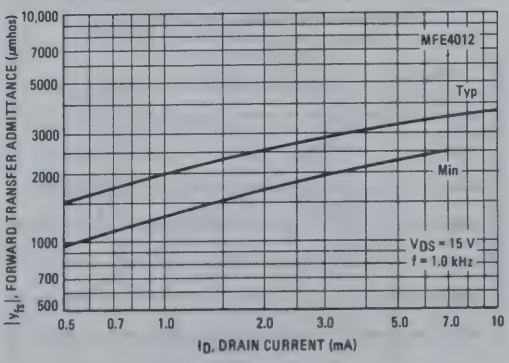


FIGURE 12



TYPICAL CURVES

FIGURE 13 – OUTPUT RESISTANCE versus DRAIN CURRENT

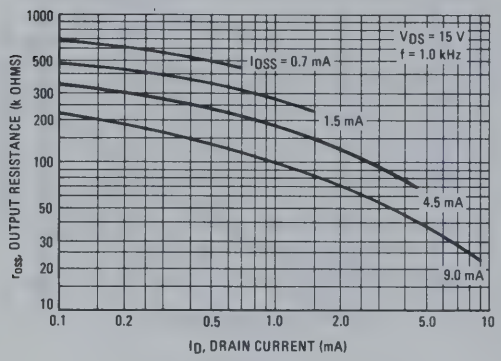


FIGURE 14 – CAPACITANCE versus DRAIN-SOURCE VOLTAGE

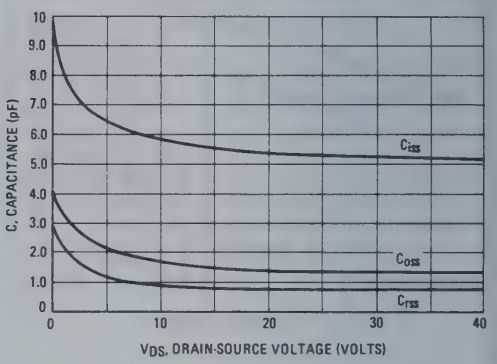


FIGURE 15 – NOISE FIGURE versus FREQUENCY

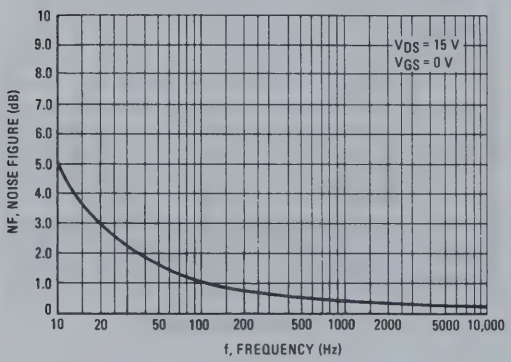


FIGURE 16 – NOISE FIGURE versus SOURCE RESISTANCE

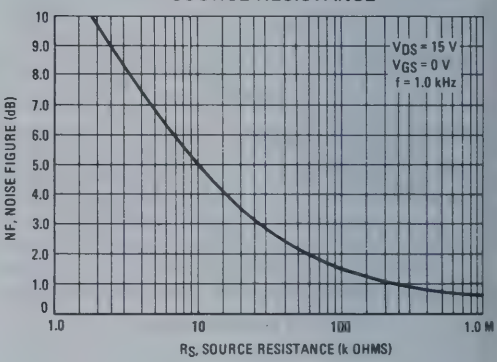


FIGURE 17 – DRAIN CURRENT TEMPERATURE COEFFICIENT versus DRAIN CURRENT

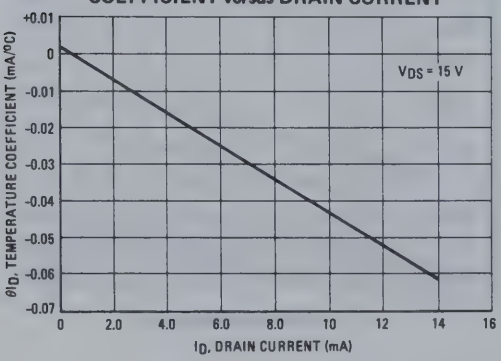


FIGURE 18 – TEMPERATURE COEFFICIENT versus DRAIN CURRENT

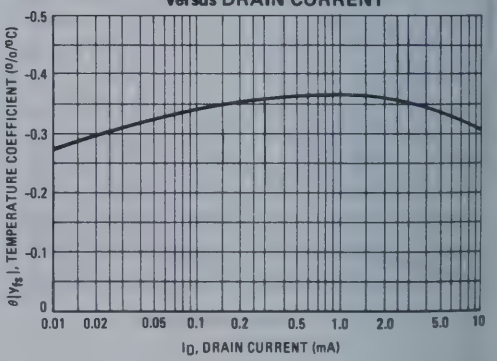
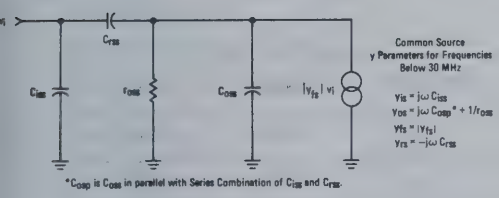


FIGURE 19 – EQUIVALENT LOW FREQUENCY CIRCUIT



$$R_S = \frac{V_{GS(max)} - V_{GS(min)}}{I_{D(max)} - I_{D(min)}} = \frac{1.9\ Vdc - 0.8\ Vdc}{(1.25\ mA - 0.75\ mA)} = 2.2\ k\ Ohms$$

$$V_G = \frac{I_{D(max)}\, V_{GS(min)} - I_{D(min)}\, V_{GS(max)}}{I_{D(max)} - I_{D(min)}}$$

$$= \frac{1.25 \times 0.80 - 0.75 \times 1.9}{0.5} = -0.9\ Vdc$$

BIAS NETWORK DESIGN FOR WORST CASE I_{DSS} VARIANCE

This Designers Data Sheet has been published to assist the circuit designer in optimizing his "worst case" design. The following example illustrates the use of the forward transfer characteristics curves (Figures 1 thru 6) in the design of a typical bias network.

Given: $V_{DD} = -30$ Vdc, $I_D = 1.0 \pm 0.25$ mAdc from -55^oC to $+125^oC$

Procedure: The MFE4010 "worst case" bias conditions across the temperature range (from Figure 4) are reproduced in Figure A. The first step in the bias network design is to determine the value of the source resistance (R_S) necessary to hold the ± 0.25 mAdc I_D bias tolerance. To solve R_S, plot $I_{D(max)}$ and $I_{D(min)}$ on Figure A and calculate R_S, and V_G.

In Figure B the maximum allowable value for R_1 will be determined by loading due to gate reverse current. Gate reverse current variations with temperature follow the pattern of all silicon devices, and, as a rule, we can assume that it will double with each 15^oC temperature rise. Therefore, we can assume a maximum reverse current of approximately 0.5 μAdc at 125^oC, based on the specified maximum 2.0 μAdc reverse at 150^oC. The variation in V_G bias versus temperature will not be too great if we chose a value for R_1 which results in a bias network current (I_1 in Figure B) greater than 5 times the maximum reverse current. Assuming a value for R_1 of 9.1 Megohms, R_2 can be solved from the equation:

$$V_G = -0.9\ Vdc \approx \frac{-30\ R_2}{9.1 + R_2}\ (\text{Ignoring } I_G)$$

$$R_2 \approx 300\ k\ Ohms$$

Using the above values of R_1 and R_2, the variation in V_G can be computed for $I_G = 0$ to $I_G = 0.5$ μAdc. V_G will vary from 0.81 Vdc at $I_G = 0.5$ μAdc to 0.96 Vdc @ $I_G = 0$. This variation will have a minimal effect on I_D, as can be seen from Figure A by plotting load lines with a slope equal to $1/R_S$ from $V_G = 0.81$ Vdc and 0.96 Vdc respectively.

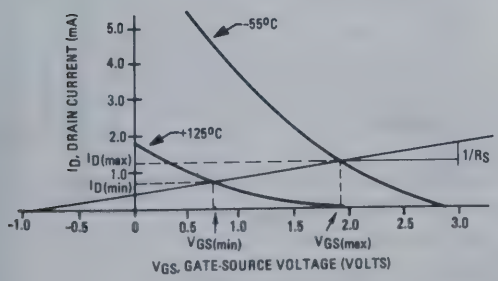


FIGURE A

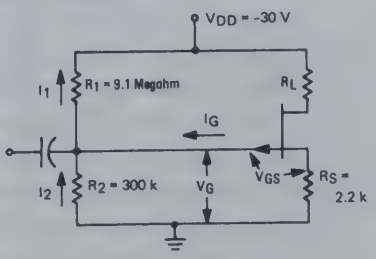
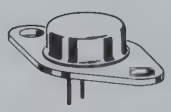


FIGURE B

MJ400 (SILICON)



CASE 80
(TO-66)

High-voltage NPN silicon transistor designed for video output circuitry in color television receivers.

Collector connected to case

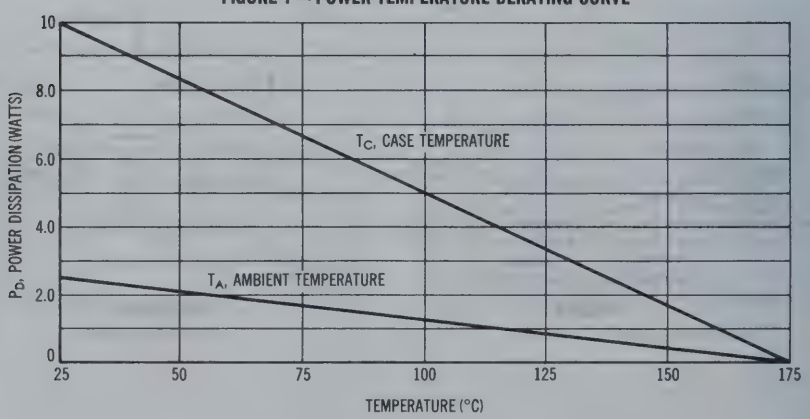
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	325	Vdc
Collector-Base Voltage	V_{CB}	350	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current-Continuous Peak	I_C	250 1000	mAdc
Base Current	I_B	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	2.5 0.0167	Watts W/°C
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	6.67 0.067	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	15	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	60	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 1.0 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	325	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	350	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 325 Vdc, I_B = 0)	I_{CEO}	—	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	300	—
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{CE(sat)}$	—	5.0	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 25 Vdc, f = 10 MHz)	f_T	15	—	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	10	pF
Small Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{fe}	25	—	—

*Pulse Test: PW ≤ 300 μs, duty cycle ≤ 2%

FIGURE 2 — CURRENT GAIN CHARACTERISTICS

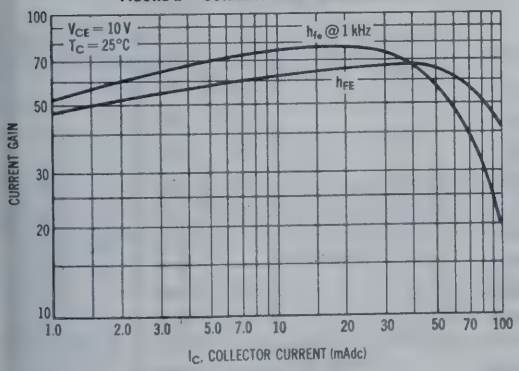
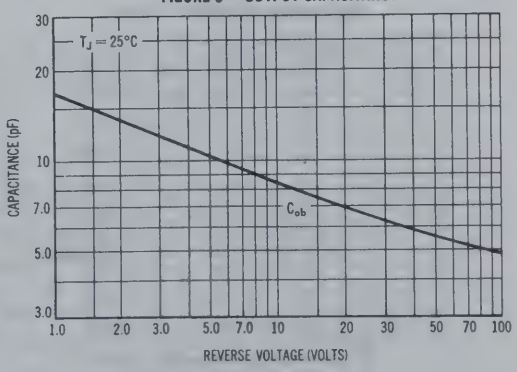
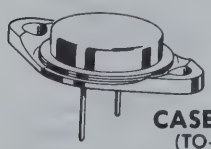


FIGURE 3 — OUTPUT CAPACITANCE



MJ413 (SILICON)
MJ423
MJ431



CASE 11 Collector connected to case
(TO-3)

High-voltage NPN silicon transistors designed for medium-to-high-voltage inverters, converters, regulators and switching circuits.

MAXIMUM RATINGS

Rating	Symbol	MJ413	MJ423	MJ431	Unit
Collector-Emitter Voltage	V_{CEX}	400	400	400	Vdc
Collector-Base Voltage	V_{CB}	400	400	400	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	5.0	Vdc
Collector Current — Continuous	I_C	10	10	10	Adc
Base Current	I_B	2.0	2.0	2.0	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	125 1.0			Watts W/°C
Operation Junction Temperature Range	T_J	-65 to +150			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	325	—	Vdc
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ413, MJ423		—	0.25	
	MJ431		—	2.5	
(V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	MJ413, MJ423		—	0.5	mAdc
	MJ431		—	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	MJ413, MJ423	I_{EBO}	—	5.0	mAdc
	MJ431		—	2.0	
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			—
(I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	MJ413		20	80	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			15	—	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	MJ423		30	90	
(I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)			10	—	
(I_C = 2.5 Adc, V_{CE} = 5.0 Vdc)	MJ431		15	35	
(I_C = 3.5 Adc, V_{CE} = 5.0 Vdc)			10	—	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 0.5 Adc, I_B = 0.05 Adc)	MJ413		—	0.8	
(I_C = 1.0 Adc, I_B = 0.10 Adc)	MJ423		—	0.8	
(I_C = 2.5 Adc, I_B = 0.5 Adc)	MJ431		—	0.7	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 0.5 Adc, I_B = 0.05 Adc)	MJ413		—	1.25	
(I_C = 1.0 Adc, I_B = 0.1 Adc)	MJ423		—	1.25	
(I_C = 2.5 Adc, I_B = 0.5 Adc)	MJ431		—	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 200 mAdc, V_{CE} = 10Vdc, f = 1.0 MHz)		f_T	2.5	—	MHz

*PW ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — ACTIVE-REGION SAFE-OPERATING AREA

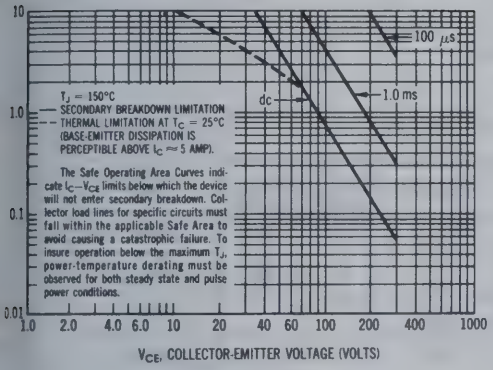


FIGURE 2 — POWER-TEMPERATURE DERATING CURVE

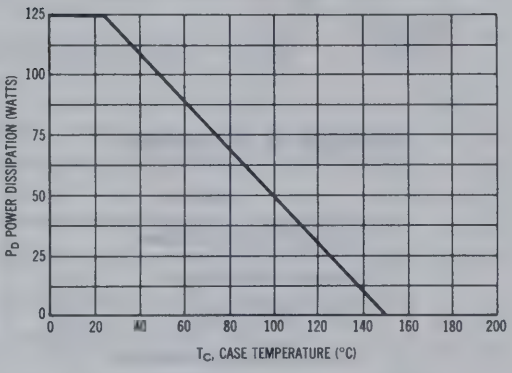


FIGURE 3 — SUSTAINING VOLTAGE TEST LOAD LINE

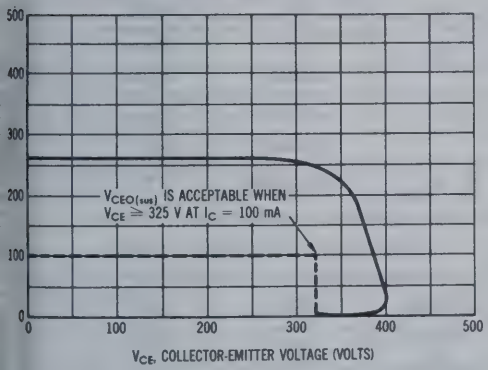


FIGURE 4 — SUSTAINING VOLTAGE TEST CIRCUIT

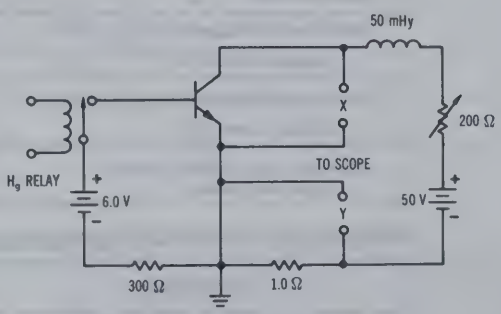


FIGURE 5 — CURRENT GAIN

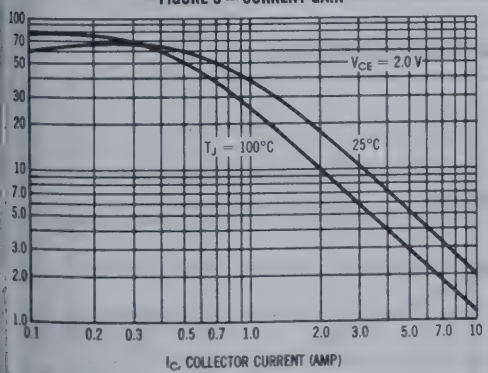
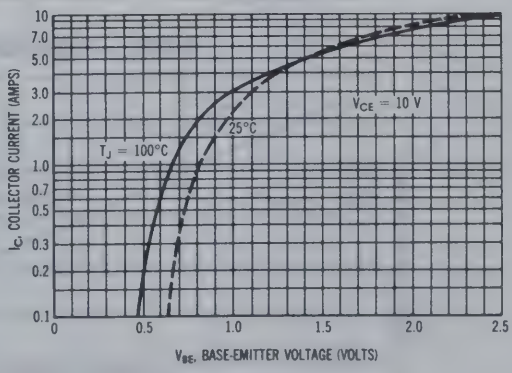


FIGURE 6 — TRANSCONDUCTANCE



MJ420 (SILICON)
MJ421



CASE 31
(TO-5)

Collector connected to case

NPN silicon high-voltage transistors designed for video output circuitry in transistorized television receivers.

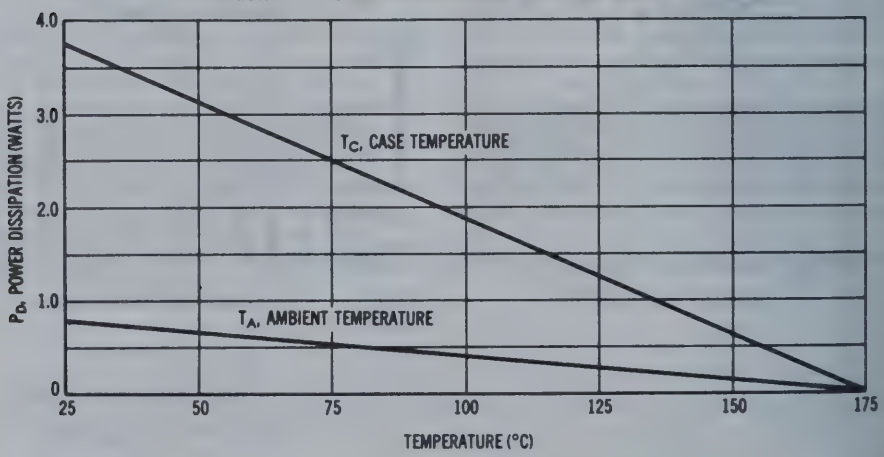
MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MJ420	MJ421	
Collector-Emitter Voltage	V_{CEO}	250	325	Vdc
Collector-Base Voltage	V_{CB}	275	350	Vdc
Emitter-Base Voltage	V_{EB}	6		Vdc
Collector Current-Continuous Peak	I_C	100 500		mAdc
Base Current	I_B	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 0.0053		Watts W/°C
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	2.5 0.025		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	40	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	187	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



MJ420, MJ421 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	MJ420 MJ421	$BV_{CEO(sus)}$*	250 325	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	MJ420 MJ421	BV_{CBO}	275 350	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	6	—	Vdc
Collector Cutoff Current (V_{CE} = rated voltage, I_B = 0)		I_{CEO}	—	1.0	mAdc
Collector Cutoff Current (V_{CB} = rated voltage, I_E = 0)		I_{CBO}	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 20 Vdc) (I_C = 10 mAdc, V_{CE} = 20 Vdc) (I_C = 30 mAdc, V_{CE} = 20 Vdc)		h_{FE}	 15 25 25	 — — 250	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)		$V_{CE(sat)}$	—	5.0	Vdc
Base-Emitter On Voltage (I_C = 30 mAdc, V_{CE} = 20 Vdc)		$V_{BE(on)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 10 MHz)		f_T	15	—	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CE} = 20 Vdc, I_C = 0)		C_{re}	—	12	pF
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	12	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 1 kHz)		h_{fe}	25	—	—

*Pulse Test: PW ≤ 300 μs, duty cycle ≤ 2%

FIGURE 2 — CURRENT GAIN CHARACTERISTICS

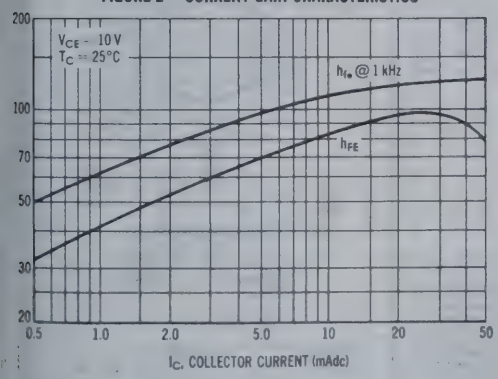
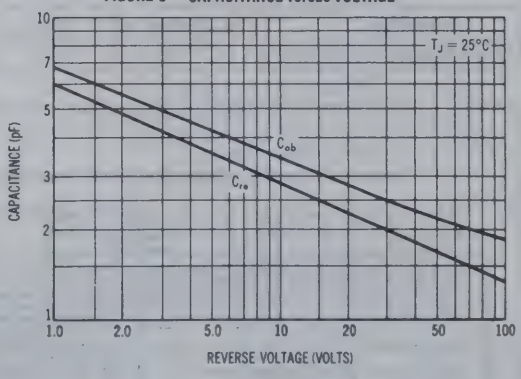


FIGURE 3 — CAPACITANCE versus VOLTAGE



MJ423
MJ431

For Specifications, See MJ413 Data.

MJ450 (SILICON)

HIGH-POWER PNP SILICON TRANSISTOR

. . . designed for high-current switching and general purpose amplifier applications.

- Low Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc @ I_C = 10 Adc
- DC Current Gain — h_{FE} = 20 (Min) @ I_C = 10 Adc
- Excellent Safe Area Characteristics

30 AMPERE
POWER TRANSISTOR
PNP SILICON

40 VOLTS
150 WATTS



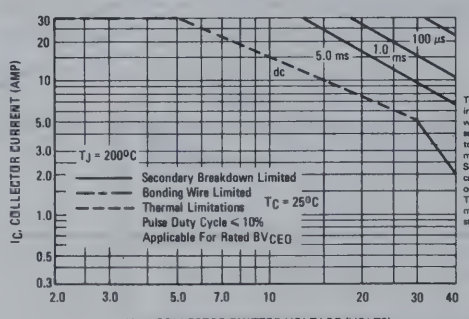
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current — Continuous	I_C	30	Adc
Base Current	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.86	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

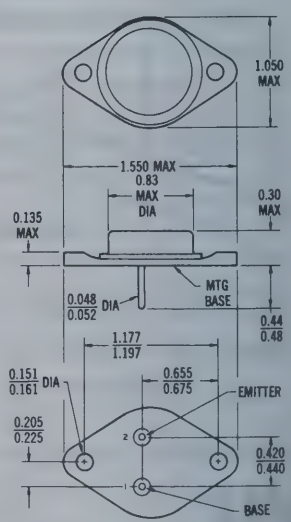
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



CASE 12
(TO-3 except Pin Diameter)
(Collector Connected to Case)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage[1] (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	1.0	mAdc
Emitter-Base Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	10	mAdc
ON CHARACTERISTICS				
DC Current Gain[1] (I_C = 10 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	20	–	–
Collector-Emitter Saturation Voltage[1] (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{CE(sat)}$	–	1.0	Vdc
Base-Emitter Saturation Voltage[1] (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{BE(sat)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	2.0	–	MHz

[1] Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – NORMALIZED DC CURRENT GAIN

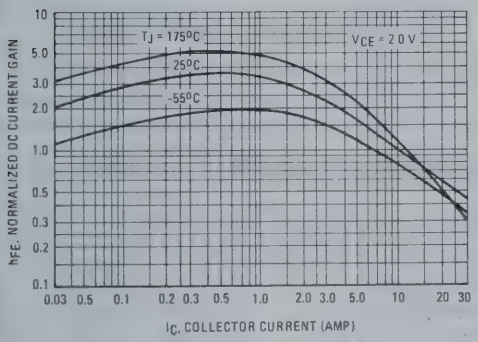


FIGURE 3 – "ON" VOLTAGES

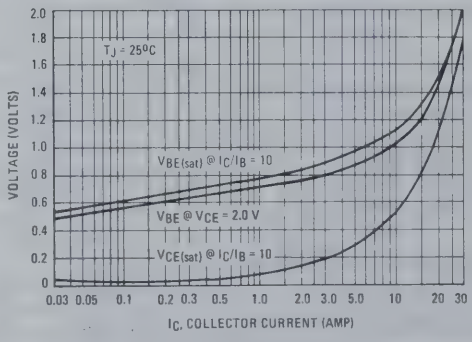
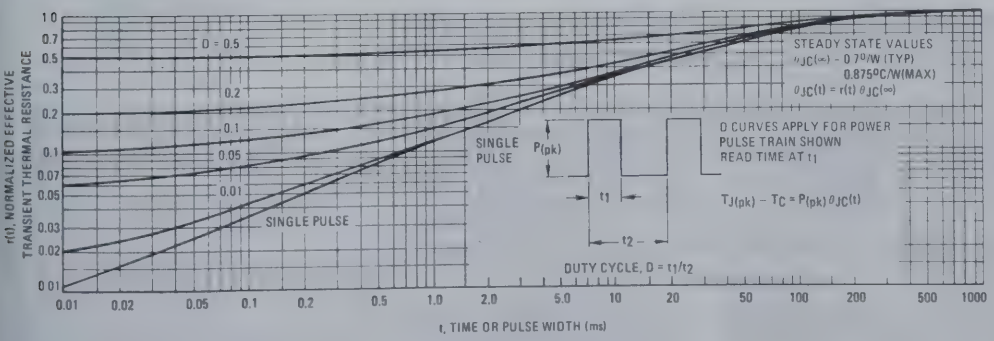


FIGURE 4 – THERMAL RESPONSE



MJ480 (SILICON)
MJ481

NPN SILICON POWER TRANSISTORS

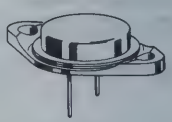
. . . designed for general-purpose and 5 to 20 Watt audio amplifier applications.

- Current-Gain–Bandwidth Product –
  f_T = 4.0 MHz (Min) @ I_C = 1.0 Adc
- DC Current Gain –
  h_{FE} = 30–200 @ I_C = 1.0 Adc
- Complements to PNP MJ490 and MJ491

4 AMPERE
POWER TRANSISTORS

NPN SILICON

40–60 VOLTS
87.5 WATTS



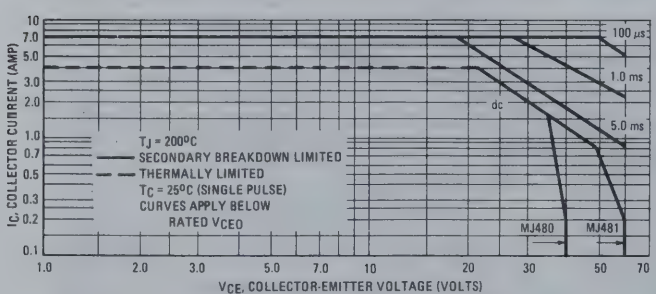
MAXIMUM RATINGS

Rating	Symbol	MJ480	MJ481	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	4.0 7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	87.5 500		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

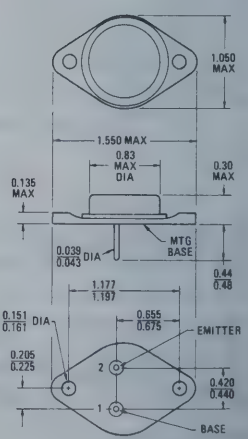
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C - V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



CASE 11
TO-3
Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0) MJ480 / MJ481	BV_{CEO}	40 / 60	– / –	Vdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	I_{CBO}	–	1.0	mAdc
(V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)		–	5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}		1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	50	–	–
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		30	200	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		10		
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	–	0.4	Vdc
(I_C = 3.0 Adc, I_B = 0.3 Adc)		–	1.2	
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$		1.0	Vdc
(I_C = 3.0 Adc, I_B = 0.3 Adc)		–	1.5	
Base-Emitter "On" Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	–	1.2	Vdc
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)			1.5	
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	4.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	200	pF

FIGURE 2 – NORMALIZED DC CURRENT GAIN

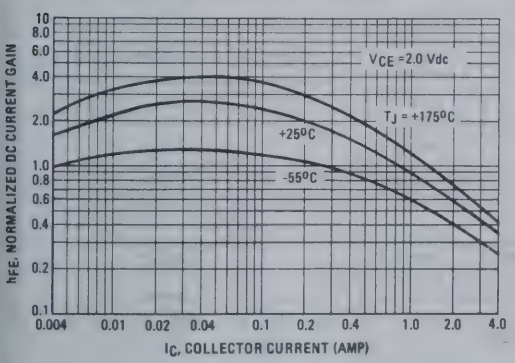


FIGURE 3 – "ON" VOLTAGES

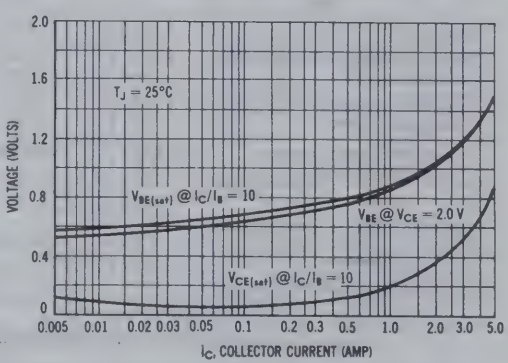
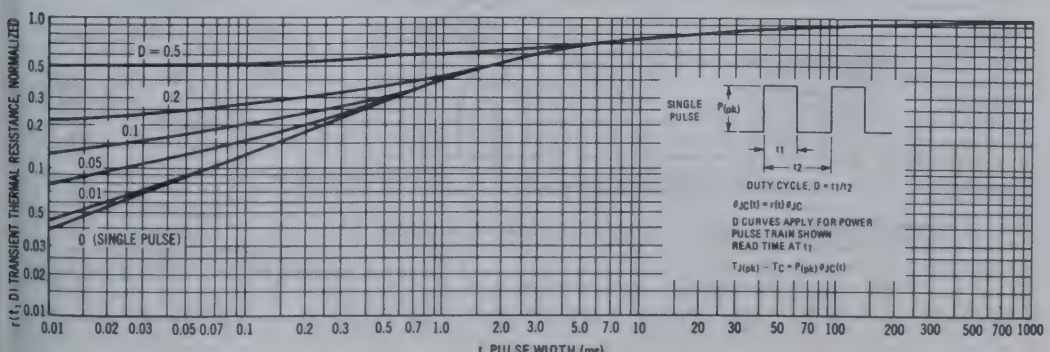


FIGURE 4 – TRANSIENT THERMAL RESISTANCE



MJ490 (SILICON)
MJ491

PNP SILICON POWER TRANSISTORS

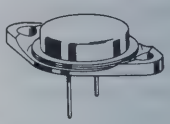
. . . designed for general-purpose and 5 to 20 Watt audio amplifier applications.

- Current-Gain—Bandwidth Product — f_T = 4.0 MHz (Min) @ I_C = 1.0 Adc
- DC Current Gain — h_{FE} = 30–200 @ I_C = 1.0 Adc
- Complements to NPN MJ480 and MJ481

4 AMPERE
POWER TRANSISTORS

PNP SILICON

40–60 VOLTS
87.5 WATTS



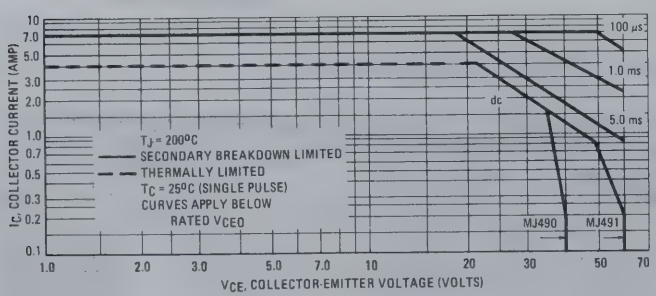
MAXIMUM RATINGS

Rating	Symbol	MJ490	MJ491	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	4.0 7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	87.5 500		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200		°C

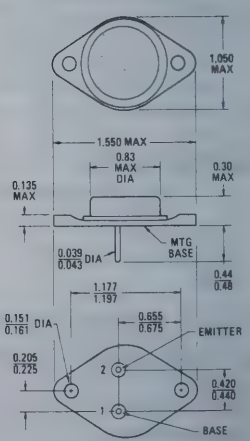
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



CASE 11
TO-3
Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0) MJ490 / MJ491	BV_{CEO}	40 / 60		Vdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	I_{CBO}		1.0	mAdc
(V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)			5.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}		1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	50	–	
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		30	200	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		10	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	–	0.4	Vdc
(I_C = 3.0 Adc, I_B = 0.3 Adc)		–	1.2	
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$		1.0	Vdc
(I_C = 3.0 Adc, I_B = 0.3 Adc)		–	1.5	
Base-Emitter "On" Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	–	1.2	Vdc
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		–	1.5	
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	4.0		MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}		200	pF

FIGURE 2 – NORMALIZED DC CURRENT GAIN

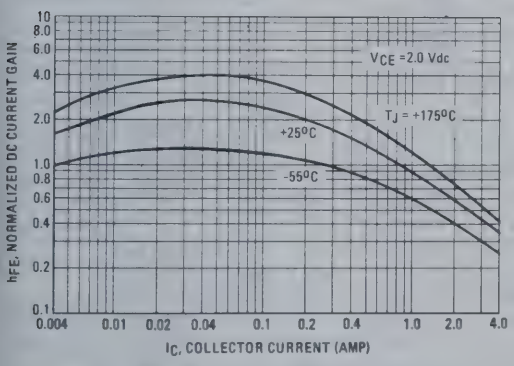


FIGURE 3 – "ON" VOLTAGE

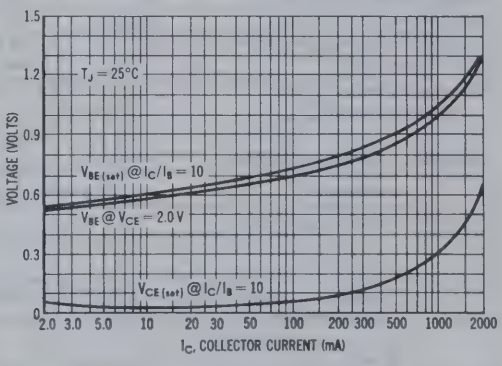
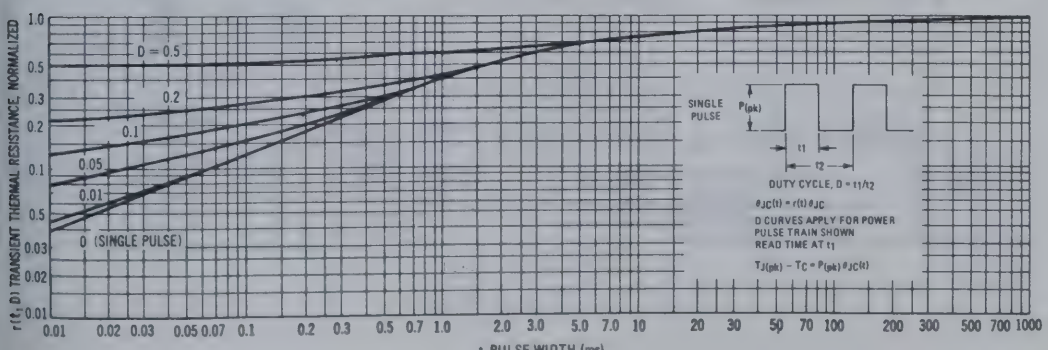


FIGURE 4 – TRANSIENT THERMAL RESISTANCE



MJ500 (SILICON)
MJ501

MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for switching and wide-band amplifier applications.

- Low Collector Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 7.0 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Collector Common to Case

7 AMPERE
POWER TRANSISTORS
PNP SILICON

60-80 VOLTS
60 WATTS

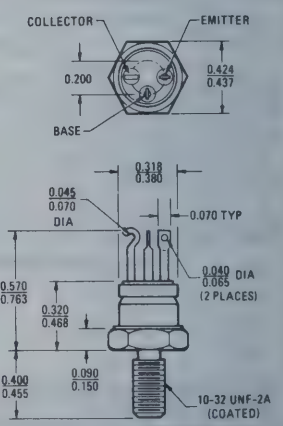


MAXIMUM RATINGS

Rating	Symbol	MJ500	MJ501	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	7.0		Adc
Base Current – Continuous	I_B	1.0		Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	60 343		Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

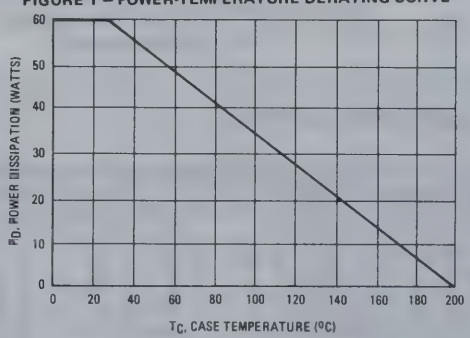
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.91	$^oC/W$



CASE 160A
TO-59
Collector Common
to Case

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



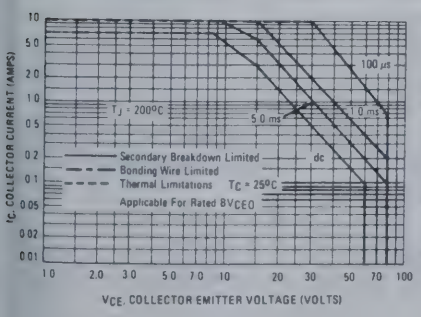
Safe Area Curves are indicated by Figure 2.
All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 50 mAdc, I_B = 0)	MJ500 MJ501	$V_{CEO(sus)}$*	60 80	– –	Vdc
Collector Cutoff Current (V_{CE} = 55 Vdc, I_B = 0) (V_{CE} = 75 Vdc, I_B = 0)	 MJ500 MJ501	I_{CEO}	 – –	 100 100	μAdc
Collector Cutoff Current (V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C) (V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	 MJ500 MJ501 MJ500 MJ501	I_{CEX}	 – – – –	 10 10 1.0 1.0	 μAdc mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_C = 0)		I_{CBO}	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 500 mAdc, V_{CE} = 2.0 Vdc) (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}*	 25 25 15	 – 180 –	–
Collector-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc) (I_C = 7.0 Adc, I_B = 0.7 Adc)		$V_{CE(sat)}$*	 – –	 0.7 1.2	Vdc
Base-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc) (I_C = 7.0 Adc, I_B = 0.7 Adc)		$V_{BE(sat)}$*	 – –	 1.2 2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	300	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	1250	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 40 Vdc, $V_{BE(off)}$ = 4.0 Vdc, I_C = 2.0 Adc, I_{B1} = 200 mAdc)	t_d	–	100	ns
Rise Time		t_r	–	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc, I_{B1} = I_{B2} = 200 mAdc)	t_s	–	1.0	μs
Fall Time		t_f	–	150	ns

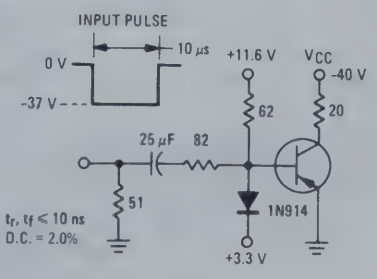
*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – SWITCHING TIME TEST CIRCUIT



MJ802 (SILICON)

HIGH-POWER NPN SILICON TRANSISTOR

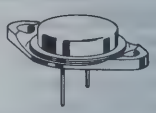
. . . for use as an output device in complementary audio amplifiers to 100-Watts music power per channel.

- High DC Current Gain — h_{FE} = 25–100 @ I_C = 7.5 A
- Excellent Safe Operating Area
- Complement to the PNP MJ4502

30 AMPERE
POWER TRANSISTOR

NPN SILICON

100 VOLTS
200 WATTS



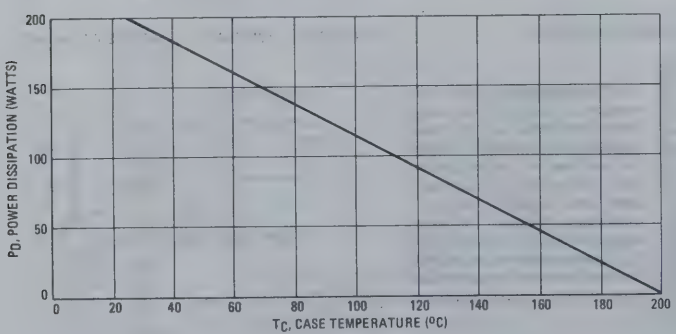
MAXIMUM RATINGS

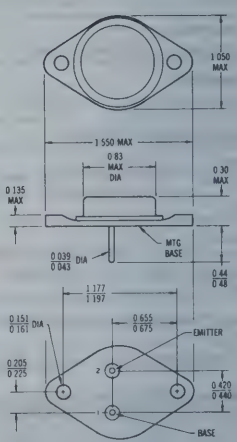
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Collector-Emitter Voltage	V_{CEO}	90	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	30	Adc
Base Current	I_B	7.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.14	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE





CASE 11
(TO-3)
Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 200 mAdc, R_{BE} = 100 Ohms)	BV_{CER}*	100	–	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc)	$BV_{CEO(sus)}$*	90	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)	I_{CBO}	–	1.0	mAdc
(V_{CB} = 100 Vdc, I_E = 0, T_C = 150°C)		–	5.0	
Emitter-Base Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	h_{FE}*	25	100	–
Base-Emitter "On" Voltage* (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$*	–	1.3	Vdc
Collector-Emitter Saturation Voltage* (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{CE(sat)}$*	–	0.8	Vdc
Base-Emitter Saturation Voltage* (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{BE(sat)}$*	–	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	2.0	–	MHz

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

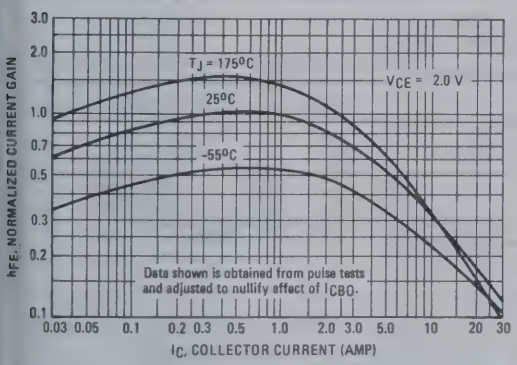


FIGURE 3 – "ON" VOLTAGES

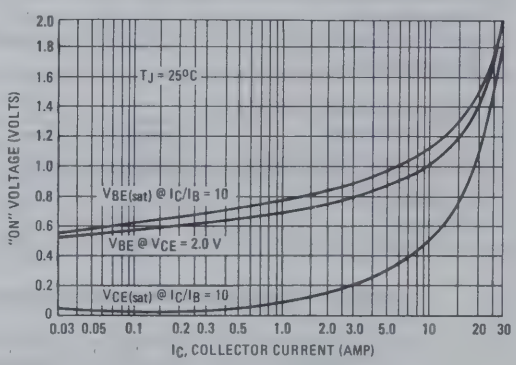
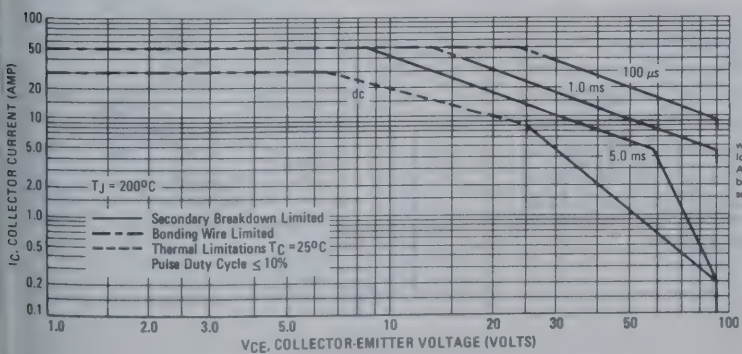


FIGURE 4 – ACTIVE REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ900, MJ901 PNP (SILICON)
MJ1000, MJ1001 NPN

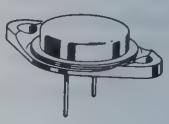
MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain – h_{FE} = 2500 (Typ) @ I_C = 3.0 Adc
- Monolithic Construction

5.0 AMPERE DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON

60–80 VOLTS
90 WATTS



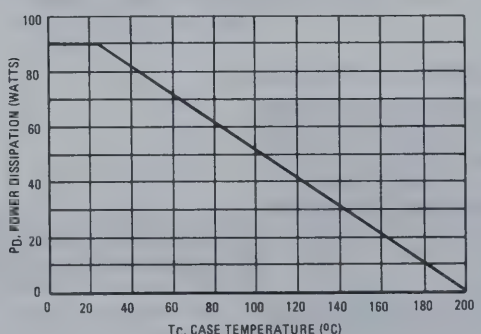
MAXIMUM RATINGS

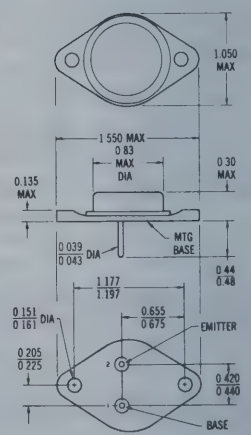
Rating	Symbol	MJ900 MJ1000	MJ901 MJ1001	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	5.0		Adc
Base Current	I_B	0.1		Adc
Total Device Dissipation @ $T_C = 25^oC$	P_D	90		Watts
Derate above 25^oC		0.515		$W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.94	$^oC/W$

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



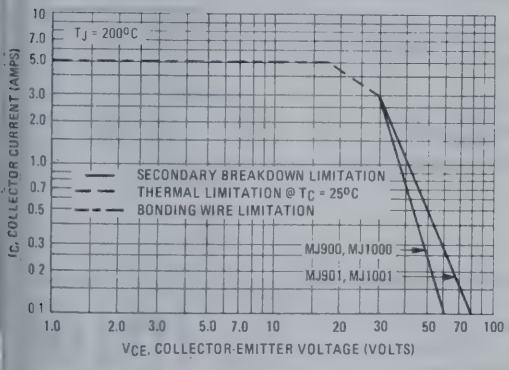


TO-3 PACKAGE
CASE 11
Collector connected to case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

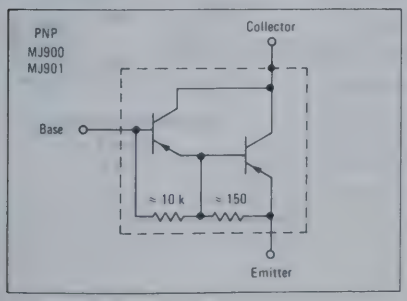
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	MJ900, MJ1000	BV_{CEO}	60	–	Vdc
	MJ901, MJ1001		80	–	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	MJ900, MJ1000		–	0.20	
(V_{CB} = 80 Vdc, I_E = 0)	MJ901, MJ1001		–	0.20	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	MJ900, MJ1000		–	2.0	
(V_{CB} = 80 Vdc, I_E = 0, T_C = 150°C)	MJ901, MJ1001		–	2.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
Collector-Emitter Leakage Current		I_{CEO}			μAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJ900, MJ1000		–	500	
(V_{CE} = 40 Vdc, I_B = 0)	MJ901, MJ1001		–	500	
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 3.0 Vdc)		h_{FE}	1000	–	–
Base-Emitter Voltage (I_C = 3.0 Adc, V_{CE} = 3.0 Vdc)		V_{BE}	–	2.5	Vdc
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain (I_C = 3.0 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)		h_{fe}	1.0	–	–

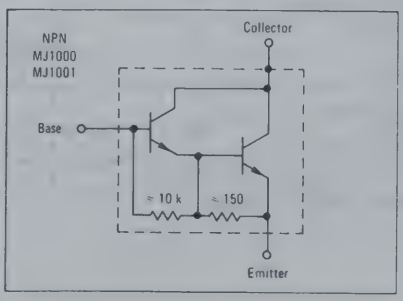
FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – DARLINGTON CIRCUIT SCHEMATIC





MJ1800 (SILICON)

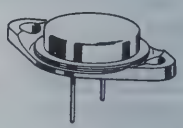
HIGH-VOLTAGE NPN SILICON TRANSISTOR

. . . designed for use in vertical deflection amplifier circuits in television receivers.

- High Collector-Emitter Voltage – V_{CER} = 500 Vdc
- Excellent Gain Linearity

5 AMPERES
POWER TRANSISTOR
NPN SILICON

500 VOLTS
100 WATTS

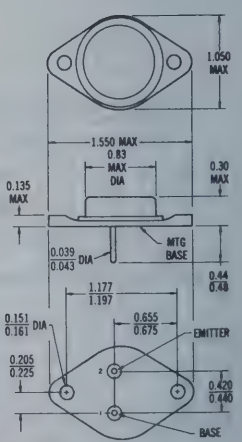


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	250	Vdc
Collector-Emitter Voltage	V_{CER}	500	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	5.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	100 0.8	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.25	$^oC/W$



Collector Connected to Case
CASE 11
TO-3

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 0.1 Adc, I_B = 0)	BV_{CEO}*	250	–	Vdc
Collector Cutoff Current (V_{CE} = 500 Vdc, R_{BE} = 1.5 k Ohms)	I_{CER}	–	200	μAdc
Emitter-Base Leakage Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 0.3 Adc, V_{CE} = 5.0 Vdc)	h_{FE1}*	35	–	–
DC Current Gain* (I_C = 0.4 Adc, V_{CE} = 5.0 Vdc)	h_{FE2}*	40	120	–
Gain Linearity	h_{FE1}/h_{FE2}	0.95	–	–

*Pulse Test: Pulse Width ≤ 500 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE

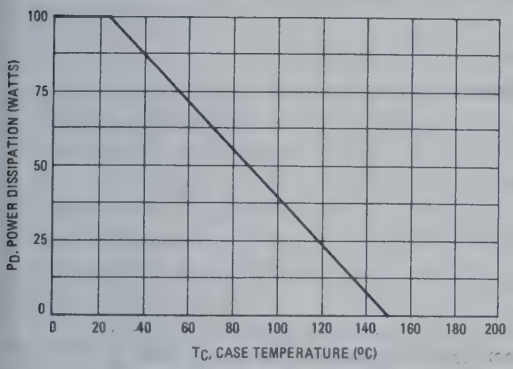


FIGURE 2 – NORMALIZED DC CURRENT GAIN

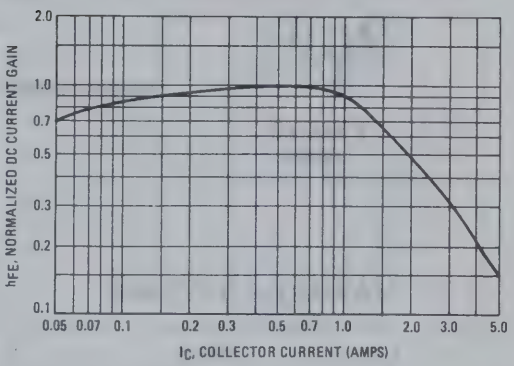
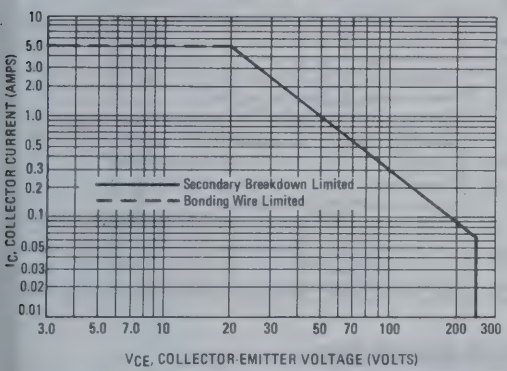


FIGURE 3 – ACTIVE-REGION DC SAFE OPERATING AREA



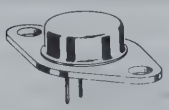
The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ3771
MJ3772

For Specifications, See 2N3771 Data.

MJ2249 (SILICON)
MJ2250
MJ3101

Medium-power NPN silicon transistors ideal for use as drivers, switches, amplifiers.



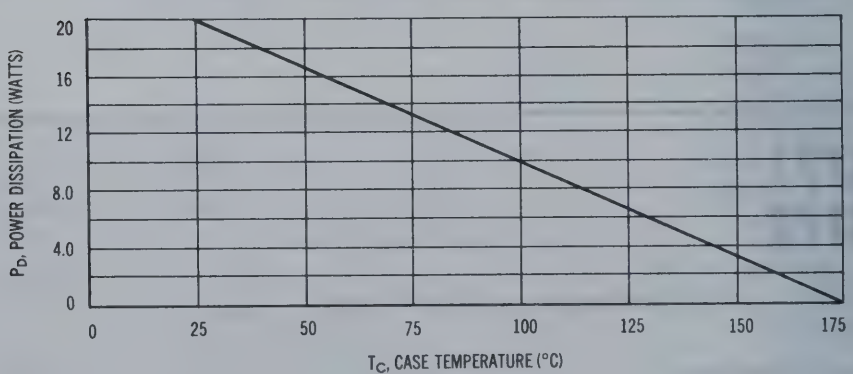
Collector connected to case

CASE 80
(TO-66)

MAXIMUM RATINGS

Rating	Symbol	MJ3101	MJ2249	MJ2250	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 6.0 →			Vdc
Collector Current - Continuous Peak	I_C	← 2.0 → ← 3.0 →			Adc
Base Current	I_B	← 0.5 →			Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	← 20 → ← 0.133 →			Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +175 →			^oC

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



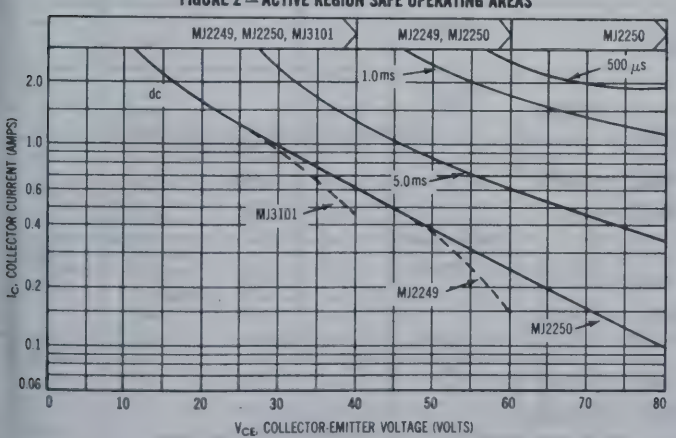
Safe Area Curves are indicated by Figure 2. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Voltage* (I_C = 100 mAdc, I_B = 0)	MJ3101	BV_{CEO}*	40	—	Vdc
	MJ2249		60	—	
	MJ2250		80	—	
Collector-Base Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	MJ3101	I_{CBO}		1.0	mAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
(V_{CB} = 60 Vdc, I_E = 0)	MJ2249		—	1.0	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
(V_{CB} = 80 Vdc, I_E = 0)	MJ2250		—	1.0	
(V_{CB} = 80 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
Emitter-Base Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	All Types	I_{EBO}	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 4.0 Vdc)	All Types	h_{FE}	25	—	—
(I_C = 100 mAdc, V_{CE} = 4.0 Vdc)†	All Types		25	200	
(I_C = 500 mAdc, V_{CE} = 4.0 Vdc)*	All Types		25*	200*	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	All Types	$V_{CE(sat)}$	—	1.0	Vdc
(I_C = 750 mAdc, I_B = 75 mAdc)	MJ3101		—	2.5	
(I_C = 1.0 Adc, I_B = 0.1 Adc)	MJ2249, MJ2250		—	2.5	
Base-Emitter Saturation Voltages (I_C = 500 mAdc, I_B = 50 mAdc)	All Types	$V_{BE(sat)}$	—	1.2	Vdc
(I_C = 750 mAdc, I_B = 75 mAdc)	MJ3101		—	1.5	
(I_C = 1.0 Adc, I_B = 0.1 Adc)	MJ2249, MJ2250		—	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)	All Types	f_T	10	—	MHz

*PULSE TEST: PW ≤ 300 μs, Duty Cycle ≤ 2.0% †Color coded h_{FE} groups available at 100 mAdc

FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. These curves can be used as long as the average power derating curve (Figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

NOTE: For additional design curves, please refer to Type 2N3766.

MJ2251 (SILICON)
MJ2252



CASE 80
(TO-66)

High-voltage NPN silicon power transistors, particularly well suited for power output stages in television, radio, phonograph and other consumer product applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage MJ2251 MJ2252	V_{CEO}	 225 300	Vdc
Emitter-Base Voltage	V_{EB}	6	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_C = 70°C Derate above 70°C	P_D	 10 0.125	 Watts W/°C
Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0) MJ2251 MJ2252	BV_{CEO}	 225 300	 — —	 — —	Vdc
Collector Cutoff Current (V_{CB} = 300 Vdc, I_E = 0)	I_{CBO}	—	—	100	μAdc
Emitter-Base Leakage Current (V_{EB} = 6 Vdc, I_C = 0)	I_{EBO}	—	—	100	μAdc
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	200	—
Small Signal Current Gain (I_C = 20 mAdc, V_{CE} = 50 Vdc, f = 10 MHz)	h_{fe}	1.0	—	—	—
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{fe}	 — —	 40 65	 — —	—
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{re}	 — —	 2.5 4.0	 — —	X10-5
Input Impedance (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{ie}	 — —	 150 75	 — —	ohms
Output Admittance (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kHz) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kHz)	h_{oe}	 — —	 5 20	 — —	μmhos

COLLECTOR CHARACTERISTICS

FIGURE 1 — MJ2251

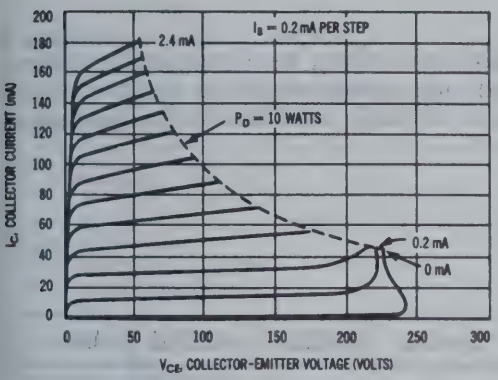


FIGURE 2 — MJ2252

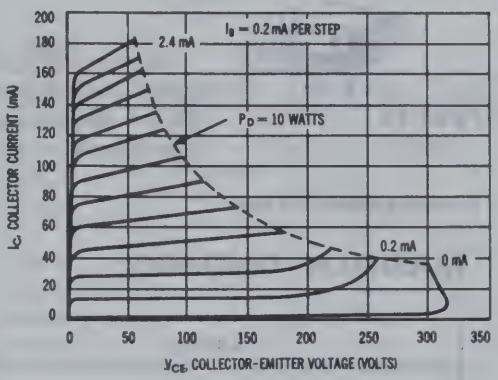


FIGURE 3 — COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

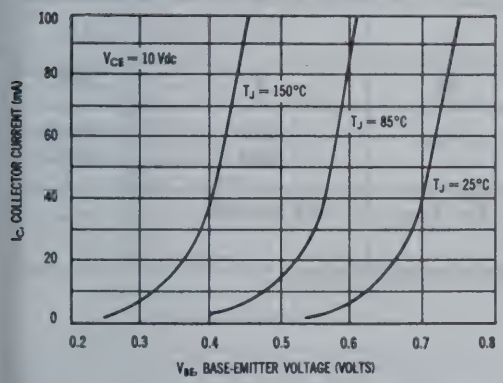


FIGURE 4 — TYPICAL LINE-OPERATED 1.5-WATT AUDIO AMPLIFIER

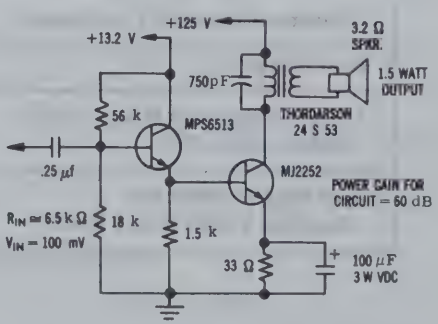


FIGURE 5 — TYPICAL TOTAL HARMONIC DISTORTION versus P_{out}

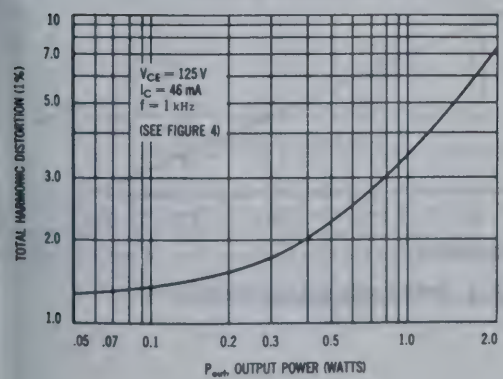
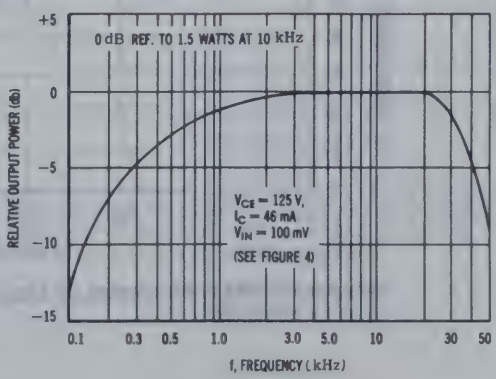


FIGURE 6 — TYPICAL FREQUENCY RESPONSE OF LINE OPERATED AUDIO AMPLIFIER



MJ2267 (SILICON)
MJ2268



CASE 11
(TO-3)

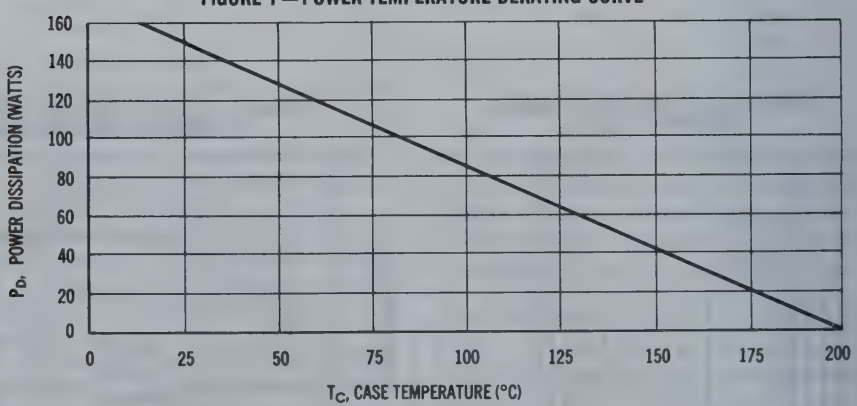
Collector connected to case

Silicon PNP power transistors, designed for medium-speed switching and high-power amplifier applications. These devices can be directly substituted for germanium types.

MAXIMUM RATINGS

Rating	Symbol	MJ2267	MJ2268	Unit
Collector-Emitter Voltage	V_{CEO}	40	55	Vdc
Collector-Base Voltage	V_{CB}	40	55	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	Vdc
Collector Current - Continuous	I_C	5.0		Adc
Base Current	I_B	3		Adc
Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	150 0.86		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figures 2, 3. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)	MJ2267	$BV_{CEO(sus)}$*	40	—	Vdc
	MJ2268		55	—	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, V_{BE} = 1.5 Vdc)	MJ2267		—	1.0	
(V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc)	MJ2268		—	1.0	
(V_{CE} = 20 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	MJ2267		—	5.0	
(V_{CE} = 30 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	MJ2268		—	5.0	
Emitter-Base Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)			20	—	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)*			20	100	
Collector-Emitter Saturation Voltage* (I_C = 4.0 Adc, I_B = 0.4 Adc)		$V_{CE(sat)}$*	—	1.0	Vdc
Base-Emitter Saturation Voltage* (I_C = 4.0 Adc, I_B = 0.4 Adc)		$V_{BE(sat)}$*	—	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc)		f_T	3.0	—	MHz

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ACTIVE REGION SAFE OPERATING AREAS

FIGURE 2 — MJ2267

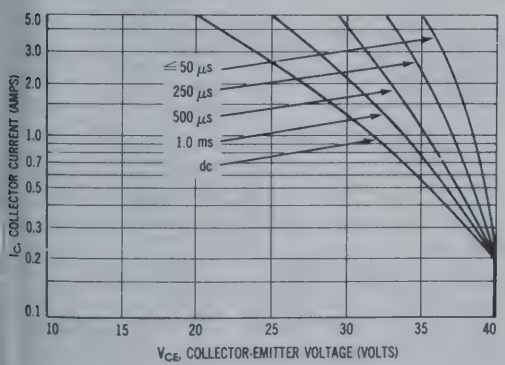
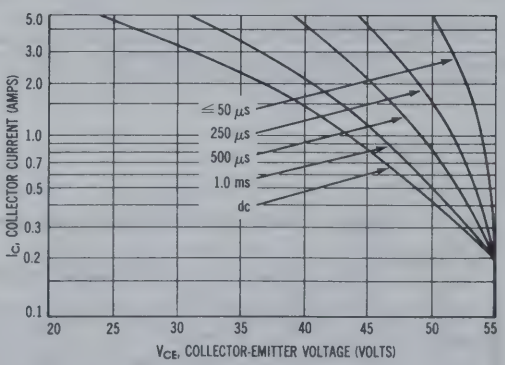


FIGURE 3 — MJ2268



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

NOTE: For additional design curves, please refer to Type 2N3789.

MJ2500, MJ2501 PNP (SILICON)
MJ3000, MJ3001 NPN

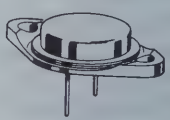
MEDIUM-POWER COMPLEMENTARY SILICON TRANSISTORS

. . . for use as output devices in complementary general purpose amplifier applications.

- High DC Current Gain – h_{FE} = 2500 (Typ) @ I_C = 5.0 Adc
- Monolithic Construction

10 AMPERE DARLINGTON POWER TRANSISTORS COMPLEMENTARY SILICON

60–80 VOLTS
150 WATTS



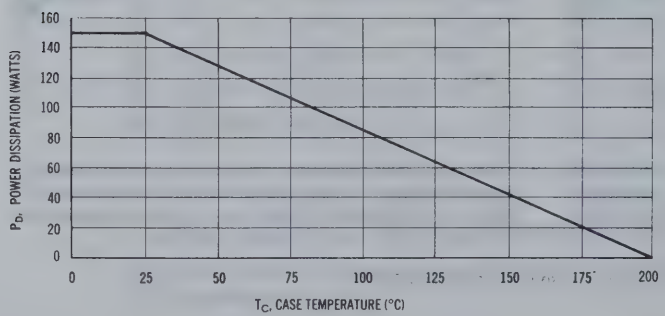
MAXIMUM RATINGS

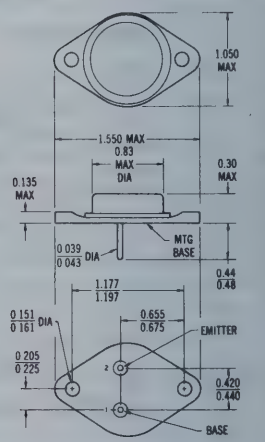
Rating	Symbol	MJ2500 MJ3000	MJ2501 MJ3001	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	10		Adc
Base Current	I_B	0.2		Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	150 0.857		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	$^oC/W$

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





TO-3
CASE 11
Collector connected to case

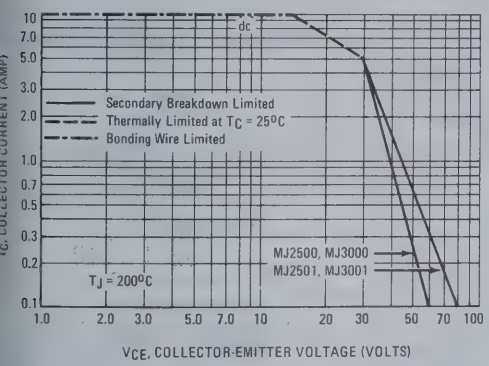
To convert inches to millimeters multiply by 25.4. All JEDEC TO-3 dimensions and notes apply.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, I_B = 0)	MJ2500, MJ3000	BV_{CEO}	60	–	Vdc
	MJ2501, MJ3001		80	–	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	MJ2500, MJ3000		–	0.4	
(V_{CB} = 80 Vdc, I_E = 0)	MJ2501, MJ3001		–	0.4	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	MJ2500, MJ3000		–	3.0	
(V_{CB} = 80 Vdc, I_E = 0, T_C = 150°C)	MJ2501, MJ3001		–	3.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
Collector-Emitter Leakage Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJ2500, MJ3000		–	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	MJ2501, MJ3001		–	1.0	
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 5.0 Adc, V_{CE} = 3.0 Vdc)		h_{FE}	1000	–	–
Base-Emitter Voltage(1) (I_C = 5.0 Adc, V_{CE} = 3.0 Vdc)		V_{BE}	–	3.0	Vdc
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain (I_C = 5.0 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)		h_{fe}	1.0	–	–

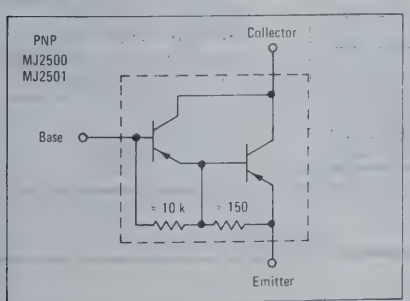
(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

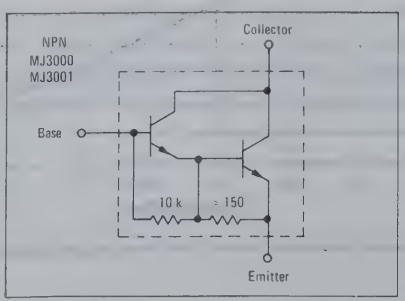
FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – DARLINGTON CIRCUIT SCHEMATIC





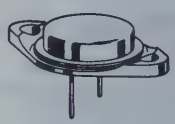
MJ2840 (SILICON)
MJ2841

HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in audio amplifier circuits utilizing complementary symmetry.

- Excellent Safe Operating Area
- DC Current Gain —
  h_{FE} = 20 - 100 @ I_C = 3.0 Adc (MJ2840)
  = 4.0 Adc (MJ2841)
- Complement to PNP MJ2940 and MJ2941

10 AMPERE
POWER TRANSISTORS
NPN SILICON
60–80 VOLTS
150 WATTS



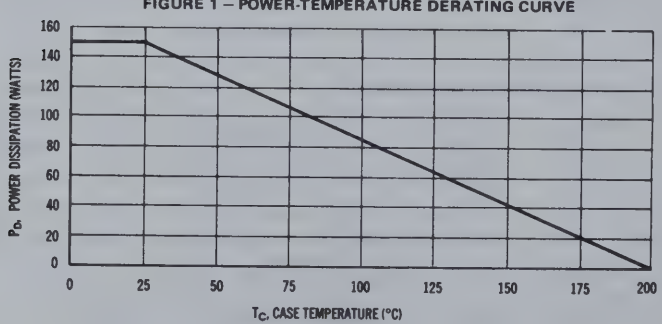
MAXIMUM RATINGS

Rating	Symbol	MJ2840	MJ2841	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	10		Adc
Base Current	I_B	4.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.85		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

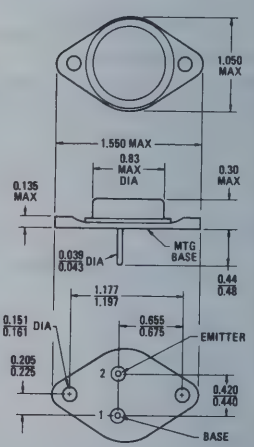
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 4. Both limits are applicable and must be observed.



CASE 11
(TO-3)
Collector Connected to Case

ELECTRICAL CHARACTERISTIC (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	MJ2840	$BV_{CEO(sus)}$	60	–	Vdc
	MJ2841		80	–	
Collector-Base Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	Both Types	I_{CBO}			mAdc
			0.1	–	
(V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)	Both Types		2.0	–	
Base-Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	Both Types	I_{EBO}	1.0	–	mAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	Both Types	h_{FE}	40	–	–
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2840		20	100	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	MJ2841		20	100	
Base-Emitter On Voltage (1) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2840	$V_{BE(on)}$	–	1.3	Vdc
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	MJ2841		–	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.0	20	MHz

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

FIGURE 2 – DC CURRENT GAIN

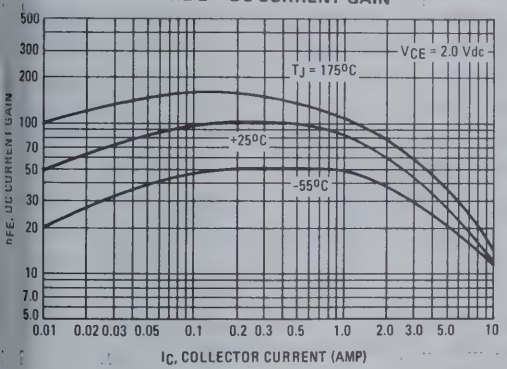


FIGURE 3 – "ON" VOLTAGES

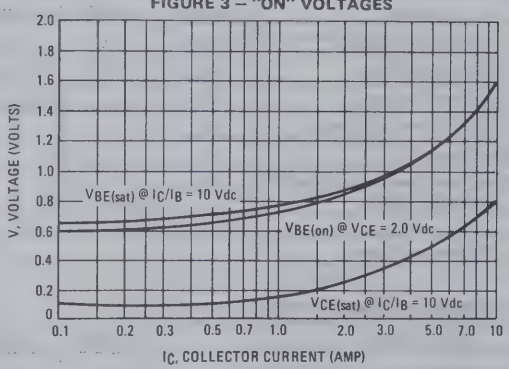
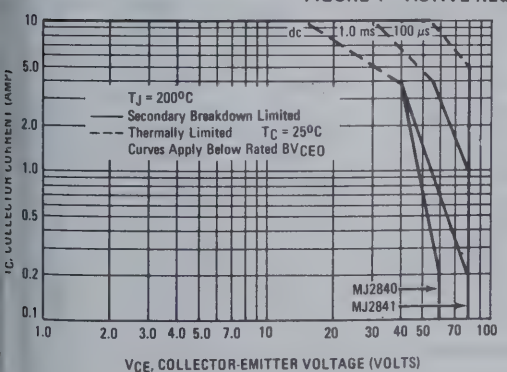


FIGURE 4 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

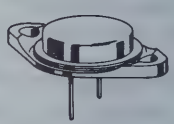
MJ2940 (SILICON)
MJ2941

HIGH-POWER PNP SILICON TRANSISTORS

. . . designed for use in audio amplifier circuits utilizing complementary symmetry.

- Excellent Safe Operating Area
- DC Current Gain –
  h_{FE} = 20 - 100 @ I_C = 3.0 Adc (MJ2940)
  = 4.0 Adc (MJ2941)
- Complement to NPN MJ2840 and MJ2841

10 AMPERE
POWER TRANSISTORS
PNP SILICON
60–80 VOLTS
150 WATTS



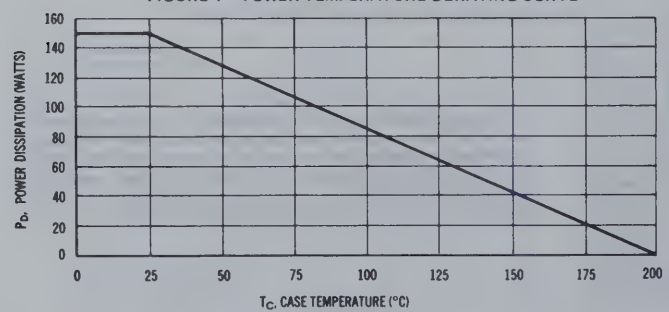
MAXIMUM RATINGS

Rating	Symbol	MJ2940	MJ2941	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	10		Adc
Base Current	I_B	4.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.85		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

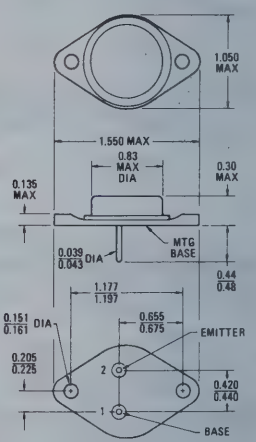
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 4. Both limits are applicable and must be observed.



CASE 11
(TO-3)
Collector Connected to Case

ELECTRICAL CHARACTERISTIC (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage[1] (I_C = 200 mAdc, I_B = 0)	MJ2940 MJ2941	$V_{CEO(sus)}$	 60 80	 – –	Vdc
Collector-Base Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	–	0.1	mAdc
(V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)			–	3.0	
Emitter-Base Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain[1] (I_C = 50 mAdc, V_{CE} = 10 Vdc)	Both Types	h_{FE}	40	–	–
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2940		20	100	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	MJ2941		20	100	
Base-Emitter On Voltage[1] (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2940	$V_{BE(on)}$	–	1.3	Vdc
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)	MJ2941		–	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		f_T	4.0	20	MHz

[1]Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

FIGURE 2 – DC CURRENT GAIN

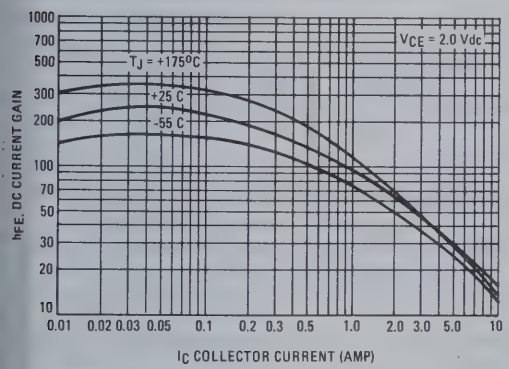


FIGURE 3 – "ON" VOLTAGES

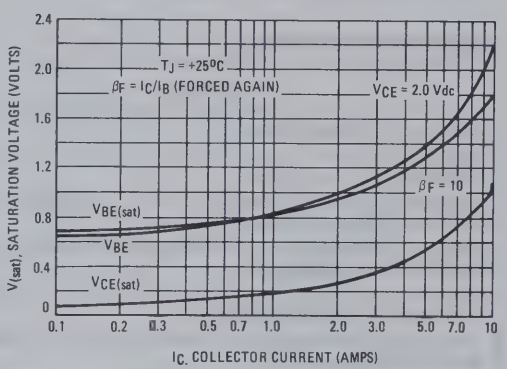
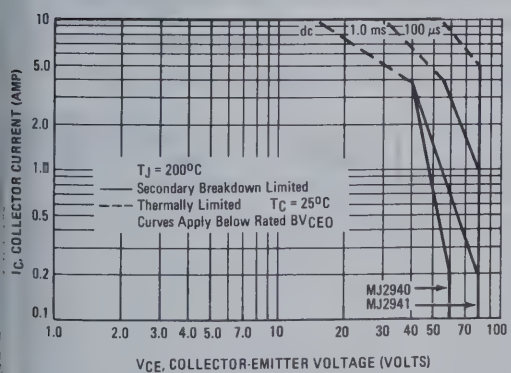


FIGURE 4 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ3029 (SILICON)
MJ3030



CASE 11
(TO-3)

Collector connected to case

NPN power transistors designed for horizontal and vertical deflection amplifier circuits for TV. Also for high power line-operated audio outputs for radio, TV, phonographs and P.A. systems.

MAXIMUM RATINGS

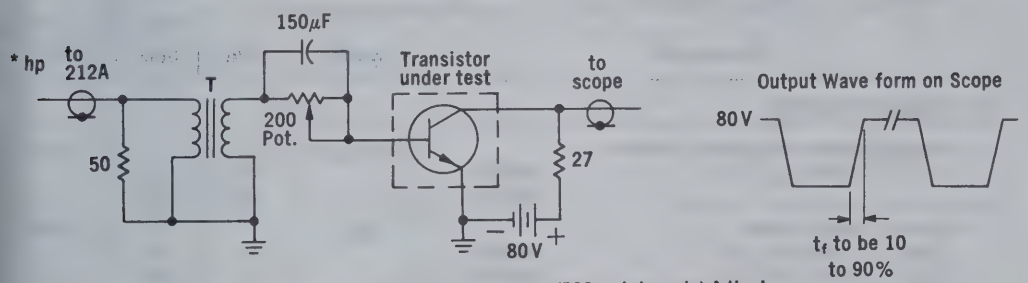
Rating	Symbol	3029	3030	Unit
Collector-Emitter Voltage	V_{CEO}	250	325	Vdc
Collector-Emitter Voltage	V_{CER}	500	-	Vdc
Collector-Emitter Voltage	V_{CEX}	-	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	3.5		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	125 1.0	125 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_C = 0)	MJ3029 MJ3030	BV_{CEO}	250 325	- -	Vdc
Collector Cutoff Current (V_{CE} = 500 Vdc, V_{BE} = 0, R_{BE} = 1.5 k ohms)	MJ3029	I_{CER}	-	1.0	mAdc
Collector Cutoff Current (V_{CE} = 700 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ3030	I_{CEX}	-	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 5.0 Vdc)	MJ3030	h_{FE}	3.75	-	-
DC Current Gain (I_C = 0.4 Adc, V_{CE} = 5.0 Vdc)	MJ3029	h_{FE1}	30	-	-
DC Current Gain (I_C = 0.3 Adc, V_{CE} = 5.0 Vdc)	MJ3029	h_{FE2}	25	-	-
Gain Linearity	MJ3029	$\frac{h_{FE1}}{h_{FE2}}$	0.95		-
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.8 Adc)		$V_{CE(sat)}$	-	2.0	Vdc
SWITCHING CHARACTERISTICS					
Fall Time (V_{CC} = 80 Vdc, I_C = 3.0 Adc, I_{B1} = I_{B2} = 0.8 Adc)	MJ3030	t_f	-	1.0	μs



* hp 212A: Set for 10μs wide pulses at 2000 pulses per sec. (500μs intervals) Adjust for I_{B1} = 0.8 A

Bias: Adjust to 1.5 V on a VTVM across the 200Ω Pot.

MJ3101

For Specifications See MJ2249 Data.

MJ3201 (SILICON)
MJ3202



CASE 80
(TO-66)

Collector connected to case

High-voltage NPN silicon transistors designed for use in line-operated equipment such as audio output amplifiers; low-current, high-voltage converters; and ac line relays.

MAXIMUM RATINGS

Rating	Symbol	MJ3201	MJ3202	Unit
Collector-Emitter Voltage	V_{CEO}	225	300	Vdc
Collector-Base Voltage	V_{CB}	225	300	Vdc
Emitter-Base Voltage	V_{EB}	3		Vdc
Collector Current-Continuous	I_C	100		mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	15 0.1		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to + 175		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	10	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise specified)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0)	MJ3201 MJ3202	BV_{CEO}	225 300	— —	Vdc
Collector Cutoff Current (V_{CB} = 225 Vdc, I_E = 0) (V_{CB} = 300 Vdc, I_E = 0)	 MJ3201 MJ3202	I_{CBO}	 — —	 0.1 0.1	mAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 50 mAdc, V_{CE} = 10 Vdc)		h_{FE}*	30	200	—
Collector-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$*	—	5.0	Vdc
Base-Emitter On Voltage* (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$*	—	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	15	—	MHz

*Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

FIGURE 1 — DC CURRENT GAIN

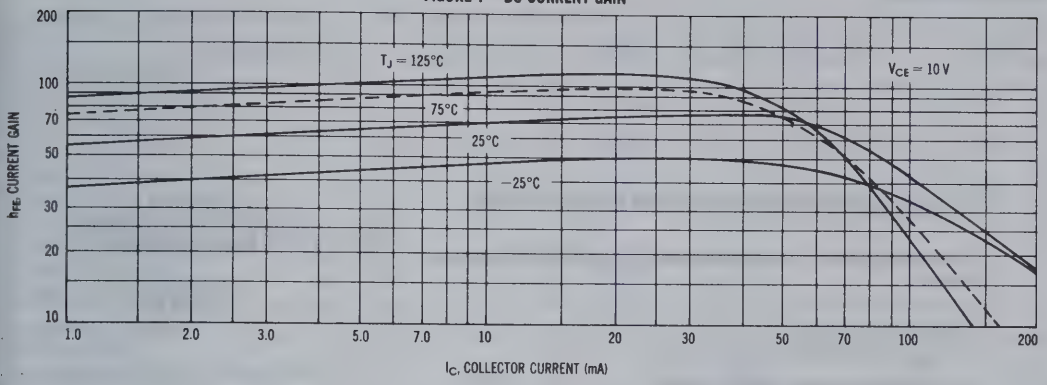


FIGURE 2 — COLLECTOR OUTPUT CHARACTERISTICS

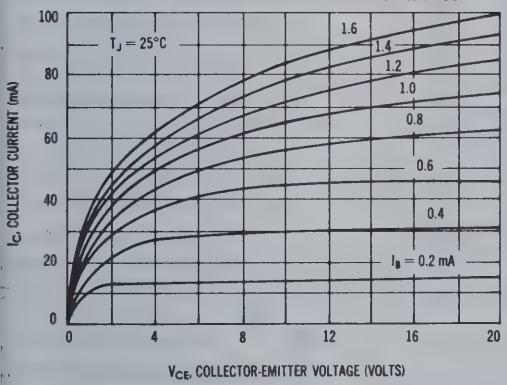


FIGURE 3 — TRANSCONDUCTANCE

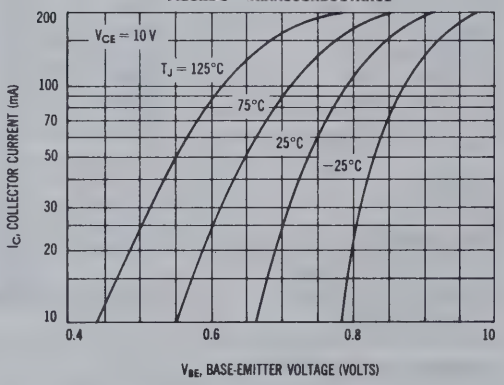


FIGURE 4 — TYPICAL AUDIO AMPLIFIER

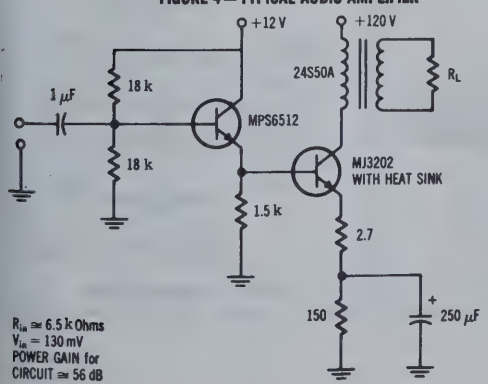
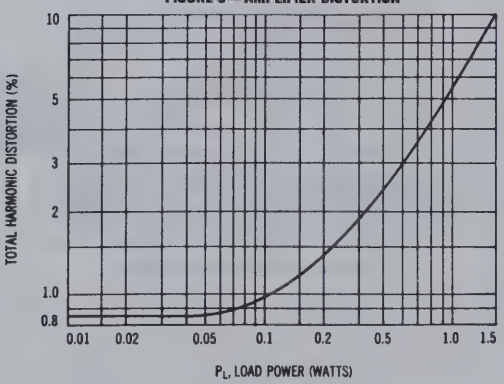


FIGURE 5 — AMPLIFIER DISTORTION



MJ3801 (SILICON)
MJ3802

MEDIUM POWER NPN SILICON TRANSISTORS

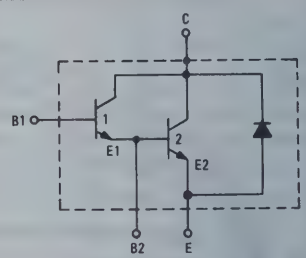
. . . designed for use in industrial and military amplifier and switching systems.

- High DC Current Gain –
  h_{FE} = 1,000 (Min) @ I_C = 10 Adc
- Low Collector-Emitter Cutoff Current –
  I_{CES} = 10 μAdc (Max) @ V_{CE} = 80 Vdc
- Darlington Connection

10 AMPERE
POWER TRANSISTORS
NPN SILICON

80 VOLTS
40 WATTS





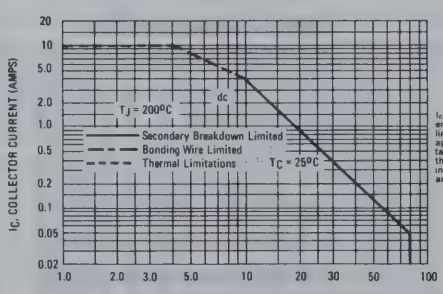
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE20}	80	Vdc
Collector-Base Voltage	V_{CB1}	80	Vdc
Collector-Base Voltage	V_{CB2}	80	Vdc
Emitter-Base Voltage	V_{E2B1}	15	Vdc
Emitter-Base Voltage	V_{E2B2}	7.5	Vdc
Emitter-Base Voltage	V_{E1B1}	7.5	Vdc
Collector Current – Continuous Peak	I_C	10 15	Adc
Base Current	I_{B1}	0.5	Adc
Base Current	I_{B2}	2.0	Adc
Commutating-Diode Current	I_D	10	Adc
Total Device Dissipation @ T_C = 25°C Derate linearly from 25°C	P_D	40 0.228	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

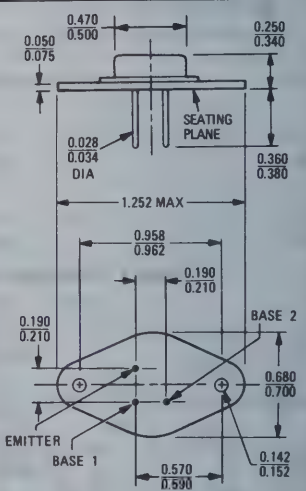
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.38	°C/W

FIGURE 1 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



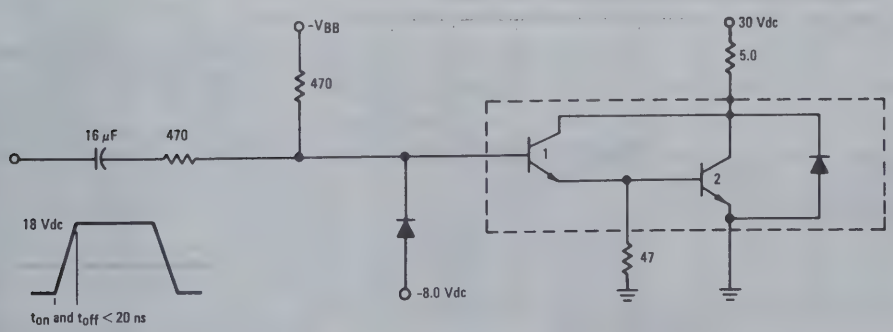
CASE 198
(STYLE 2)

(Collector Connected to Case)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown (I_C = 25 mAdc, I_{B1} = I_{B2} = 0)		BV_{CEO}	80	–	Vdc
Collector-Base Cutoff Current (V_{CB1} = 80 Vdc, I_{B2} = 0)		I_{CB1O}	–	10	μAdc
Collector-Emitter Cutoff Current		I_{CE2S}			μAdc
(V_{CE} = 80 Vdc, V_{B1E} = 0, V_{B1E} = 0)			–	10	
(V_{CE} = 80 Vdc, V_{B1E} = 0, V_{B1E} = 0, T_C = 150°C)			–	1.0	mAdc
Emitter Cutoff Current (V_{EB1} = 15 Vdc, I_C = 0, I_{B2} = 0)		I_{E2B1O}	–	10	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc, I_{B2} = 0)	MJ3801		20,000	–	
	MJ3802		2000	–	
(I_C = 6.0 Adc, V_{CE} = 4.0 Vdc, I_{B2} = 0)	MJ3801		10,000	60,000	
	MJ3802		1000	20,000	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc, I_{B2} = 0)	MJ3801		1000	–	
	MJ3802		250	–	
Collector-Emitter Saturation Voltage		$V_{CE2(sat)}$			Vdc
(I_C = 6.0 Adc, I_{B1} = 15 mAdc, I_{B2} = 0)			–	1.5	
(I_C = 10 Adc, I_{B1} = 25 mAdc, I_{B2} = 0)			–	2.0	
(I_C = 10 Adc, I_{B1} = 50 mAdc, I_{B2} = 0)			–	2.0	
Base-Emitter Voltage (I_C = 6.0 Adc, V_{CE} = 2.0 Vdc, I_{B2} = 0)		V_{B1E2}	–	2.0	Vdc
Base-Emitter Saturation Voltage		$V_{B1E2(sat)}$			Vdc
(I_C = 10 Adc, I_{B1} = 25 mAdc, I_{B2} = 0)	MJ3801		–	2.5	
(I_C = 10 Adc, I_{B1} = 50 mAdc, I_{B2} = 0)	MJ3802		–	2.5	
Commutating-Diode Forward Voltage (I_E = 6.0 Adc, I_{B1} = I_{B2} = 0)		V_{E2C}	–	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (V_{CE1} = 10 Vdc, I_C = 1.0 Adc, I_{B2} = 0, f = 1.0 MHz)		f_T	50	–	MHz
Output Capacitance (V_{CB1} = 10 Vdc, I_E = I_{B2} = 0, f = 1.0 MHz)		C_{ob1}	–	75	pF
SWITCHING CHARACTERISTICS					
Delay Time	(I_C = 6.0 Adc, $I_{B1(on)}$ = $I_{B1(off)}$ = 15 mAdc, V_{CC} = 30 Vdc, V_{OB1} = 8.0 Vdc, R_{B2E2} = 47 Ohms)	t_d	–	200	ns
Rise Time		t_r	–	200	ns
Storage Time		t_s	–	3.0	μs
Fall Time		t_f	–	200	ns

FIGURE 2 – THERMAL RESPONSE SWITCHING CIRCUIT



MJ4502 (SILICON)

HIGH-POWER PNP SILICON TRANSISTOR

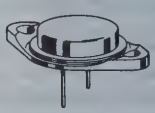
. . . for use as an output device in complementary audio amplifiers to 100-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25-100 @ I_C = 7.5 A
- Excellent Safe Operating Area
- Complement to the NPN MJ802

30 AMPERE
POWER TRANSISTOR

PNP SILICON

100 VOLTS
200 WATTS



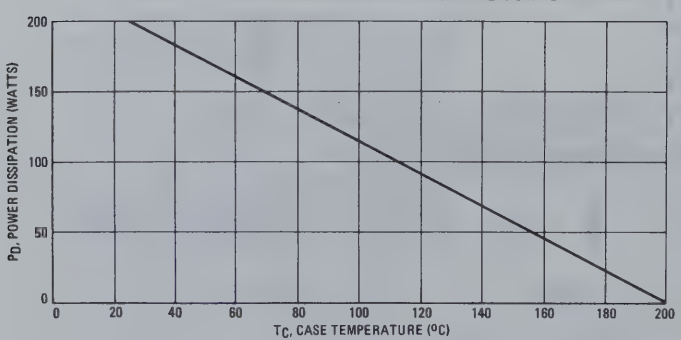
MAXIMUM RATINGS

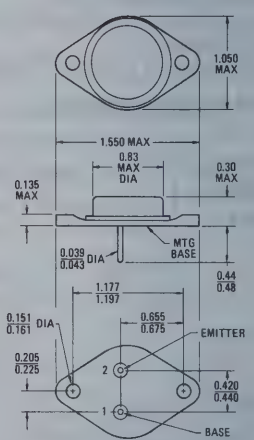
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Collector-Emitter Voltage	V_{CEO}	90	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	30	Adc
Base Current	I_B	7.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	200 1.14	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





CASE 11
(TO-3)

Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 200 mAdc, R_{BE} = 100 Ohms)	BV_{CER}*	100	–	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc)	$BV_{CEO(sus)}$*	90	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	– –	1.0 5.0	mAdc
Emitter-Base Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	h_{FE}*	25	100	–
Base-Emitter "On" Voltage* (I_C = 7.5 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$*	–	1.3	Vdc
Collector-Emitter Saturation Voltage* (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{CE(sat)}$*	–	0.8	Vdc
Base-Emitter Saturation Voltage* (I_C = 7.5 Adc, I_B = 0.75 Adc)	$V_{BE(sat)}$*	–	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current Gain – Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	2.0	–	MHz

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – DC CURRENT GAIN

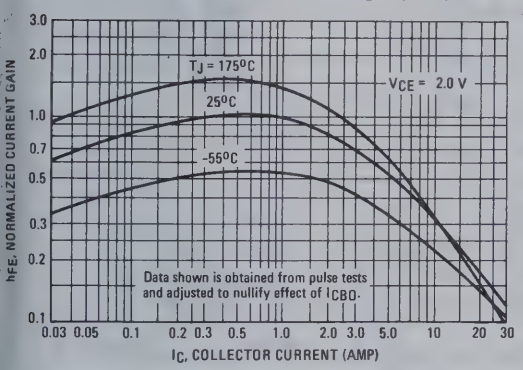


FIGURE 3 – "ON" VOLTAGES

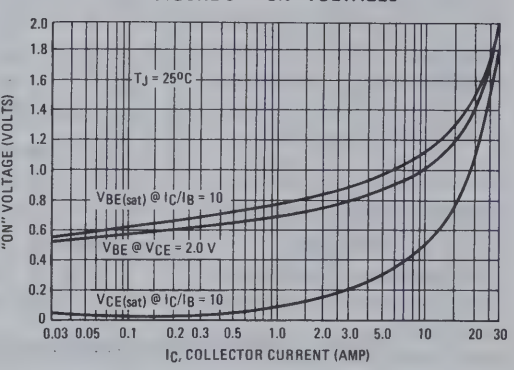
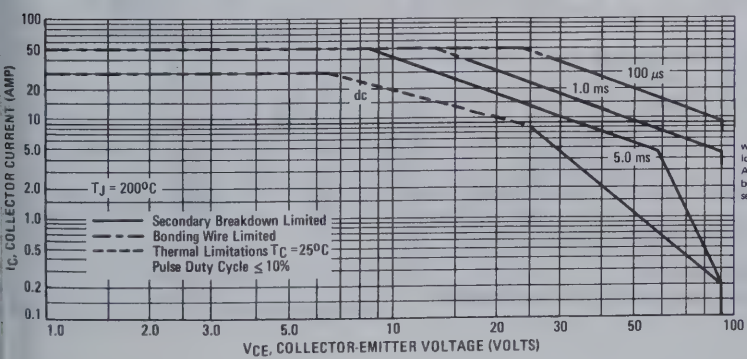


FIGURE 4 – ACTIVE REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJ6700 (SILICON)
MJ6701

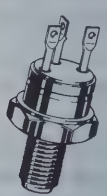
MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for switching and wide-band amplifier applications.

- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 7.0 Adc
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact, High Dissipation TO-59 Case
- Isolated Collector Configuration – 700 V Breakdown

7 AMPERE
POWER TRANSISTORS
PNP SILICON

60-80 VOLTS
60 WATTS



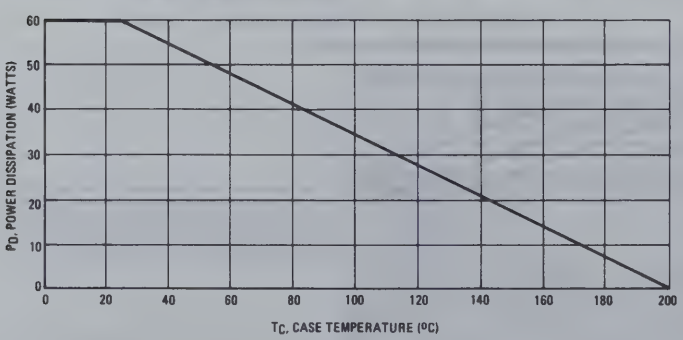
MAXIMUM RATINGS

Rating	Symbol	MJ6700	MJ6701	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	60 343		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

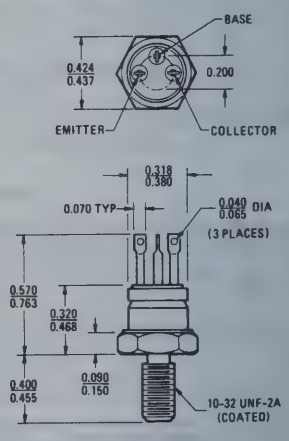
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.91	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. All limits are applicable and must be observed.



Isolated Collector

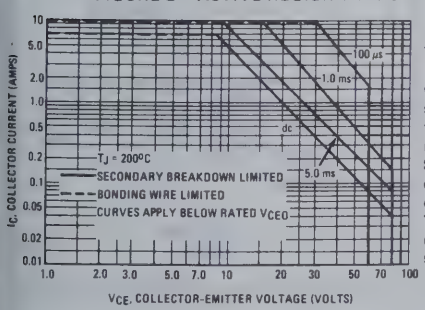
CASE 160
TO-59

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 50 mAdc, I_B = 0)	MJ6700	$BV_{CEO(sus)}$*	60	–	Vdc
	MJ6701		80	–	
Collector Cutoff Current (V_{CE} = 55 Vdc, I_B = 0)	MJ6700	I_{CEO}	–	100	μAdc
(V_{CE} = 75 Vdc, I_B = 0)	MJ6701		–	100	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJ6700		–	10	μAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJ6701		–	10	
(V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ6700		–	1.0	mAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ6701		–	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	–	10	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		h_{FE}*	25	–	–
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)			25	180	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			15	–	
Collector-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		$V_{CE(sat)}$*	–	0.7	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)			–	1.2	
Base-Emitter Saturation Voltage* (I_C = 2.0 Adc, I_B = 0.2 Adc)		$V_{BE(sat)}$*	–	1.2	Vdc
(I_C = 7.0 Adc, I_B = 0.7 Adc)			–	2.0	
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	300	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	1250	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 40 Vdc, $V_{BE(off)}$ = 4.0 Vdc,	t_d	–	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 200 mAdc)	t_r	–	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	t_s	–	1.0	μs
Fall Time	I_{B1} = I_{B2} = 200 mAdc)	t_f	–	150	ns

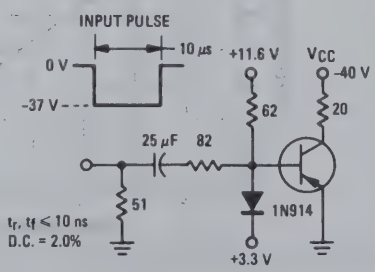
*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – SWITCHING TIME TEST CIRCUIT



MJ7000 (SILICON)

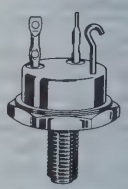
HIGH-POWER NPN SILICON TRANSISTOR

. . . designed for use in industrial power amplifier and switching circuits applications.

- High DC Current Gain –
  h_{FE} = 20–100 @ I_C = 10 Adc
- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 100 Vdc (Min) @ I_C = 100 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.7 Vdc (Max) @ I_C = 30 Adc

30 AMPERE
POWER TRANSISTOR
NPN SILICON

100 VOLTS
150 WATTS



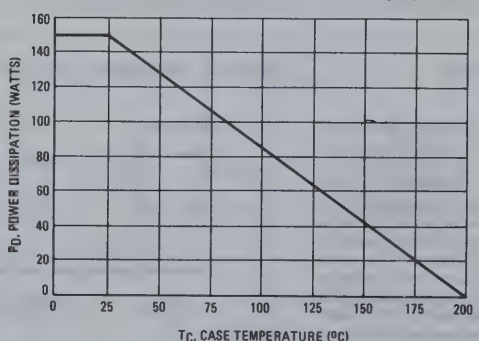
MAXIMUM RATINGS

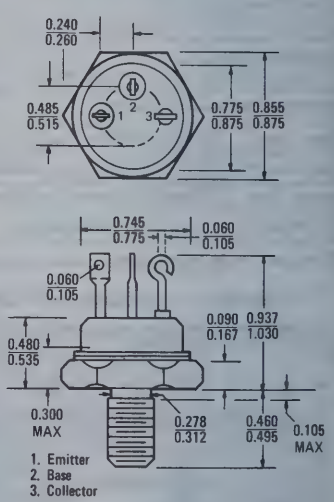
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	30	Adc
Base Current – Continuous	I_B	10	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.855	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





CASE 188
TO-63

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$*	100	–	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 50 Vdc, I_B = 0)	I_{CEO}	–	10	μAdc
Collector-Emitter Cutoff Current (V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{CEX}	–	5.0	μAdc
Collector-Base Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)	I_{CBO}	–	5.0	μAdc
Emitter-Base Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	μAdc
ON CHARACTERISTICS				
DC Current Gain*	h_{FE}*			–
(I_C = 1.0 Adc, V_{CE} = 4.0 Vdc)		20	–	
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)		20	100	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)		10	–	
Collector-Emitter Saturation Voltage*	$V_{CE(sat)}$*			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)		–	1.0	
(I_C = 30 Adc, I_B = 4.0 Adc)		–	1.7	
Base-Emitter Saturation Voltage*	$V_{BE(sat)}$*			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)		–	1.7	
(I_C = 30 Adc, I_B = 4.0 Adc)		–	2.25	
Base-Emitter On Voltage* (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$*	–	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, f = 20 MHz)	f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	600	pF

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MJ7200 (SILICON)
MJ7201

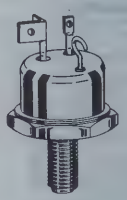
HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in high reliability power amplifier and switching circuits applications.

- High DC Current Gain –
  h_{FE} = 20–100 @ I_C = 20 Adc
- High Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 100 Vdc (Min) @ I_C = 200 mAdc – MJ7201
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.5 Vdc (Max) @ I_C = 40 Adc
- High Current-Gain–Bandwidth Product –
  f_T = 20 MHz (Min) @ I_C = 0.7 Adc

60 AMPERE
POWER TRANSISTORS
NPN SILICON

80–100 VOLTS
300 WATTS



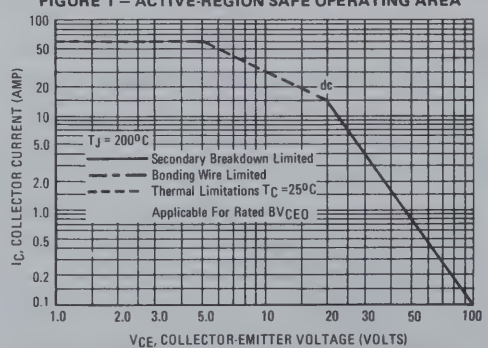
MAXIMUM RATINGS

Rating	Symbol	MJ7200	MJ7201	Unit
Collector-Emitter Voltage	V_{CEO}	80	100	Vdc
Collector-Base Voltage	V_{CB}	100	120	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous Peak	I_C	60 90		Adc
Base Current – Continuous	I_B	20		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.72		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

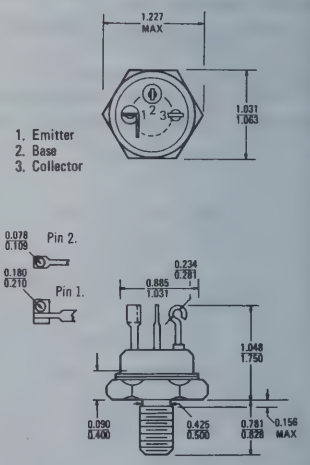
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.58	°C/W

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



CASE 177
TO-114

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	MJ7200	$V_{CEO(sus)}$*	80	–	Vdc
	MJ7201		100	–	
Collector-Emitter Cutoff Current		I_{CEX}			
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ7200		–	100	μAdc
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJ7201		–	100	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ7200		–	2.0	mAdc
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ7201		–	2.0	
Collector-Base Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 100 Vdc, I_E = 0)	MJ7200		–	100	
(V_{CB} = 120 Vdc, I_E = 0)	MJ7201		–	100	
Emitter-Base Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 80 Vdc, I_B = 0)	MJ7200		–	1.0	
(V_{CE} = 100 Vdc, I_B = 0)	MJ7201		–	1.0	
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			–
(I_C = 5.0 Adc, V_{CE} = 5.0 Vdc)			15	–	
(I_C = 20 Adc, V_{CE} = 5.0 Vdc)			20	100	
(I_C = 40 Adc, V_{CE} = 5.0 Vdc)			12	75	
(I_C = 60 Adc, V_{CE} = 5.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 20 Adc, I_B = 2.0 Adc)			–	1.0	
(I_C = 40 Adc, I_B = 4.0 Adc)			–	1.5	
(I_C = 60 Adc, I_B = 8.0 Adc)			–	2.5	
Base-Emitter Saturation Voltage* (I_C = 40 Adc, I_B = 4.0 Adc)		$V_{BE(sat)}$*	–	2.5	Vdc
Base-Emitter On Voltage*		$V_{BE(on)}$*			Vdc
(I_C = 20 Adc, V_{CE} = 5.0 Vdc)			–	1.6	
(I_C = 60 Adc, V_{CE} = 5.0 Vdc)			–	3.2	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.7 Adc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	20	–	MHz
Output Capacitance (I_E = 0, V_{CB} = 10 Vdc, f = 100 kHz)		C_{ob}	–	1200	pF

*Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

MJ8100 (SILICON)
MJ8101

MEDIUM-POWER PNP SILICON TRANSISTORS

. . . designed for switching and wide band amplifier applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 5.0 Amp
- DC Current Gain Specified to 5 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact TO-39 Case for Critical Space-Limited Applications.

5 AMPERE
POWER TRANSISTORS

PNP SILICON

60 - 80 VOLTS
10 WATTS

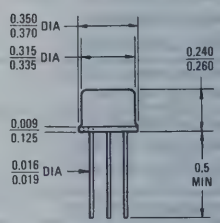


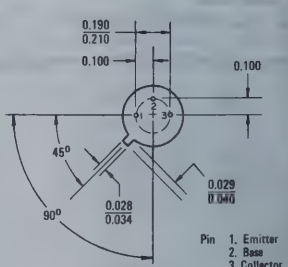
MAXIMUM RATINGS

Rating	Symbol	MJ8100	MJ8101	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	5.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 57.2		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200		°C

THERMAL CHARACTERISTICS

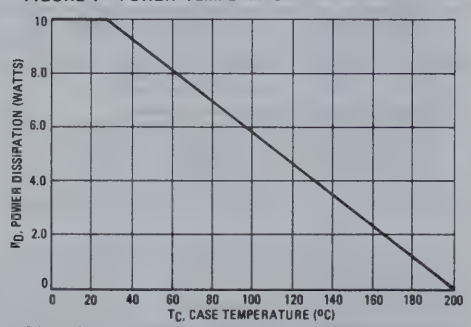
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	°C/W





CASE 79
TO-39

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



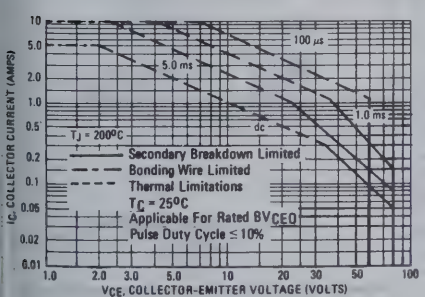
Safe Area Curves are indicated by Figure 2. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 50 mAdc, I_B = 0)	MJ8100	$BV_{CEO(sus)}$*	60	–	Vdc
	MJ8101		80	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 55 Vdc, I_B = 0)	MJ8100		–	100	
(V_{CE} = 75 Vdc, I_B = 0)	MJ8101		–	100	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJ8100		–	10	
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	MJ8101		–	10	
(V_{CE} = 55 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ8100		–	1.0	mAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	MJ8101		–	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			–
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)			25	–	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)			25	180	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			15	–	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)			–	0.7	
(I_C = 5.0 Adc, I_B = 0.5 Adc)			–	1.2	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)			–	1.2	
(I_C = 5.0 Adc, I_B = 0.5 Adc)			–	1.8	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	300	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	1250	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 40 Vdc, $V_{BE(off)}$ = 4.0 Vdc,	t_d	–	100	ns
Rise Time	I_C = 2.0 Adc, I_{B1} = 0.2 Adc)	t_r	–	100	ns
Storage Time	(V_{CC} = 40 Vdc, I_C = 2.0 Adc,	t_s	–	1.0	μs
Fall Time	I_{B1} = I_{B2} = 0.2 Adc)	t_f	–	150	ns

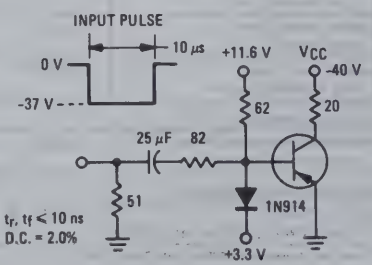
*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – SWITCHING TIME TEST CIRCUIT



MJ8400 (SILICON)

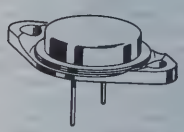
HIGH-VOLTAGE NPN SILICON TRANSISTOR

. . . designed for single unit use in horizontal deflection output circuits for line operated color television receivers that use a solid-state rectifier.

- High Breakdown Voltage – V_{CES} = 1400 Vdc
- Fast Fall Time – t_f = 1.1 μs (Max) @ I_C = 3.0 Adc
- Low Collector - Emitter Saturation Voltage – $V_{CE(sat)}$ = 2.0 Vdc @ I_C = 3.0 Adc

4 AMPERE
POWER TRANSISTOR
NPN SILICON

1400 VOLTS
125 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	600	Vdc
Collector-Emitter Voltage	V_{CES}	1400	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	4.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

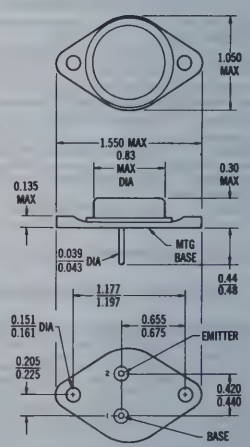
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 100 mAdc, I_B = 0)	BV_{CEO}*	600	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Leakage Current (V_{CE} = 600 Vdc, I_B = 0)	I_{CEO}	–	1.0	mAdc
Collector Cutoff Current (V_{CE} = 1400 Vdc, V_{EB} = 0)	I_{CES}	–	1.0	mAdc
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 1.0 Adc)	$V_{CE(sat)}$	–	2.0	Vdc
SWITCHING CHARACTERISTICS				
Fall Time (Figure 3) (V_{CC} = 80 Vdc, I_C = 3.0 Adc, I_{B1} = 1.0 Adc)	t_f	–	1.1	μs

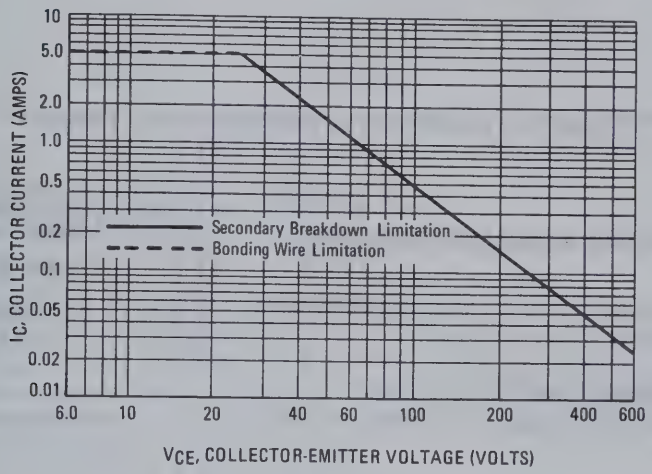
*Pulse Test: Pulse Width ≤ 500 μs, Duty Cycle ≤ 2.0%.



Collector Connected to Case

CASE 11
TO-3

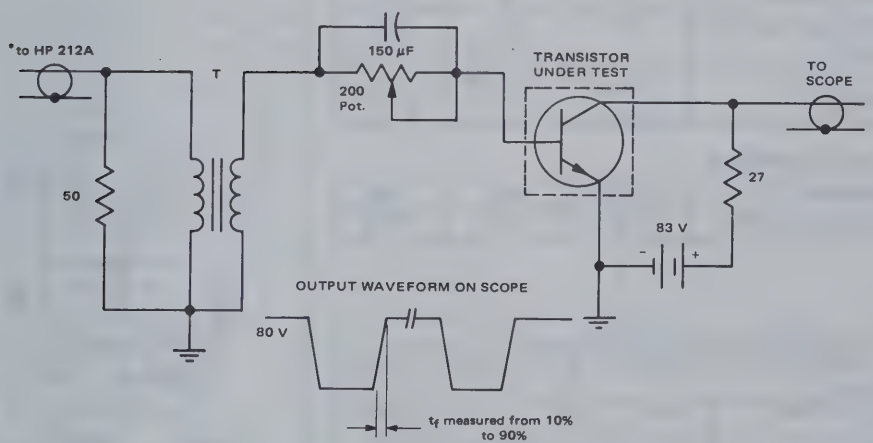
FIGURE 1 – ACTIVE-REGION DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

Transistors should be used with receivers employing solid-state high-voltage rectifiers – as rectifier arcs may destroy the units. Use of a pulse limiter is also highly recommended.

FIGURE 2 – TEST CIRCUIT FOR FALL TIME



*HP 212A: Set for 10 μs wide pulses at 2000 pulses per sec. (500 μs intervals). Adjust for I_{B1} = 1.0 A.
Bias: Adjust to 1.5 V on a VTVM across the 200 Ω Pot.
T: Pulse Transformer: Motorola Part No. 25D68782A01.

MJ9000 (SILICON)

HIGH-VOLTAGE NPN SILICON TRANSISTOR

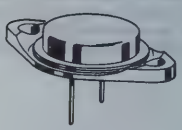
. . . designed for single unit use in color horizontal deflection output circuits in television receivers.

- High Collector-Emitter Voltage — V_{CES} = 700 Vdc
- Fast Fall Time — t_f = 1.1 μs (Max) @ I_C = 6.0 Adc

10 AMPERE
POWER TRANSISTOR

NPN SILICON

700 VOLTS
125 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	325	Vdc
Collector-Emitter Voltage	V_{CES}	700	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	10	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +150	°C

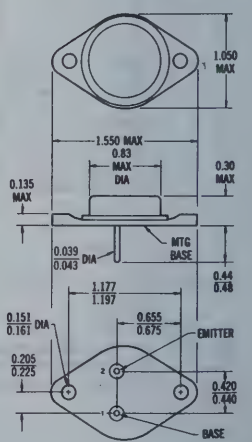
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 0.1 Adc, I_B = 0)	BV_{CEO}*	325	–	Vdc
Collector Cutoff Current (V_{CE} = 700 Vdc, V_{EB} = 0)	I_{CES}	–	1.0	mAdc
ON CHARACTERISTICS				
Collector-Emitter Saturation Voltage (I_C = 6.0 Adc, I_B = 1.6 Adc)	$V_{CE(sat)}$	–	2.0	Vdc
SWITCHING CHARACTERISTICS				
Fall Time (See Figure 3) (V_{CC} = 80 Vdc, I_C = 6.0 Adc, I_{B1} = 1.6 Adc)	t_f	–	1.1	μs

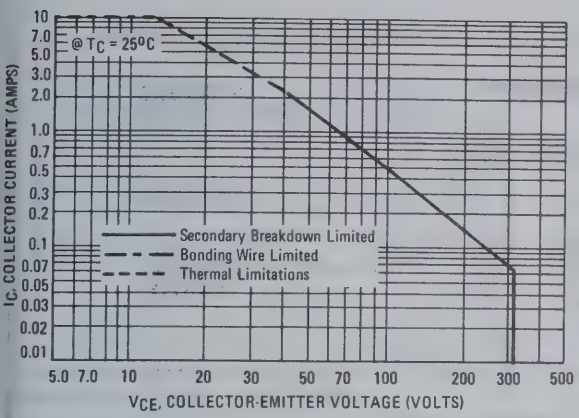
*Pulse Test: Pulse Width ≤ 500 μs, Duty Cycle ≤ 2.0%.



Collector Connected to Case

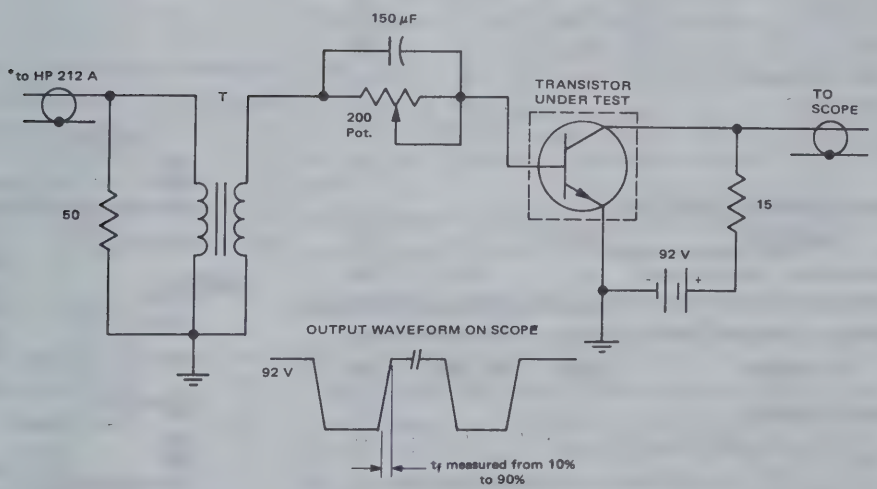
CASE 11
TO-3

FIGURE 1 – ACTIVE-REGION DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 2 – TEST CIRCUIT FOR FALL TIME



*HP 212A: Set for 10 μs wide pulses at 2000 pulses per sec. (500 μs intervals). Adjust for I_{B1} = 1.6 A.
Bias: Adjust to 1.5 V on a VTVM across the 200 Ω Pot.
T: Pulse Transformer: Motorola Part No. 25D68782A01.

MJE105 (SILICON)

MEDIUM-POWER PNP SILICON TRANSISTOR

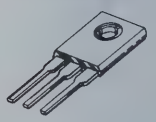
. . . for use as an output device in complementary audio amplifiers up to 20-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25-100 @ I_C = 2.0 A
- Thermopad High-Efficiency Compact Package
- Complementary to NPN MJE205

5 AMPERE
POWER TRANSISTOR

PNP SILICON

50 VOLTS
65 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	5.0	Adc
Base Current	I_B	2.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D†	65 0.522	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

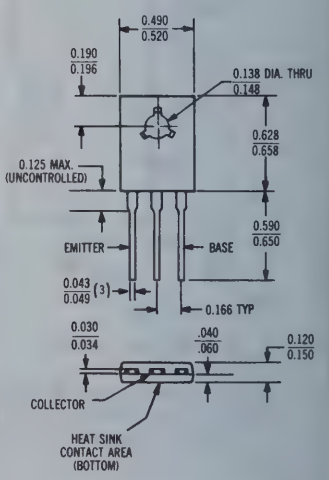
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.92	°C/W

†Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage‡ (I_C = 100 mAdc, I_B = 0)	BV_{CEO}‡	50	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	- -	0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	-
Base-Emitter Voltage (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	-	1.2	Vdc

‡ Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

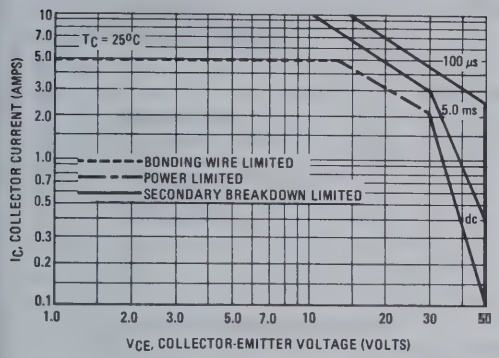


CASE 90

When mounting the device, torque not to exceed 8.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

FIGURE 1 – ACTIVE REGION DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. To insure operation below the maximum T_J, the power-temperature derating curve, Figure 4, must be observed for both steady state and pulse power conditions.

FIGURE 2 – "ON" VOLTAGES

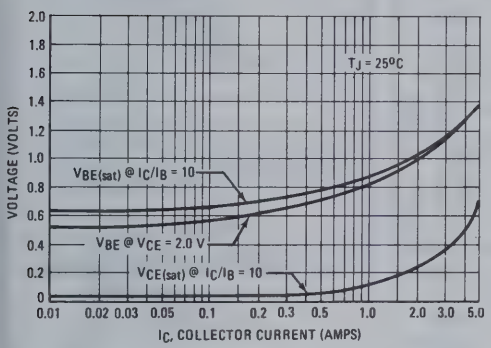


FIGURE 3 – NORMALIZED DC CURRENT GAIN

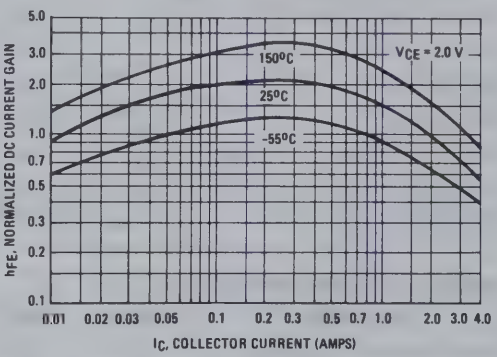
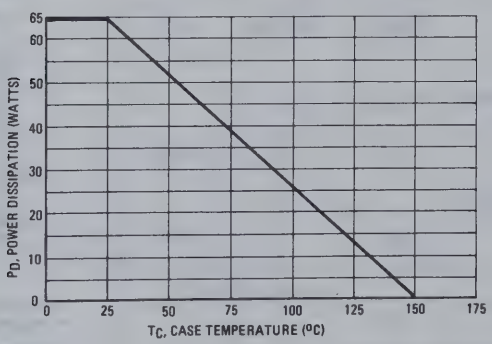


FIGURE 4 – POWER-TEMPERATURE DERATING CURVE



MJE205 (SILICON)

MEDIUM-POWER NPN SILICON TRANSISTOR

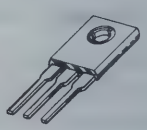
. . . for use as an output device in complementary audio amplifiers up to 20-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25-100 @ I_C = 2.0 A
- Thermopad High-Efficiency Compact Package
- Complementary to PNP MJE105

5 AMPERE
POWER TRANSISTOR

NPN SILICON

50 VOLTS
65 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	5.0	Adc
Base Current	I_B	2.5	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D†	65 0.522	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

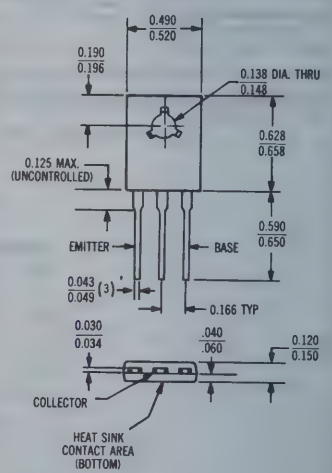
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.92	°C/W

† Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage‡ (I_C = 100 mAdc, I_B = 0)	BV_{CEO}‡	50	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	- -	0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	-
Base-Emitter Voltage (I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	-	1.2	Vdc

‡ Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

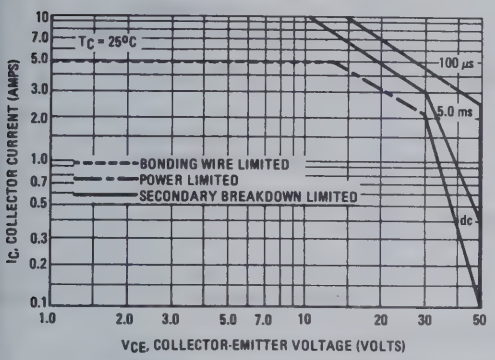


CASE 90

When mounting the device, torque not to exceed 8.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

FIGURE 1 – ACTIVE REGION DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. To insure operation below the maximum T_J, the power-temperature derating curve, Figure 4, must be observed for both steady state and pulse power conditions.

FIGURE 2 – "ON" VOLTAGES

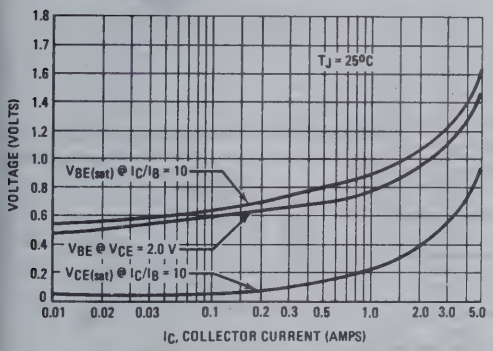


FIGURE 3 – NORMALIZED DC CURRENT GAIN

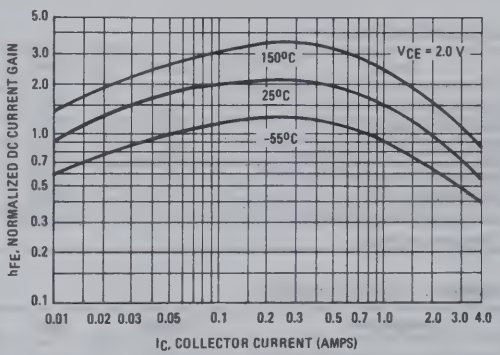
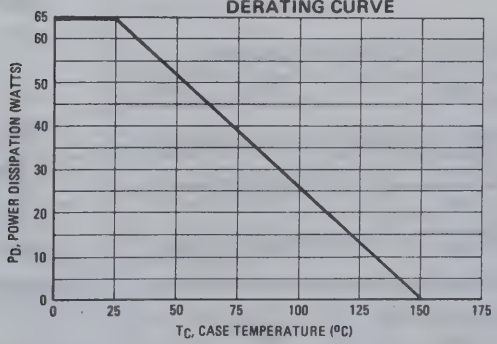


FIGURE 4 – POWER-TEMPERATURE DERATING CURVE



MJE340 (SILICON)

PLASTIC MEDIUM POWER NPN SILICON TRANSISTOR

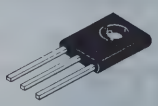
. . . designed for power output stages for television, radio, phonograph and other consumer product applications.

- Suitable for Transformerless, Line-Operated Equipment
- Thermopad Construction Provides High Power Dissipation Rating for High Reliability

0.5 AMPERE POWER TRANSISTOR

NPN SILICON

300 VOLTS
20.8 WATTS



MAXIMUM RATINGS

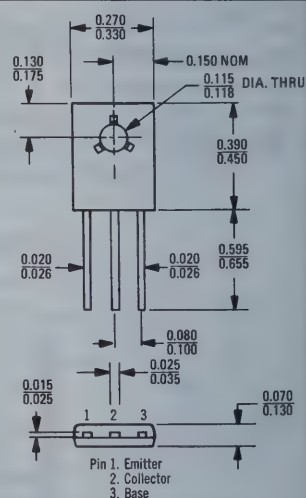
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	20.8 0.167	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.0	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 1.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	300	—	Vdc
Collector Cutoff Current (V_{CB} = 300 Vdc, I_E = 0)	I_{CBO}	—	100	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	—	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	240	—



Pin 1. Emitter
2. Collector
3. Base

When mounting the device, torque not to exceed 6.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

CASE 77-02

FIGURE 1 – POWER TEMPERATURE DERATING CURVE

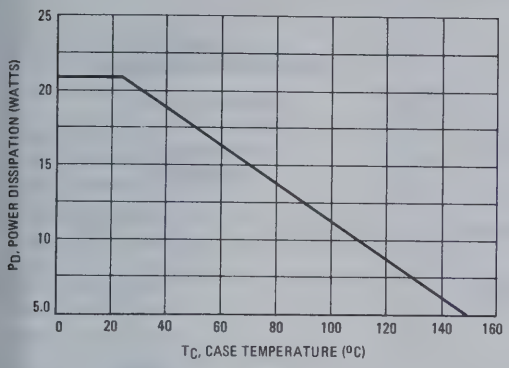


FIGURE 2 – "ON" VOLTAGES

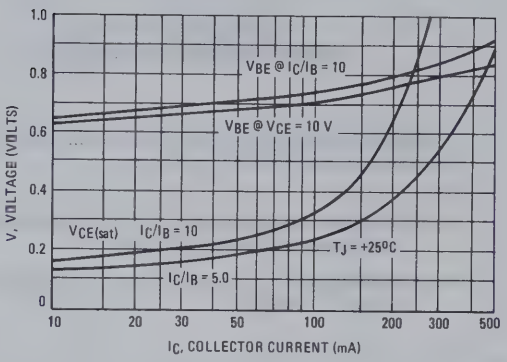
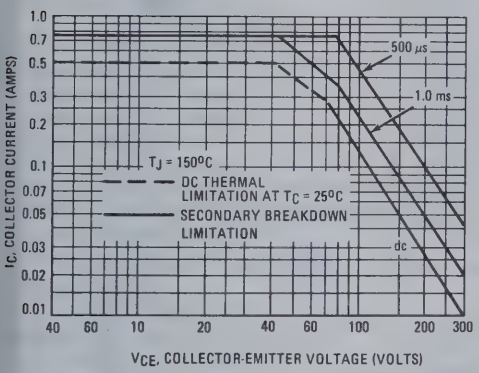
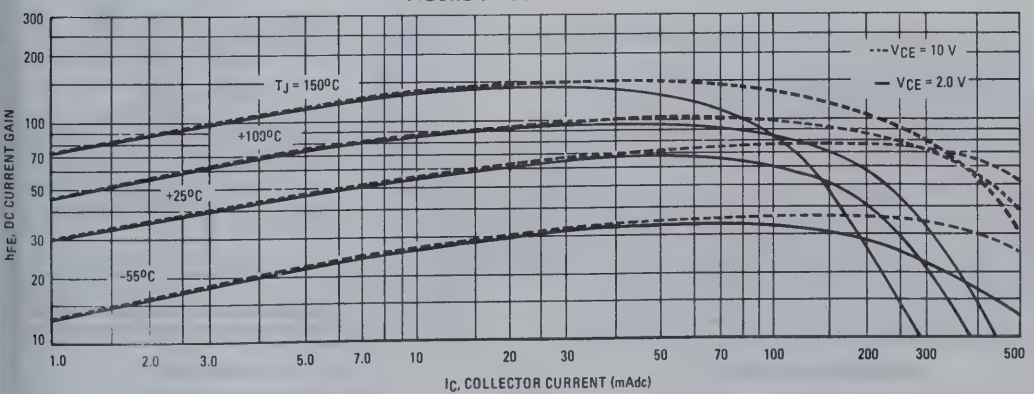


FIGURE 3 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 4 – CURRENT GAIN



MJE341 (SILICON)
MJE344

PLASTIC NPN SILICON
MEDIUM-POWER TRANSISTORS

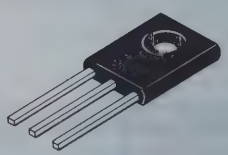
. . . designed for power output stages in television, radio, phonograph and other consumer product applications.

- Recommended for 1.5 W Class A Output in Transformer Coupled, Line-Operated Equipment — MJE341
- Ideal for Audio Output Circuitry in Black and White Television Receivers — MJE344

0.5 AMPERE
POWER TRANSISTORS

NPN SILICON

150–200 VOLTS
20.8 WATTS



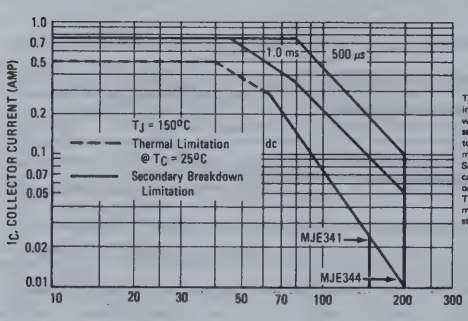
MAXIMUM RATINGS

Rating	Symbol	MJE341	MJE344	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	Vdc
Collector-Base Voltage	V_{CB}	175	200	Vdc
Emitter-Base Voltage	V_{EB}	3.0	5.0	Vdc
Collector Current — Continuous	I_C	500		mAdc
Base Current	I_B	250		mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	20.8 0.167		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150		^oC

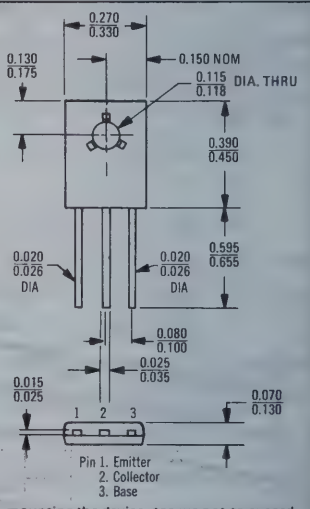
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.0	$^oC/W$

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



When mounting the device, torque not to exceed 6.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

CASE 77-02

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 1.0 mAdc, I_B = 0)	MJE341 MJE344	$V_{CEO(sus)}$	 150 200	 – –	Vdc
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 150 Vdc, I_B = 0)	MJE341		–	1.0	
(V_{CE} = 200 Vdc, I_B = 0)	MJE344		–	1.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 175 Vdc, I_E = 0)	MJE341		–	0.3	
(V_{CB} = 200 Vdc, I_E = 0)	MJE344		–	0.1	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{EB} = 3.0 Vdc, I_C = 0)	MJE341		–	0.1	
(V_{EB} = 5.0 Vdc, I_C = 0)	MJE344		–	0.1	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MJE341		20	–	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	MJE341 MJE344		25 30	200 300	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MJE341		20	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	Both Types		–	1.0	
(I_C = 150 mAdc, I_B = 15 mAdc)	MJE341		–	2.3	
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 25 Vdc, f = 10 MHz)		f_T	15	–	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	15	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	–	–

FIGURE 2 – CURRENT GAIN

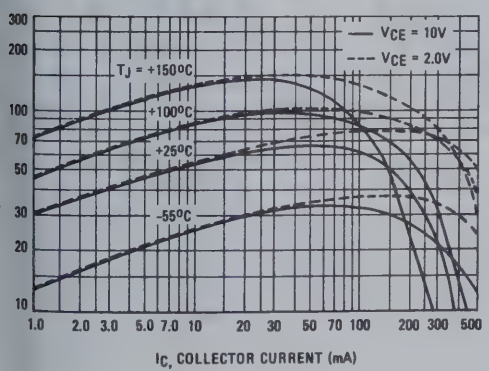
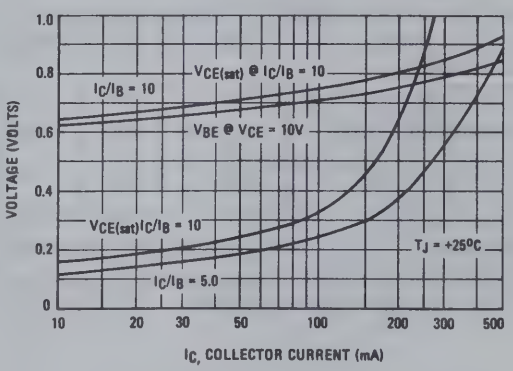


FIGURE 3 – "ON" VOLTAGES



MJE370 (SILICON)

PLASTIC MEDIUM-POWER PNP SILICON TRANSISTOR

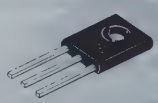
. . . designed for use in 5 to 10 Watt audio amplifiers utilizing complementary symmetry circuitry.

- DC Current Gain – h_{FE} = 25 (Min) @ I_C = 1.0 Adc
- MJE370 is Complementary with NPN MJE520

3 AMPERE POWER TRANSISTOR

PNP SILICON

30 VOLTS
25 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous – Peak	I_C	3.0 4.0	Adc
Base Current – Continuous	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	25 0.2	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

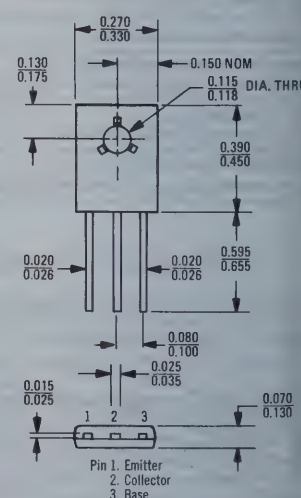
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	5.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$*	30	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain* (V_{CE} = 1.0 Vdc, I_C = 1.0 Adc)	h_{FE}	25	–	–

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

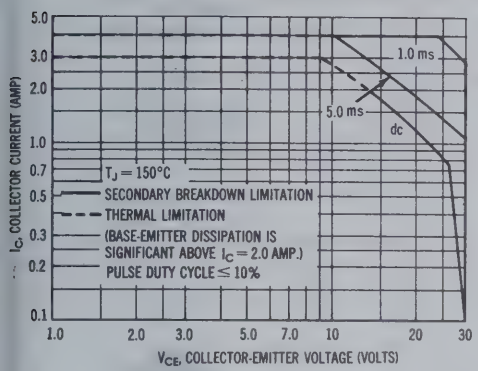


When mounting the device, torque not to exceed 6.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

CASE 77-02

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 2 – DC CURRENT GAIN

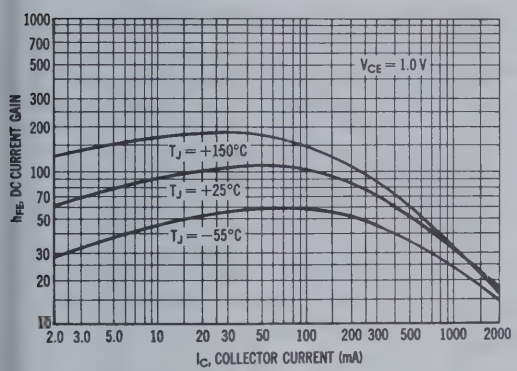


FIGURE 3 – "ON" VOLTAGE

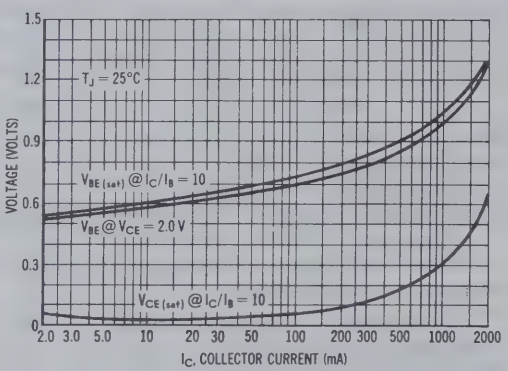
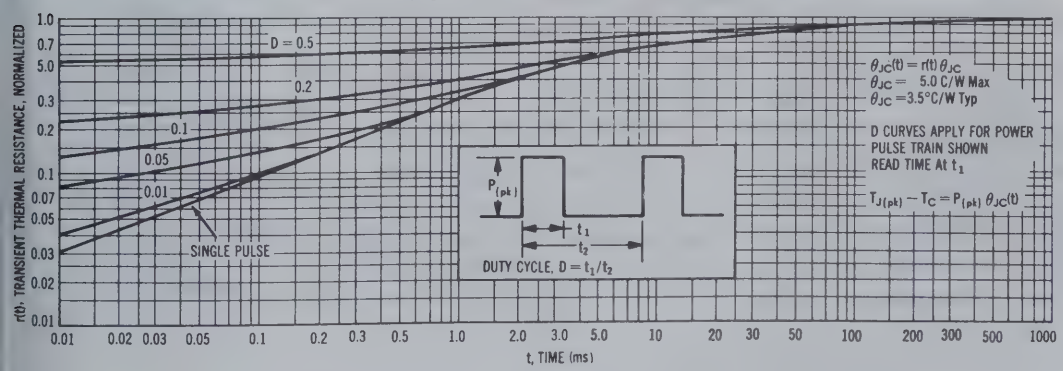


FIGURE 4 – THERMAL RESPONSE



MJE371 (SILICON)

PLASTIC MEDIUM-POWER PNP SILICON TRANSISTOR

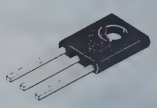
. . . designed for use in 5 to 10 Watt audio amplifiers utilizing complementary symmetry circuitry.

- DC Current Gain – h_{FE} = 40 (Min) @ I_C = 1.0 Adc
- MJE371 is Complementary with NPN MJE521

3 AMPERE POWER TRANSISTOR

PNP SILICON

40 VOLTS
40 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous – Peak	I_C	3.0 4.0	Adc
Base Current – Continuous	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 320	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150	°C

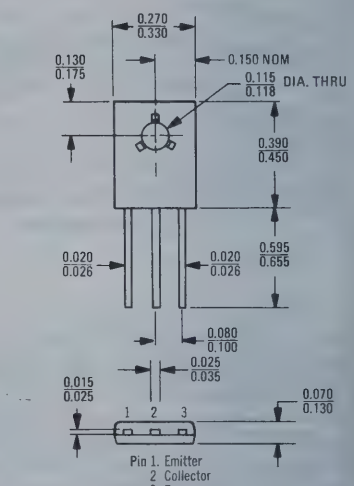
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$*	40	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain* (V_{CE} = 1.0 Vdc, I_C = 1.0 Adc)	h_{FE}	40	–	–

*Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.



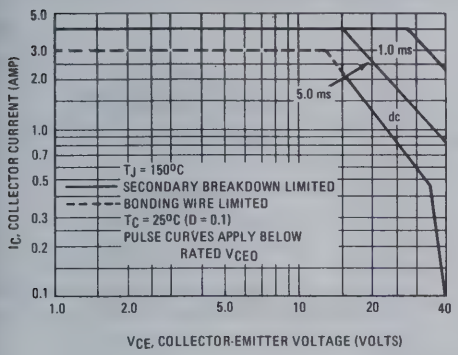
Pin 1. Emitter
2 Collector
3. Base

When mounting the device, torque not to exceed 6.0 in.-lb

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

CASE 77-02

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 2 – NORMALIZED DC CURRENT GAIN

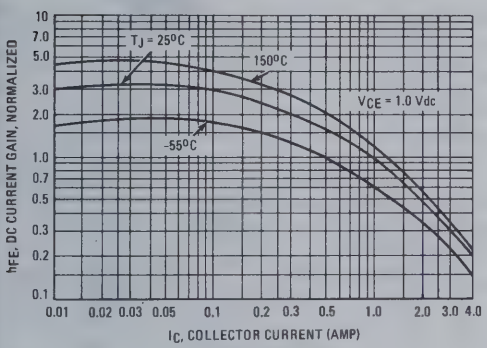


FIGURE 3 – "ON" VOLTAGE

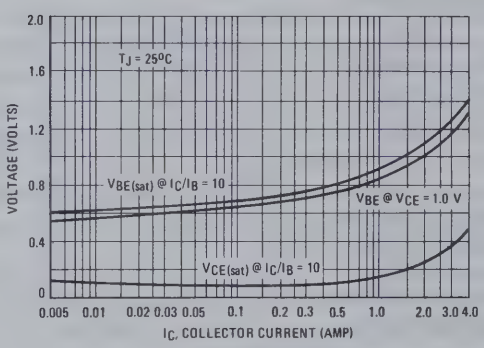
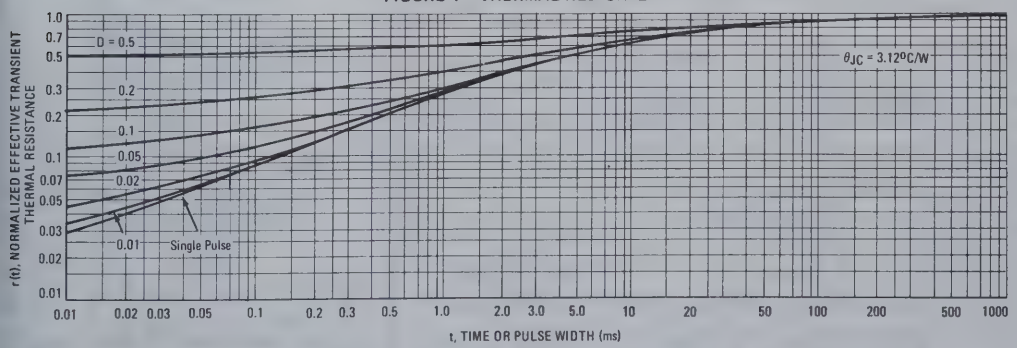


FIGURE 4 – THERMAL RESPONSE



MJE520 (SILICON)

PLASTIC MEDIUM-POWER NPN SILICON TRANSISTOR

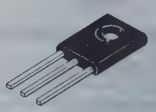
. . . designed for use in 5 to 10 Watt audio amplifiers utilizing complementary symmetry circuitry.

- DC Current Gain — h_{FE} = 25 (Min) @ I_C = 1.0 Adc
- MJE520 is Complementary with PNP MJE370

3 AMPERE POWER TRANSISTOR

NPN SILICON

30 VOLTS
25 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous — Peak	I_C	3.0 4.0	Adc
Base Current — Continuous	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	25 0.2	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	–65 to +150	°C

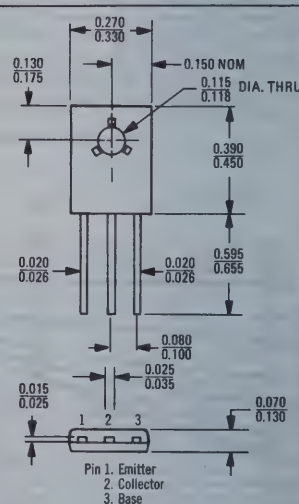
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	5.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$*	30	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain* (V_{CE} = 1.0 Vdc, I_C = 1.0 Adc)	h_{FE}	25	–	–

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

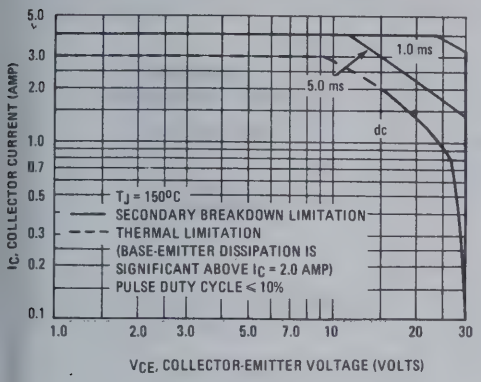


When mounting the device, torque not to exceed 6.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

CASE 77-02

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 2 – DC CURRENT GAIN

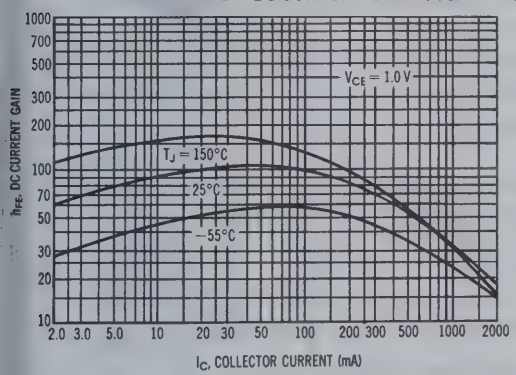


FIGURE 3 – "ON" VOLTAGE

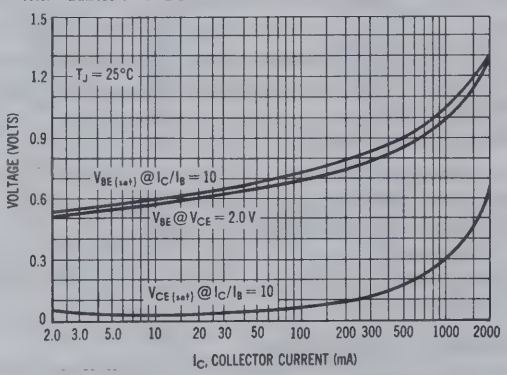
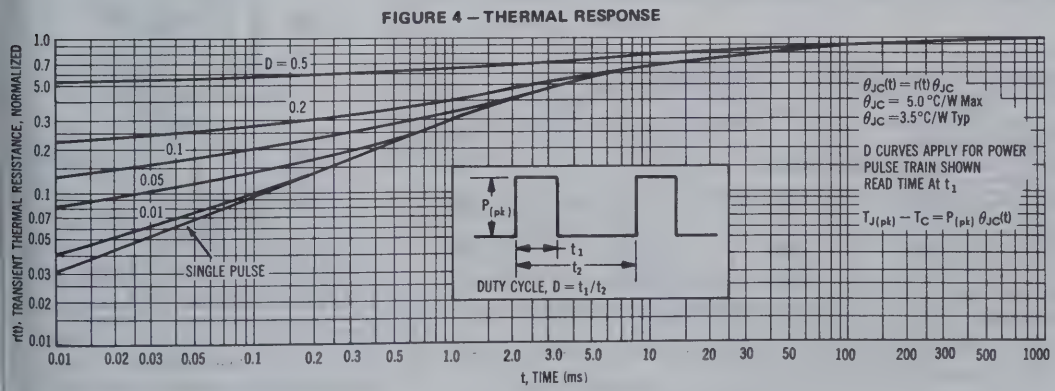


FIGURE 4 – THERMAL RESPONSE



MJE521 (SILICON)

PLASTIC MEDIUM-POWER NPN SILICON TRANSISTOR

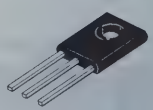
. . . designed for use in 5 to 10 Watt audio amplifiers utilizing complementary symmetry circuitry.

- DC Current Gain – h_{FE} = 40 (Min) @ I_C = 1.0 Adc
- MJE521 is Complementary with PNP MJE371

3 AMPERE POWER TRANSISTOR

NPN SILICON

40 VOLTS
40 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous – Peak	I_C	3.0 4.0	Adc
Base Current – Continuous	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	40 320	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

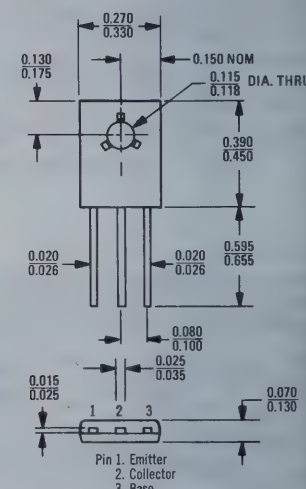
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.12	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$*	40	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter-Base Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain* (V_{CE} = 1.0 Vdc, I_C = 1.0 Adc)	h_{FE}*	40	–	–

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

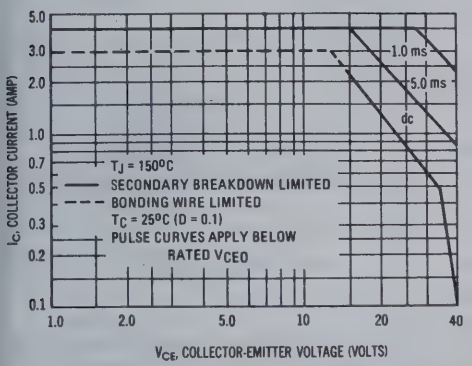


When mounting the device, torque not to exceed 6.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

CASE 77-02

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 2 – NORMALIZED DC CURRENT GAIN

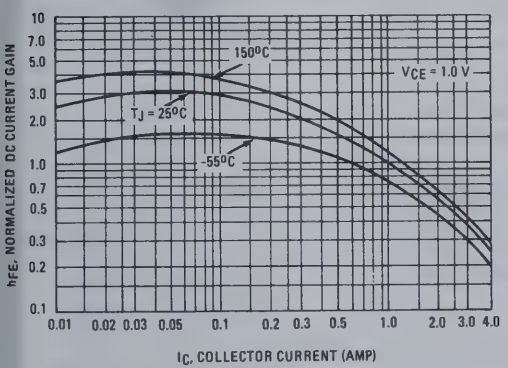


FIGURE 3 – "ON" VOLTAGE

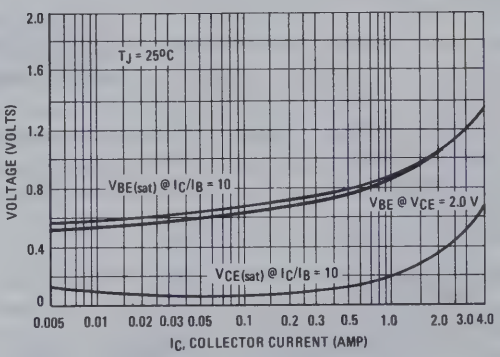
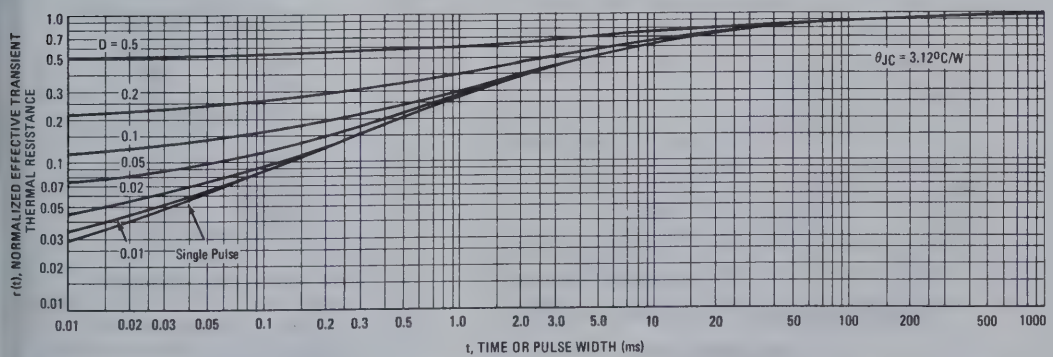


FIGURE 4 – THERMAL RESPONSE



MJE1090 thru MJE1093 PNP (SILICON)
MJE1100 thru MJE1103 NPN

PLASTIC MEDIUM-POWER
COMPLEMENTARY SILICON TRANSISTORS

. . . for use as output devices in complementary general-purpose amplifier applications.

- High DC Current Gain —
  h_{FE} = 750 (Min) @ I_C = 3.0 and 4.0 Adc
- Monolithic Construction

5.0 AMPERE
DARLINGTON
POWER TRANSISTORS
COMPLEMENTARY SILICON

60-80 VOLTS
70 WATTS



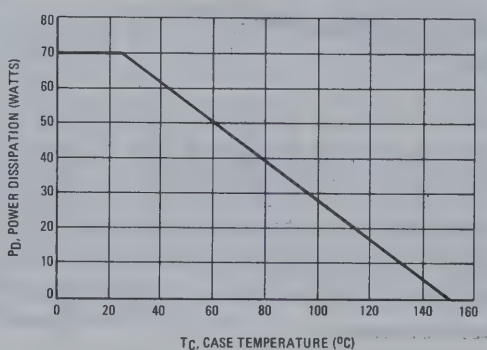
MAXIMUM RATINGS

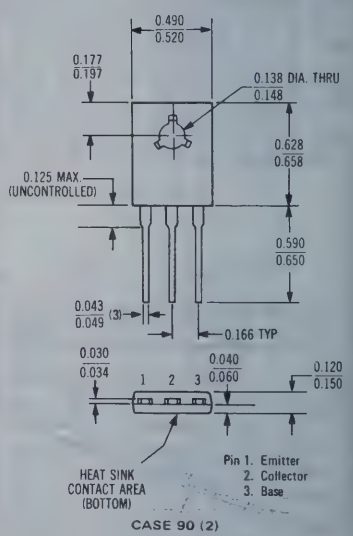
Rating	Symbol	MJE1090 MJE1091 MJE1100 MJE1101	MJE1092 MJE1093 MJE1102 MJE1103	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	5.0		Adc
Base Current	I_B	0.1		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	70 0.56		Watts W/°C
Operating and Storage Junction Temperating Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.79	°C/W

FIGURE 1 – POWER TEMPERATURE DERATING CURVE





CASE 90 (2)

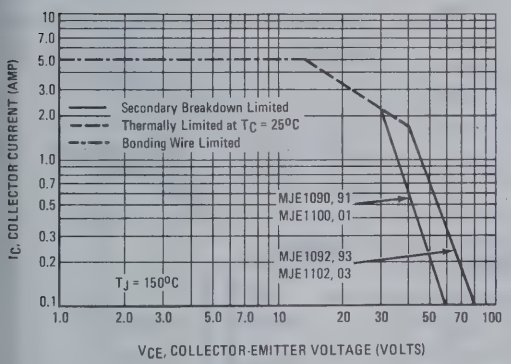
When mounting the device, torque not to exceed 8.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

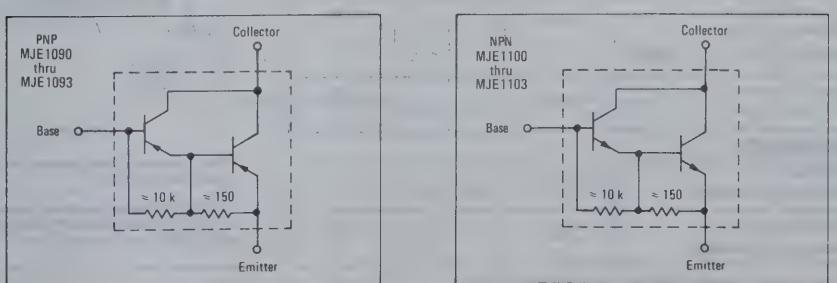
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	MJE1090, MJE1091, MJE1100, MJE1101	BV_{CEO}	60	–	Vdc
	MJE1092, MJE1093, MJE1102, MJE1103		80	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 30 Vdc, I_B = 0)	MJE1090, MJE1091, MJE1100, MJE1101		–	500	
(V_{CE} = 40 Vdc, I_B = 0)	MJE1092, MJE1093, MJE1102, MJE1103		–	500	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = Rated BV_{CEO}, I_E = 0)			–	0.2	
(V_{CB} = Rated BV_{CEO}, I_E = 0, T_C = 100°C)			–	2.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 3.0 Adc, V_{CE} = 3.0 Vdc)	MJE1090, MJE1092, MJE1100, MJE1102		750	–	
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)	MJE1091, MJE1093, MJE1101, MJE1103		750	–	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 3.0 Adc, V_{CE} = 3.0 Vdc)	MJE1090, MJE1092, MJE1100, MJE1102		–	2.5	
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)	MJE1091, MJE1093, MJE1101, MJE1103		–	2.5	
DYNAMIC CHARACTERISTICS					
Small-Signal Current Gain (I_C = 3.0 Adc, V_{CE} = 3.0 Vdc, f = 1.0 MHz)		h_{fe}	1.0	–	–

FIGURE 2 – DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – DARLINGTON CIRCUIT SCHEMATIC



MJE2801 (SILICON)

HIGH-POWER NPN SILICON TRANSISTOR

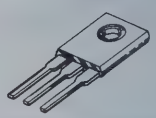
. . . for use as an output device in complementary audio amplifiers up to 35-Watts music power per channel.

- High DC Current Gain — h_{FE} = 25-100 @ I_C = 3.0 A
- Thermopad High-Efficiency Compact Package
- Complementary to PNP MJE2901

10 AMPERE POWER TRANSISTOR

NPN SILICON

60 VOLTS
90 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	10	Adc
Base Current	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D†	90 0.72	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

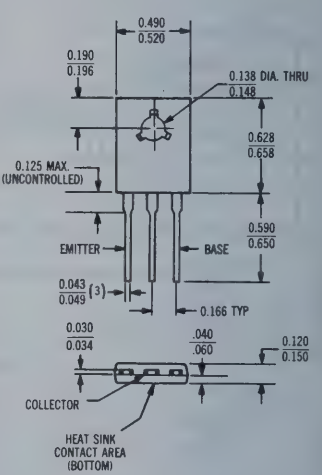
	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

† Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, I_B = 0)	BV_{CEO}††	60	-	Vdc
Collector-Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	- -	0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	-
Base-Emitter Voltage (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	-	1.4	Vdc

†† Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

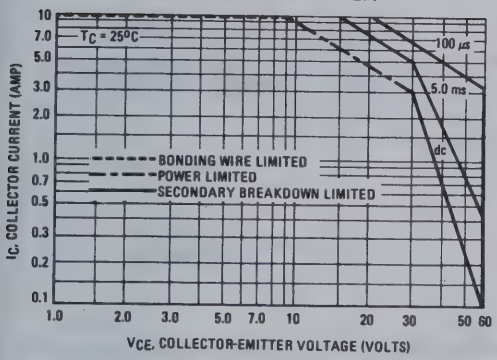


CASE 90

When mounting the device, torque not to exceed 8.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

FIGURE 1 – ACTIVE REGION DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. To insure operation below the maximum T_J, the power-temperature derating curve, Figure 4, must be observed for both steady state and pulse power conditions.

FIGURE 2 – "ON" VOLTAGES

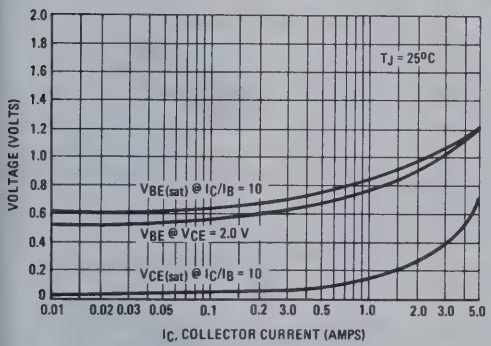


FIGURE 3 – CURRENT GAIN

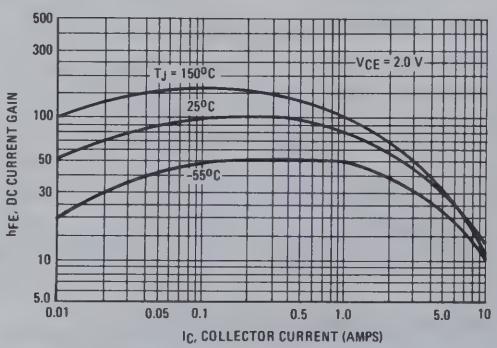
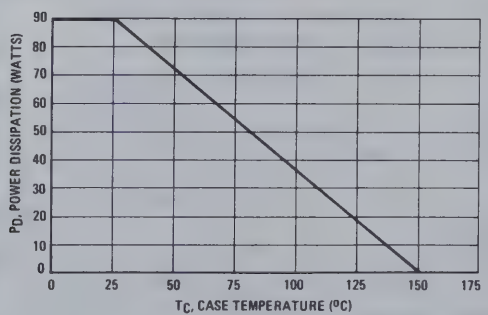


FIGURE 4 – POWER-TEMPERATURE DERATING CURVE



MJE2901 (SILICON)

HIGH-POWER PNP SILICON TRANSISTOR

. . . for use as an output device in complementary audio amplifiers up to 35-Watts music power per channel.

- High DC Current Gain – h_{FE} = 25-100 @ I_C = 3.0 A
- Thermopad High-Efficiency Compact Package
- Complementary to NPN MJE2801

10 AMPERE
POWER TRANSISTOR

PNP SILICON

60 VOLTS
90 WATTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	10	Adc
Base Current	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D†	90 0.72	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

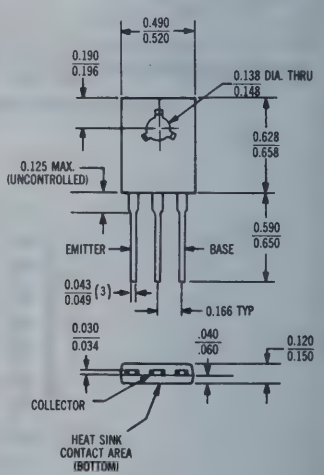
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

†Safe Area Curves are indicated by Figure 1. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, I_B = 0)	BV_{CEO}††	60	-	Vdc
Collector-Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	- -	0.1 2.0	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	25	100	-
Base-Emitter Voltage (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	V_{BE}	-	1.4	Vdc

†† Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

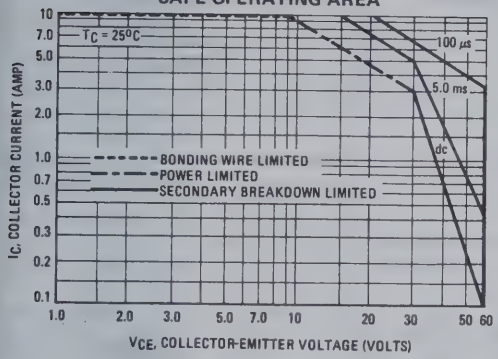


CASE 90

When mounting the device, torque not to exceed 8.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

FIGURE 1 – ACTIVE REGION DC SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. To insure operation below the maximum T_J, the power-temperature derating curve, Figure 4, must be observed for both steady state and pulse power conditions.

FIGURE 2 – "ON" VOLTAGES

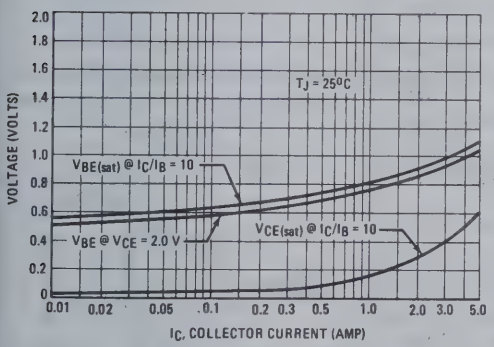


FIGURE 3 – CURRENT GAIN

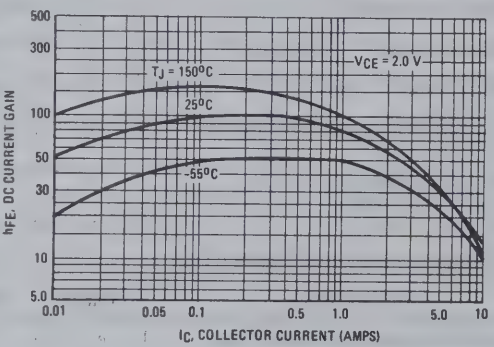
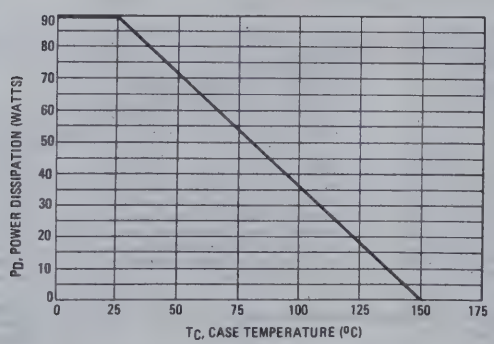


FIGURE 4 – POWER-TEMPERATURE DERATING CURVE



MJE2955 (SILICON)

HIGH POWER PNP SILICON TRANSISTOR

. . . designed for use in general-purpose amplifier and switching applications.

- DC Current Gain Specified to 10 Amperes
- High Current-Gain—Bandwidth Product — f_T = 2.0 MHz (Min) @ I_C = 500 mAdc
- Thermopad High-Efficiency Compact Package
- Complement to NPN MJE3055

10 AMPERE
POWER TRANSISTOR

PNP SILICON

60 VOLTS
90 WATTS



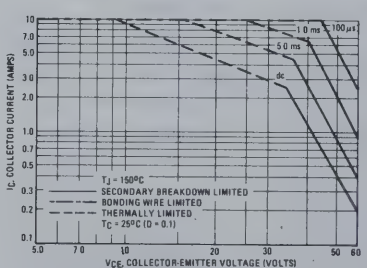
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	70	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	10	Adc
Base Current - Continuous	I_B	6.0	Adc
Total Device Dissipation @ T_C = 25°C* Derate above 25°C	P_D*	90 0.718	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

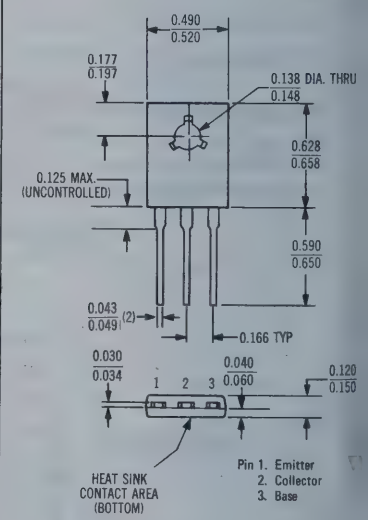
FIGURE 1 — ACTIVE REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 150°C$. $T_{J(pk)}$ may be calculated from the data in Figure 2. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

*Safe Area Curves are indicated by Figure 1 — Both thermal and safe area limits are applicable and must be observed.



CASE 90 (2)

When mounting the device, torque not to exceed 8.0 in.-lb.

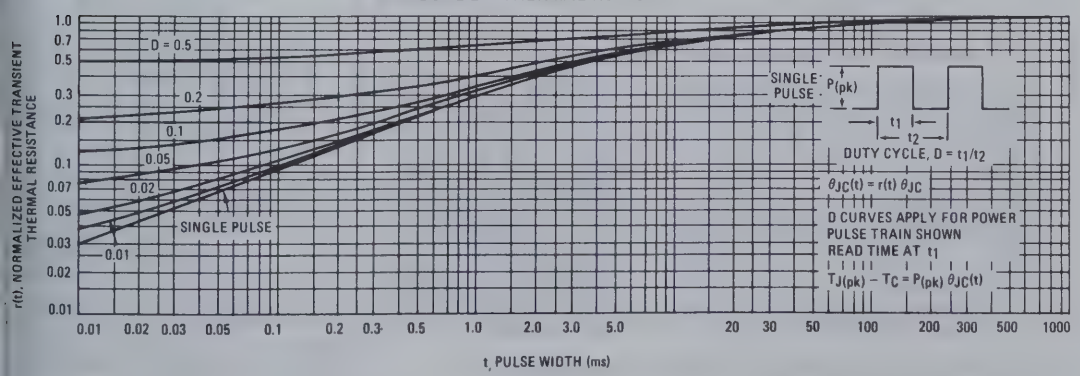
If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	60	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	-	700	μAdc
Collector Cutoff Current (V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEX}	- -	1.0 5.0	mAdc
Collector Cutoff Current (V_{CB} = 70 Vdc, I_E = 0) (V_{CB} = 70 Vdc, I_E = 0, T_C = 150°C)	I_{CBO}	- -	1.0 10	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	-	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	h_{FE}*	20 5.0	70 -	-
Collector-Emitter Saturation Voltage* (I_C = 4.0 Adc, I_B = 0.4 Adc) (I_C = 10 Adc, I_B = 3.3 Adc)	$V_{CE(sat)}$*	- -	1.1 8.0	Vdc
Base-Emitter On Voltage* (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$*	-	1.8	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 500 kHz)	f_T	2.0	-	MHz

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – THERMAL RESPONSE



MJE3055 (SILICON)

HIGH POWER NPN SILICON TRANSISTOR

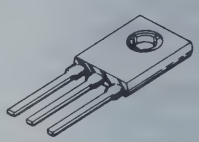
. . . designed for use in general-purpose amplifier and switching applications.

- DC Current Gain Specified to 10 Amperes
- High Current-Gain—Bandwidth Product — f_T = 2.0 MHz (Min) @ I_C = 500 mAdc
- Thermopad High-Efficiency Compact Package
- Plastic Version of 2N3055

10 AMPERE
POWER TRANSISTOR

NPN SILICON

60 VOLTS
90 WATTS

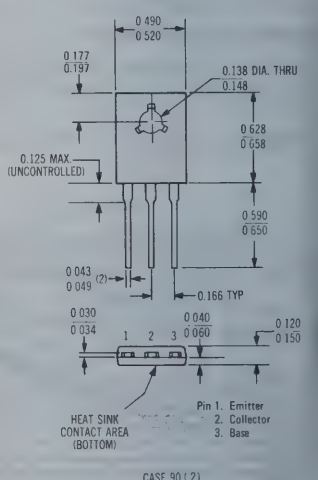


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	70	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	10	Adc
Base Current - Continuous	I_B	6.0	Adc
Total Device Dissipation @ T_C = 25°C* Derate above 25°C	P_D*	90 0.718	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.39	°C/W

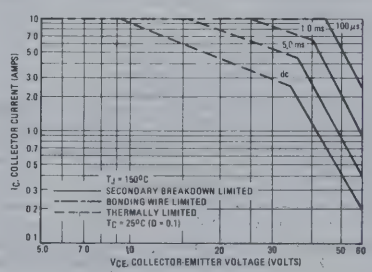


CASE 90 (2)

When mounting the device, torque not to exceed 8.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

FIGURE 1 — ACTIVE REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C—V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 1 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)}$ ≤150°C. $T_{J(pk)}$ may be calculated from the data in Figure 2. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

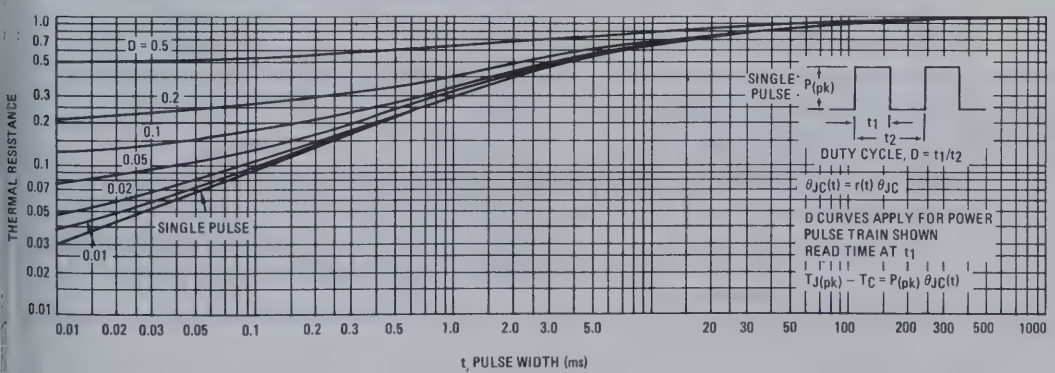
*Safe Area Curves are indicated by Figure 1 — Both thermal and safe area limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	60	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	-	700	μAdc
Collector Cutoff Current (V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{CEX}	-	1.0	mAdc
(V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)		-	5.0	
Collector Cutoff Current (V_{CB} = 70 Vdc, I_E = 0)	I_{CBO}	-	1.0	mAdc
(V_{CB} = 70 Vdc, I_E = 0, T_C = 150°C)		-	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	-	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	h_{FE}*	20	70	-
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)		5.0	-	
Collector-Emitter Saturation Voltage* (I_C = 4.0 Adc, I_B = 0.4 Adc)	$V_{CE(sat)}$*	-	1.1	Vdc
(I_C = 10 Adc, I_B = 3.3 Adc)		-	8.0	
Base-Emitter On Voltage* (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$*	-	1.8	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 500 kHz)	f_T	2.0	-	MHz

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – THERMAL RESPONSE



MJE3439, MJE3440 (SILICON)

NPN SILICON HIGH-VOLTAGE POWER TRANSISTORS

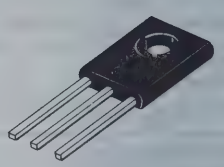
. . . designed for use as video output amplifiers in television receivers and in line operated audio output amplifiers.

- High DC Current Gain –
  h_{FE} = 40–160 @ I_C = 20 mAdc
- Current-Gain–Bandwidth Product –
  f_T = 15 MHz (Min) @ I_C = 10 mAdc
- Low Output Capacitance –
  C_{ob} = 10 pF (Max) @ f = 1.0 MHz

0.3 AMPERE

NPN SILICON POWER TRANSISTORS

250–350 VOLTS
15 WATTS



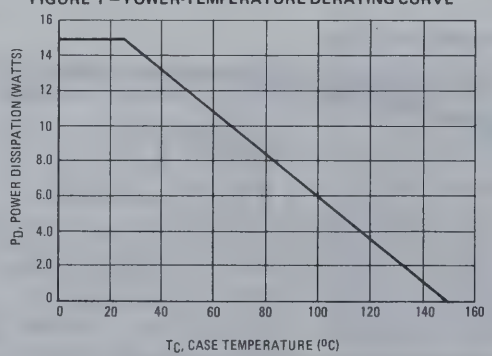
MAXIMUM RATINGS

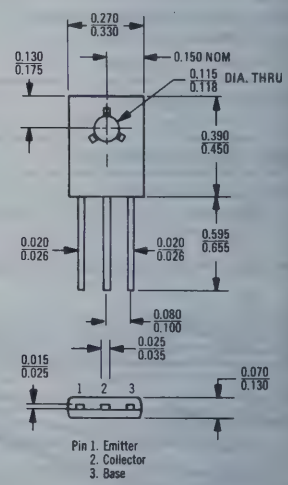
Rating	Symbol	MJE3439	MJE3440	Unit
Collector-Emitter Voltage	V_{CEO}	350	250	Vdc
Collector-Base Voltage	V_{CB}	450	350	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	0.3		Adc
Base Current	I_B	150		mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	15 0.12		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	8.33	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





Pin 1. Emitter
2. Collector
3. Base

When mounting the device, torque not to exceed 6.0 in.-lb.

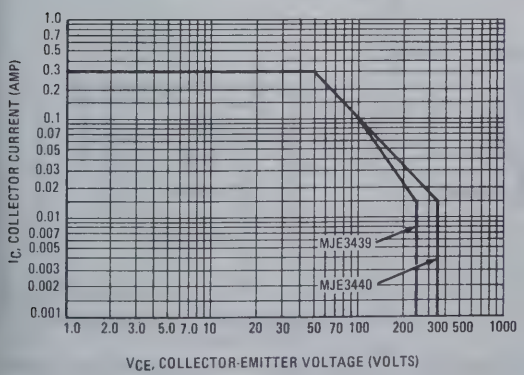
If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

CASE 77-02

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 5.0 mAdc, I_B = 0)	MJE3439		350	–	
(I_C = 50 mAdc, I_B = 0)	MJE3440		250	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 300 Vdc, I_B = 0)	MJE3439		–	20	
(V_{CE} = 200 Vdc, I_B = 0)	MJE3440		–	50	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 450 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJE3439		–	500	
(V_{CE} = 300 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	MJE3440		–	500	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 360 Vdc, I_E = 0)	MJE3439		–	20	
(V_{CB} = 250 Vdc, I_E = 0)	MJE3440		–	20	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	20	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)			30	–	
(I_C = 20 mAdc, V_{CE} = 10 Vdc)			40	160	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)		$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 4.0 mAdc)		$V_{BE(sat)}$	–	1.3	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)		f_T	15	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	10	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	–	–

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MLED600

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for applications requiring high visibility, low drive power and very fast response time. This device is used in panel and circuit condition indicators, light modulators, shaft or position encoders, punched card readers, optical switching, and logic circuits.

- High Brightness — 450 fL (Typ)
- Visible Red Emission — 660 nm (Typ)
- Low Drive Current — 10 mA for 50 fL
- Unique Molded Lens for Durability and Long Life
- Economical Plastic Package

LIGHT-EMITTING DIODE
VISIBLE RED
PN GALLIUM ARSENIDE PHOSPHIDE

100 MILLIWATTS



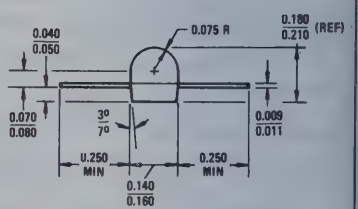
ACTUAL SIZE

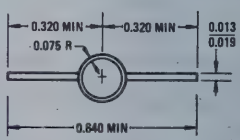


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	100 1.67	mW mW/°C
Operating Junction Temperature Range	T_J	-40 to +85	°C
Storage Temperature Range	T_{stg}	-40 to +100	°C

(1) Printed Circuit Board Mounting

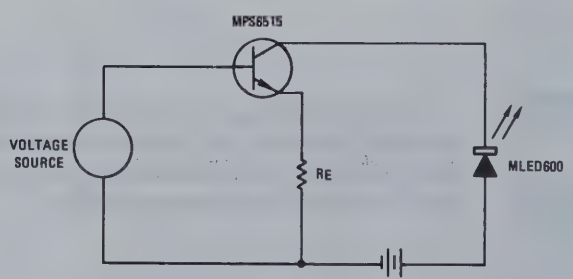




CASE 171(2)

(2) Cathode indicated by square bonding pad on bottom of device.

FIGURE 1 — TYPICAL DRIVE CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 4.0 V, R_L = 1.0 Megohm)	–	I_R	–	100	–	nA
Reverse Breakdown Voltage (I_R = 10 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.5	1.8	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Brightness (Note 1)	3	B				fL
(I_F = 10 mA)			50	–	–	
(I_F = 20 mA)			–	450	–	
Peak Emission Wavelength	4	λ_P	–	660	–	nm
Spectral Line Width	4	$\Delta\lambda$	–	20	–	nm

NOTE:

1. Measured with Photo Research Spectra Spot Brightness Meter Model UB 1/4° with "Spectar" L-175 lens.

FIGURE 2 – FORWARD CHARACTERISTICS

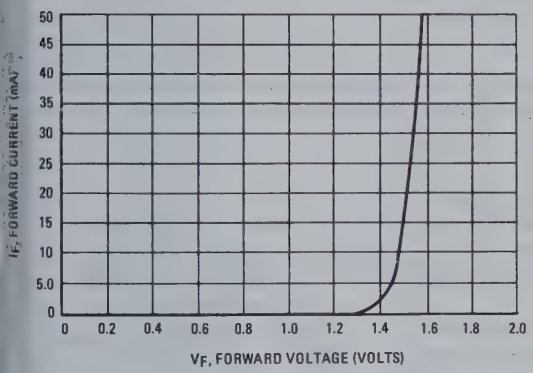


FIGURE 3 – BRIGHTNESS

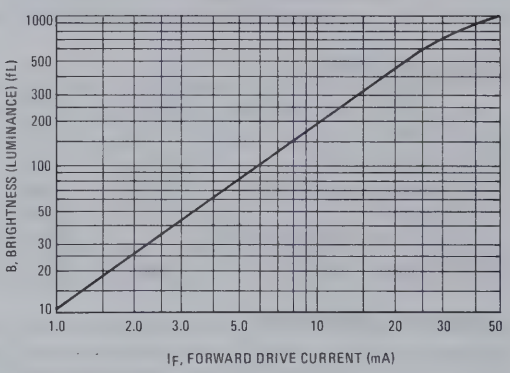
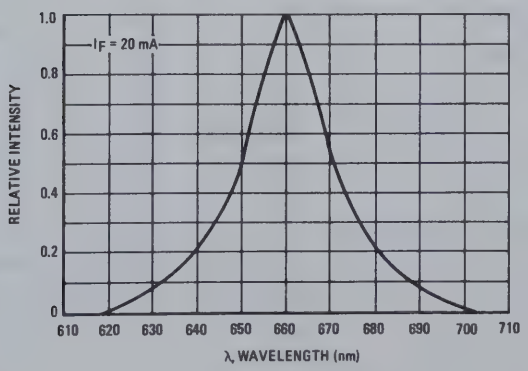


FIGURE 4 – RELATIVE INTENSITY



MLED610

VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for applications requiring high visibility, low drive power and very fast response time. This device is used in panel and circuit condition indicators, light modulators, shaft or position encoders, punched card readers, optical data links, optical switching, and logic circuits.

- High Brightness – 450 fL (Typ)
- Visible Red Emission – 660 nm (Typ)
- Low Drive Current – 10 mA for 50 fL
- Hermetic Pill Package for Durability, Long Life and Reliability
- Pill Package Allows Printed Circuit Board Assembly
- Small Size for High Density Mounting

LIGHT-EMITTING DIODE
VISIBLE RED
PN GALLIUM ARSENIDE PHOSPHIDE

100 MILLIWATTS

Actual Size

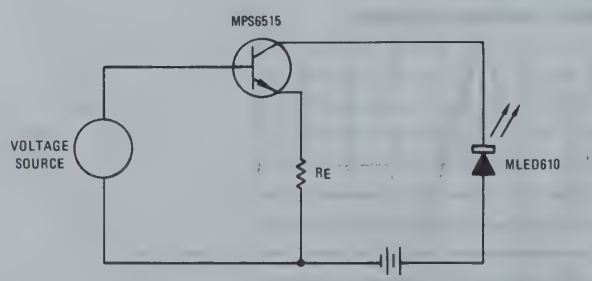


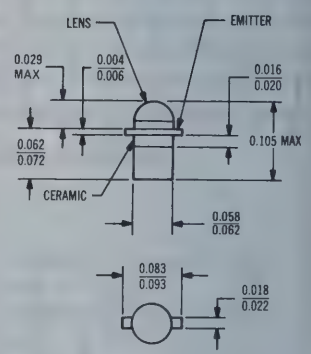
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	50	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D(1)	200 2.67	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

(1) Printed Circuit Board Mounting

FIGURE 1 – TYPICAL DRIVE CIRCUIT





CASE 81A-02

Cathode connected to case

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 4.0 V, R_L = 1.0 Megohm)	–	I_R	–	100	–	nA
Reverse Breakdown Voltage (I_R = 10 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.5	1.8	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Brightness (Note 1)	3	B				fL
(I_F = 10 mA)			50	–	–	
(I_F = 20 mA)			–	450	–	
Peak Emission Wavelength	4	λ_P	–	660	–	nm
Spectral Line Width	4	$\Delta\lambda$	–	20	–	nm

NOTE:

1. Measured with Photo Research Spectra Spot Brightness Meter Model UB 1/4° with "Spectar" L-175 lens.

FIGURE 2 – FORWARD CHARACTERISTICS

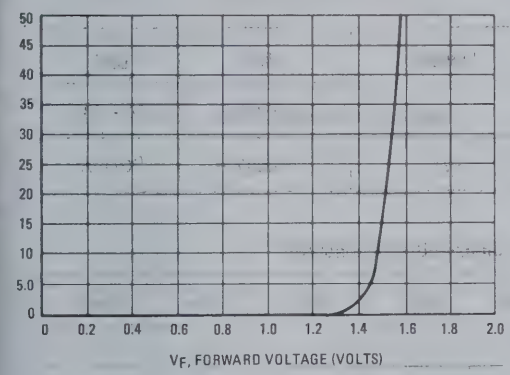


FIGURE 3 – BRIGHTNESS

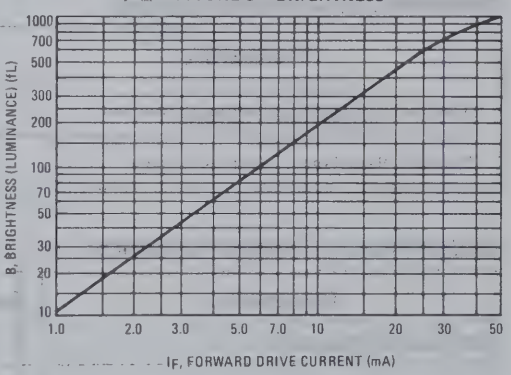
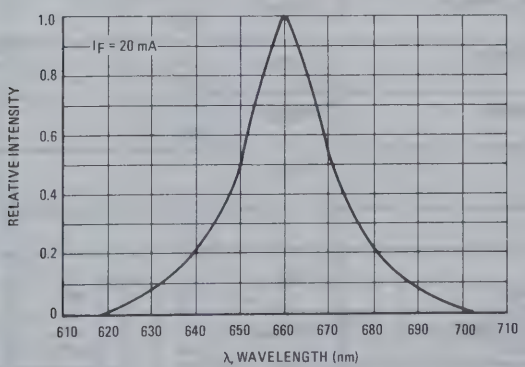


FIGURE 4 – RELATIVE INTENSITY



MM380 (GERMANIUM)



PNP germanium selective metal etch transistor designed for use in UHF oscillator applications.

CASE 22
(TO-18)

Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	0.3	Vdc
Total Device Dissipation T_A = 25°C	P_D	250	mW
Derate above 25°C		3.33	mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.300	°C/mW
Thermal Resistance, Junction to Case	θ_{JC}	0.200	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	10	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	0.3	—	—	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc)	h_{FE}	15	50	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.07	0.15	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	0.40	0.45	Vdc

MM380 (Continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 3 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	600	—	MHz
Maximum Frequency of Oscillation (I_C = 3 mAdc, V_{CE} = 10 Vdc)	f_{max}	—	1500	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	1.4	1.8	pF
Collector-Base Time Constant (I_E = 3 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r'_b C_c$	—	9	12	ps

COMMON-BASE y PARAMETERS

V_{CB} = 10 Vdc, f = 930 MHz, T_A = 25°C

FIGURE 1 — INPUT ADMITTANCE

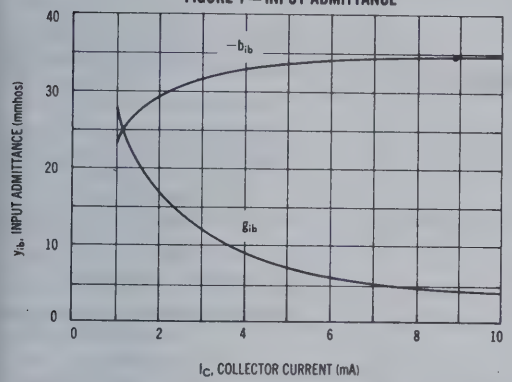


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

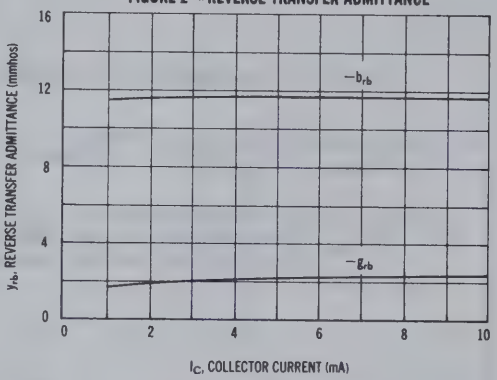


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

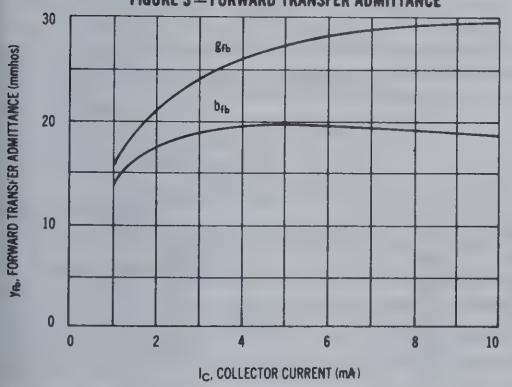


FIGURE 4 — OUTPUT ADMITTANCE

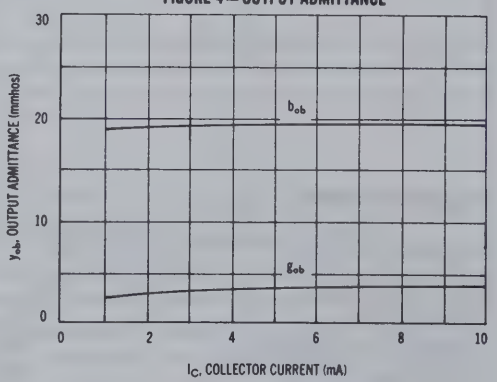
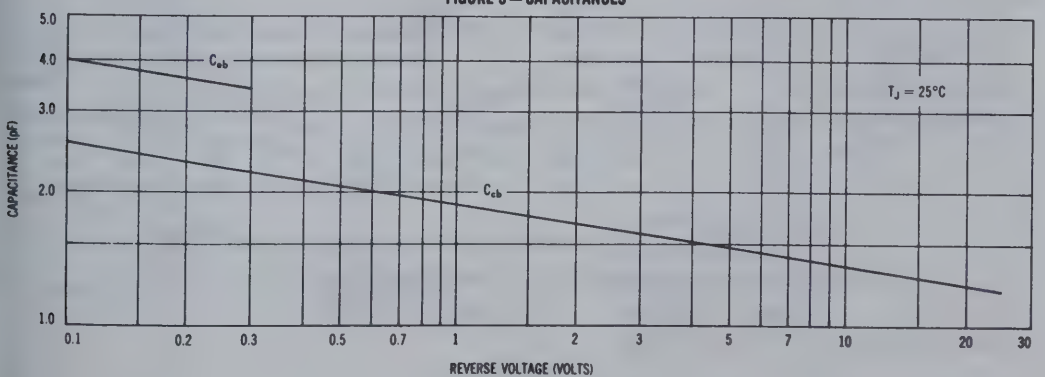


FIGURE 5 — CAPACITANCES



MM404 (GERMANIUM)
MM404A

PNP GERMANIUM SWITCHING TRANSISTORS

. . . designed for medium-speed saturated switching applications.

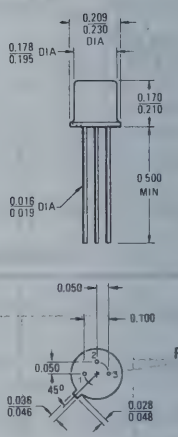
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.2 Vdc (Max) @ I_C = 24 mAdc
- High Emitter-Base Breakdown Voltage –
  BV_{EBO} = 12 Vdc (Min) @ I_E = 20 μAdc – MM404
  = 25 Vdc (Min) @ I_E = 20 μAdc – MM404A

PNP GERMANIUM SWITCHING TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MM404	MM404A	Unit
Collector-Emitter Voltage	V_{CES}	24	35	Vdc
Collector-Base Voltage	V_{CB}	25	40	Vdc
Emitter-Base Voltage	V_{EB}	12	25	Vdc
Collector Current – Continuous	I_C	150		mAdc
Emitter Current	I_E	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 4.0		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +100		°C



CASE 22 (1)
TO-18

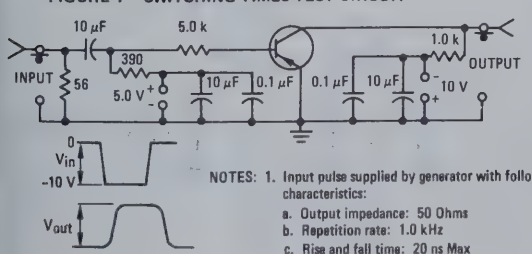
MM404, MM404A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 20 μAdc, I_E = 0)	MM404	BV_{CBO}	25	–	–	Vdc
	MM404A		40	–	–	
Emitter-Base Breakdown Voltage (I_E = 20 μAdc, I_C = 0)	MM404	BV_{EBO}	12	–	–	Vdc
	MM404A		25	–	–	
Punch-Through Voltage[1] (V_{EBfl} = 1.0 Vdc)	MM404	V_{pt}	24	–	–	Vdc
	MM404A		35	–	–	
Emitter-Base Floating Potential (V_{CB} = 35 Vdc, I_E = 0)	MM404A	V_{EBfl}	–	–	1.0	Vdc
Collector Cutoff Current (V_{CB} = 12 Vdc, I_E = 0)		I_{CBO}	–	0.8	5.0	μAdc
(V_{CB} = 12 Vdc, I_E = 0, T_A = 80°C)			–	20	90	
Emitter Cutoff Current (V_{EB} = 2.5 Vdc, I_C = 0)		I_{EBO}	–	0.5	2.5	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 12 mAdc, V_{CE} = 0.15 Vdc)		h_{FE}	30	80	–	–
(I_C = 24 mAdc, V_{CE} = 0.20 Vdc)			24	90	–	
Collector-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc)		$V_{CE(sat)}$	–	0.09	0.15	Vdc
(I_C = 24 mAdc, I_B = 1.0 mAdc)			–	0.09	0.20	
Base-Emitter Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc)		V_{BE}	–	0.27	0.35	Vdc
(I_C = 24 mAdc, I_B = 1.0 mAdc)			–	0.30	0.40	
SMALL-SIGNAL CHARACTERISTICS						
Alpha Cutoff Frequency (I_E = 1.0 mAdc, V_{CB} = 6.0 Vdc)		f_{hfb}	4.0	25	–	MHz
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 1.0 MHz)	MM404	C_{ob}	–	8.0	20	pF
(V_{CB} = 6.0 Vdc, I_E = 1.0 mAdc, f = 2.0 MHz)	MM404A		–	8.0	20	
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{ie}	–	3.0	–	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{re}	–	8.0	–	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{fe}	–	135	–	–
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{oe}	–	50	–	μmhos
SWITCHING CHARACTERISTICS						
Delay Time (Figure 1)		t_d	–	0.07	–	μs
Rise Time (Figure 1)		t_r	–	0.12	–	μs
Storage Time (Figure 1)		t_s	–	0.20	–	μs
Fall Time (Figure 1)		t_f	–	0.10	–	μs
Stored Base Charge (Figure 2)		Q_{sb}	–	300	1400	pC

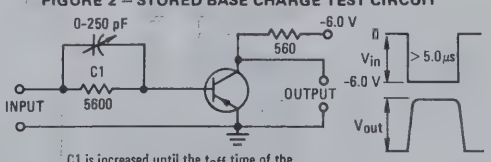
[1] V_{pt} is determined by measuring the emitter-base floating potential V_{EBfl}, using a voltmeter with 11 megohms minimum input impedance. The collector-base voltage, V_{CB}, is measured until V_{EBfl} = −1.0 Vdc; this value of V_{CB} = (V_{pt} + 1).

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



NOTES: 1. Input pulse supplied by generator with following characteristics:
a. Output impedance: 50 Ohms
b. Repetition rate: 1.0 kHz
c. Rise and fall time: 20 ns Max

FIGURE 2 – STORED BASE CHARGE TEST CIRCUIT



C1 is increased until the t_{off} time of the output waveform is decreased to 0.2 μs. Q_{sb} is then calculated by Q_{sb} = C1 V_{in}.

2. Waveforms monitored on scope with following characteristics:
a. Input resistance – 10 Megohms Min
b. Input capacitance – 15 pF Max
c. Rise time – 15 ns Max

3. All resistors ± 1.0% tolerance.

MM709 (SILICON)



Collector connected to case

CASE 27
(TO-52)

NPN silicon annular transistor designed for ultra-high speed switching and amplifier application.

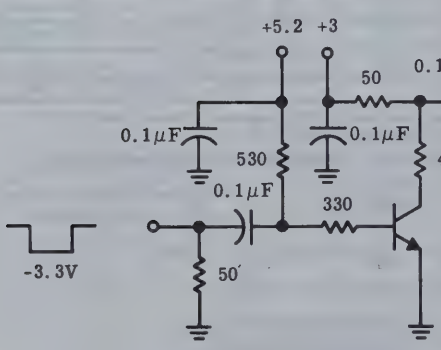
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (1 to 30 mA)	V_{CEO}	8	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	400 2.3	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	750 4.3	mW $mW/^oC$
Operating Junction Temperature Range	T_J	200	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

THERMAL CHARACTERISTICS

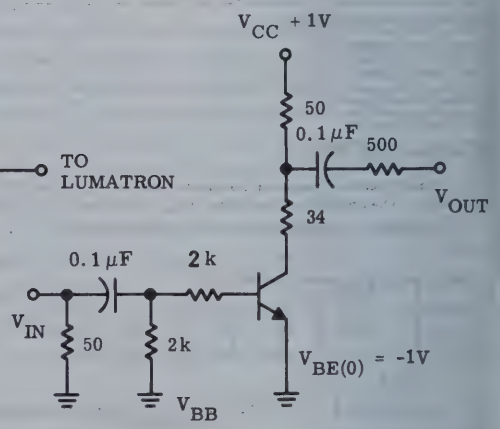
Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.233	$^oC/W$
Thermal Resistance, Junction to Ambient	θ_{JA}	0.436	$^oC/W$

FIGURE 1 — CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



SKL
OR
EQUIVALENT
PW≥200 ns

FIGURE 2 — t_{on} & t_{off} TEST CIRCUIT



ELECTRICAL CHARACTERISTICS

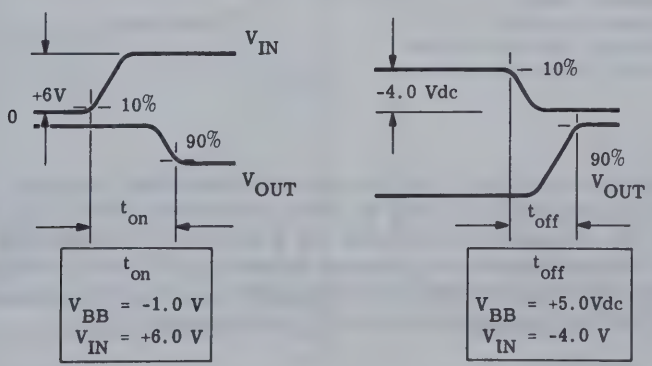
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	8	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4	-	Vdc
Collector Cutoff Current (V_{CB} = 5 Vdc) (V_{CB} = 5 Vdc, T_A = 125°C)	I_{CBO}	- -	.015 20	μAdc
DC Forward Current Transfer Ratio* (I_C = 10 mAdc, V_{CE} = 0.5 V) (I_C = 30 mAdc, V_{CE} = 1 V) (I_C = 10 mAdc, V_{CE} = 0.5 V, T_A = -55°C)	h_{FE}*	15 12 8	120 - -	-
Collector Saturation Voltage* (I_C = 3 mAdc, I_B = 0.15 mAdc)	$V_{CE(sat)}$*	-	.35	Vdc
Base-Emitter Saturation Voltage* (I_C = 3 mAdc, I_B = 0.15 mAdc)	$V_{BE(sat)}$*	0.70	0.85	Vdc
Current Gain Bandwidth Product (I_C = 5 mAdc, V_{CE} = 4 Vdc)	f_T	300	-	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	3	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_E = 0, f = 100 kHz)	C_{ib}	-	2	pF

SWITCHING CHARACTERISTICS

Charge Storage Time - See Figure 1 (I_C = I_{B1} = $-I_{B2}$ = 5.0 mAdc)	t_s	-	5	ns
Turn-On Time - See Figure 2 (I_C = 10 mAdc, I_B = 2.0 mAdc, I_{B2} = 1.0 mAdc)	t_{on}	-	12	ns
Turn-Off Time - See Figure 2 (I_C = 10 mAdc, I_{B1} = $-I_{B2}$ = 1.0 mAdc)	t_{off}	-	10	ns

*Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%.

INPUT & OUTPUT PULSE WAVEFORMS V_{in} RISE TIME ≤ 1 ns



MM1139 (GERMANIUM)



CASE 20
(TO-72)

PNP germanium selective metal etch transistor for use in FM mixer and IF amplifier applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	0.3	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	125 1.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}*	0.6	°C/mW
Thermal Resistance, Junction to Lead	θ_{JL}*	0.4	°C/mW

* In this transistor the collector is electrically and thermally isolated from the case with the result that the primary path of heat conduction is through the collector lead; therefore, the amount of heat sink on the lead will determine the thermal characteristics. Thermal resistance, junction to lead (θ_{JL}) = 0.4 °C / mW. In a typical application where the lead connects to a small RF coil, thermal resistance junction to ambient (θ_{JA}) will be approximately 0.2°C/mW greater than θ_{JL}.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, I_B = 0)	BV_{CEO}	15	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	0.3	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	0.7	8	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc)	h_{FE}	15	35	—	—
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	550	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{cb}	—	0.17	0.30	pF
Collector-Base Time Constant (I_E = 2 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	—	3.5	6	ps
FUNCTIONAL TEST					
Conversion Gain (108 to 10.7 MHz) (I_C = 3 mAdc, V_{CE} = 10 Vdc, Test Circuit Figure 7)	—	—	22	—	dB

CONVERSION GAIN CHARACTERISTICS

(TEST CIRCUIT FIGURE 7)

FIGURE 1 — VARIATION WITH COLLECTOR CURRENT

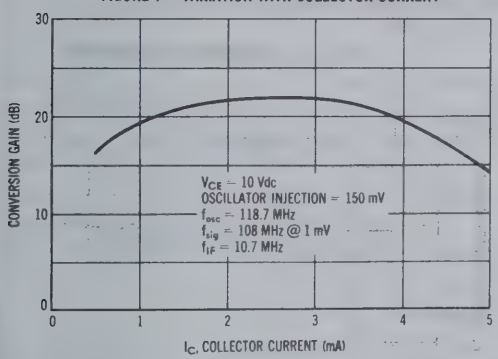
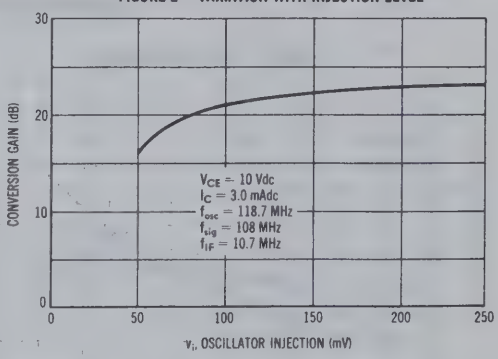


FIGURE 2 — VARIATION WITH INJECTION LEVEL



COMMON-EMITTER y PARAMETERS

V_{CE} = 10 Vdc, f = 105 MHz, T_A = 25°C

FIGURE 3 — INPUT ADMITTANCE

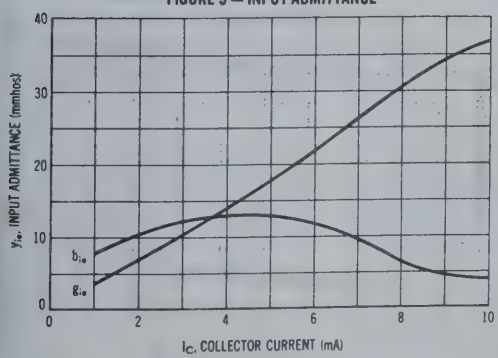


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

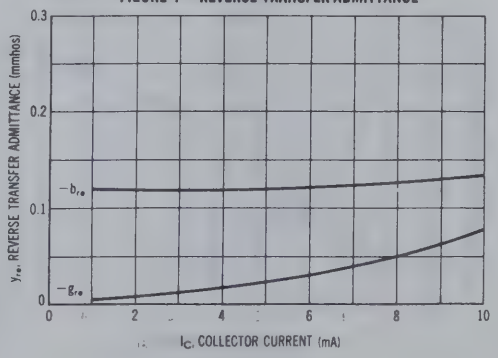


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

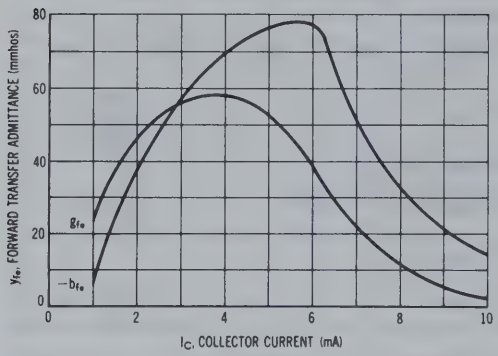


FIGURE 6 — OUTPUT ADMITTANCE

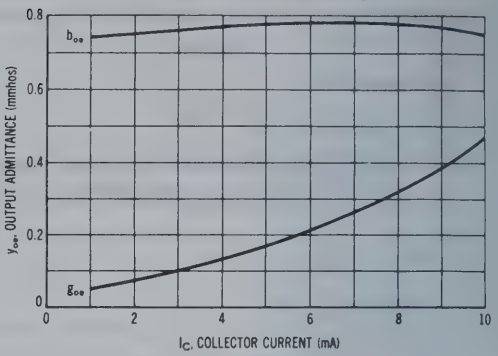


FIGURE 7 — MIXER TEST CIRCUIT

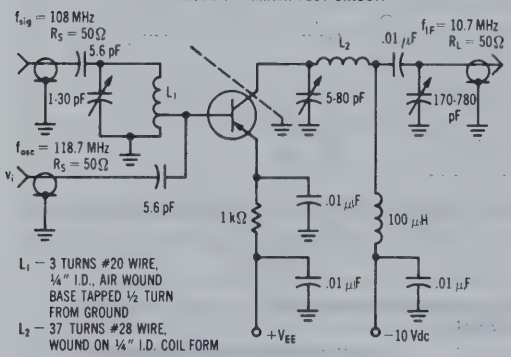
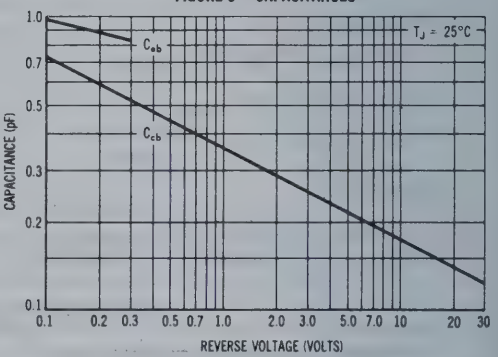


FIGURE 8 — CAPACITANCES



COMMON-EMITTER y PARAMETERS

V_{CE} = 10 V, f = 10.7 MHz, T_A = 25°C

FIGURE 9 — INPUT ADMITTANCE

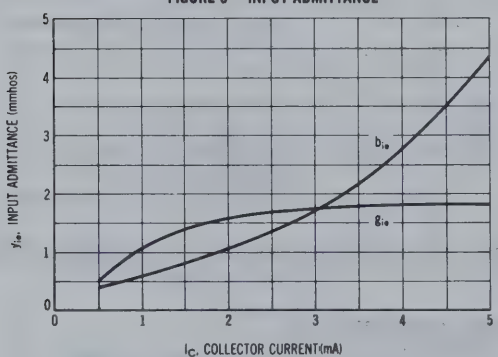


FIGURE 10 — REVERSE TRANSFER ADMITTANCE

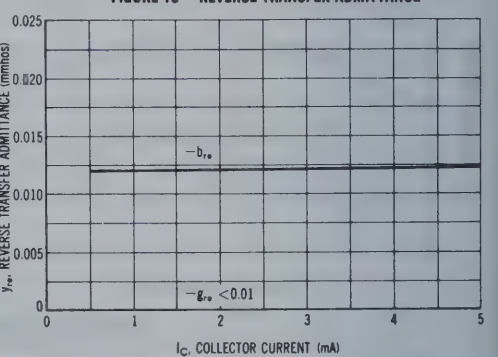


FIGURE 11 — FORWARD TRANSFER ADMITTANCE

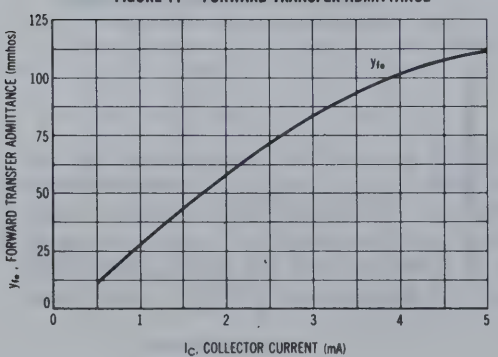
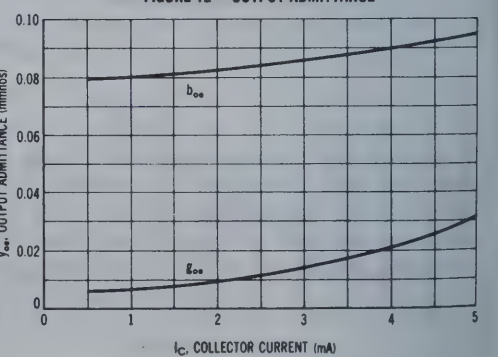


FIGURE 12 — OUTPUT ADMITTANCE



MM1500 (SILICON)
MM1501



NPN silicon RF power transistors designed for UHF amplifier, frequency multiplier, and oscillator applications.

CASE 23
(TO-107)

Collector connected to case
AVAILABLE WITH TO-102 STUD

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltagee	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to 200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	50	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)		$BV_{CEO(sus)}$	15	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	30	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	4	—	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	—	—	0.1	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)			—	—	100	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM1500	f_T	—	1500	—	MHz
	MM1501		—	1000	—	
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	3.2	5	pF
Collector-Base Time Constant (I_E = 100 mAdc, V_{CB} = 15 Vdc, f = 31.8 MHz)	MM1500	$r_b'C_c$	—	7	—	ps
	MM1501		—	10	—	
FUNCTIONAL TEST						
Power Output, Figure 1 (V_{CB} = 20 Vdc, R_L = 50 ohms, f = 1500 MHz)	MM1500	P_{out}	250	—	—	mW
	MM1501		150	—	—	

FIGURE 1 — POWER OUTPUT TEST CIRCUIT

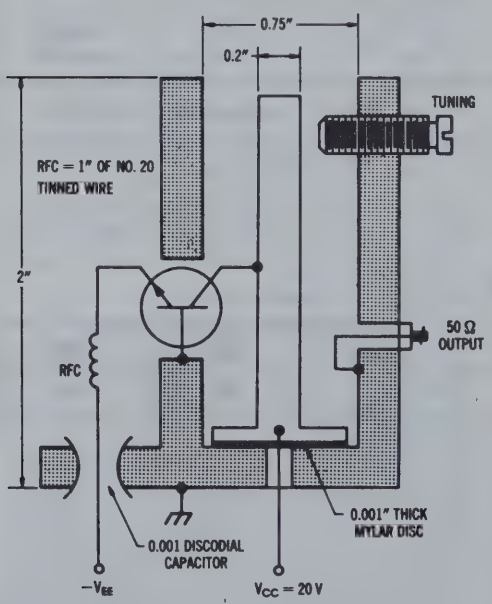
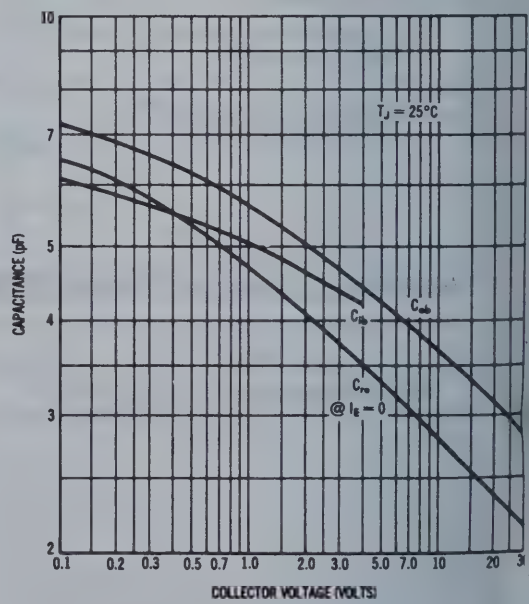


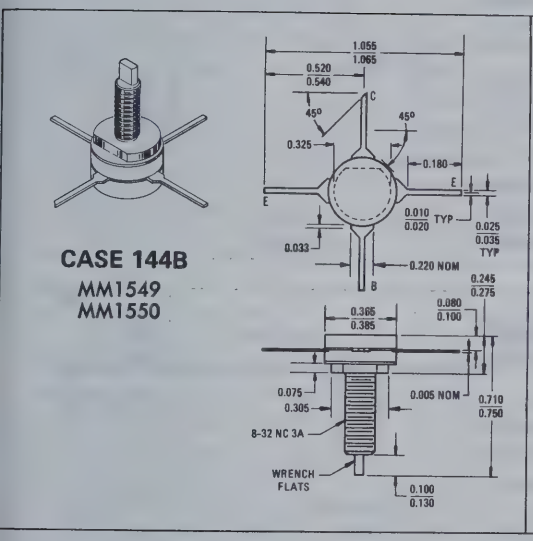
FIGURE 2 — CAPACITANCES



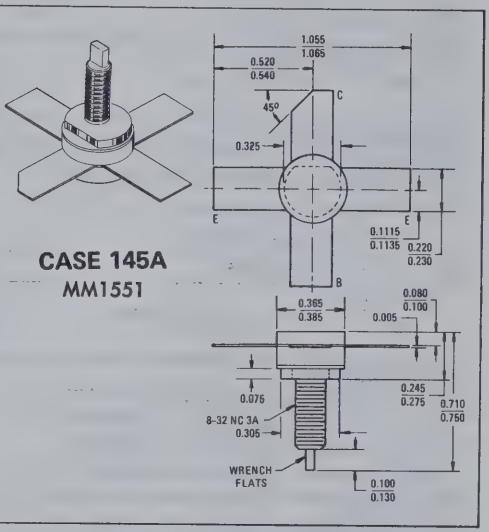
MM1549 (SILICON)
MM1550
MM1551

BEING REPLACED BY 2N5635/2N5637

NPN silicon RF power transistors designed for VHF/UHF amplifier applications. Suitable for use in driver and output stages in 28 volt systems up to 470 MHz. Ideal for 225-400 MHz communications equipment.



CASE 144B
MM1549
MM1550



CASE 145A
MM1551

MAXIMUM RATINGS

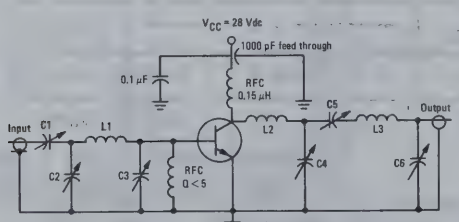
Rating	Symbol	MM1549	MM1550	MM1551	Unit
Collector-Emitter Voltage	V_{CEO}	← 35 →			Vdc
Collector-Base Voltage	V_{CB}	← 60 →			Vdc
Emitter-Base Voltage	V_{EB}	← 4.0 →			Vdc
Collector Current	I_C	1.0	1.5	3.0	Adc
Total Device Dissipation @ T_C = 25°C	P_D	7.5	15	30	Watts
Derate above 25°C		43	86	171	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage*		BV_{CEO}*				Vdc
(I_C = 100 mAdc, I_B = 0)	MM1549		35	-	-	
(I_C = 200 mAdc, I_B = 0)	MM1550, MM1551		35	-	-	
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 100 mAdc, V_{BE} = 0)	MM1549		60	-	-	
(I_C = 200 mAdc, V_{BE} = 0)	MM1550, MM1551		60	-	-	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	MM1549		4.0	-	-	
(I_E = 5.0 mAdc, I_C = 0)	MM1550		4.0	-	-	
(I_E = 10 mAdc, I_C = 0)	MM1551		4.0	-	-	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 30 Vdc, I_E = 0)	MM1549		-	-	0.1	
	MM1550		-	-	1.0	
	MM1551		-	-	1.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MM1549		5.0	-	-	
(I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	MM1550		5.0	-	-	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	MM1551		5.0	-	-	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	MM1549		-	-	10	
	MM1550		-	-	20	
	MM1551		-	-	30	
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain		G_{PE}				dB
(P_{out} = 2.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	MM1549		6.2	9.2	-	
(P_{out} = 7.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	MM1550		5.7	7.0	-	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	MM1551		4.6	5.8	-	
Power Output		P_{out}				Watts
(P_{in} = 0.6 Watt, V_{CE} = 28 Vdc, f = 400 MHz)	MM1549		2.5	3.2	-	
(P_{in} = 2.0 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	MM1550		7.5	8.4	-	
(P_{in} = 7.0 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	MM1551		20	22	-	
Collector Efficiency		η				%
(P_{out} = 2.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	MM1549		50	-	-	
(P_{out} = 7.5 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	MM1550		50	-	-	
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 400 MHz)	MM1551		60	-	-	

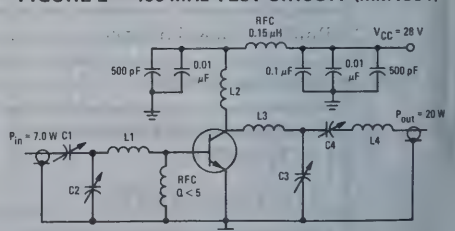
* Pulsed through 25 mH inductor.

FIGURE 1 – 400 MHz TEST CIRCUIT (MM1549, MM1550)



C1 – 1.0-10 pF piston trimmer
C2, C3, C4, C5 – 1.0-30 pF piston trimmer
C6 – 1.0-20 pF piston trimmer
L1, L2, L3 – 1 turn, #14 AWG, 1/4" dia.

FIGURE 2 – 400 MHz TEST CIRCUIT (MM1551)

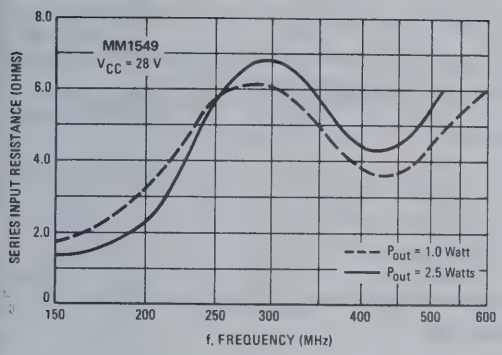


C1 – 1.0-30 pF piston trimmer
C2, C3, C4 – 1.0-10 pF piston trimmer
L1 – 12 nH, #14 straight wire, 3/4" long
L2 – 30 nH, 3 Turns #16 AWG, ¼" O. D., ½" L.
L3 – 40 nH, 1 Turn #16 AWG, 3/8 O. D.
L4 – 10 nH, 1/4" wide, 3/8" long Cu Strap

CIRCUIT DESIGN DATA

REAL INPUT IMPEDANCE versus FREQUENCY

FIGURE 3



IMAGINARY INPUT IMPEDANCE versus FREQUENCY

FIGURE 4

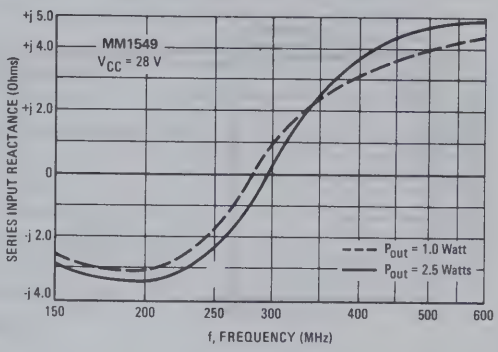


FIGURE 5

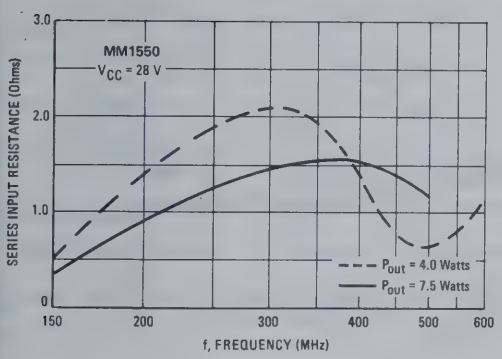


FIGURE 6

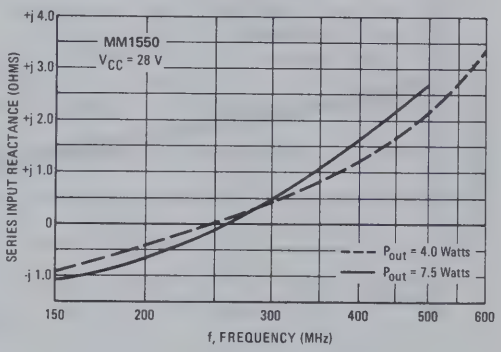


FIGURE 7

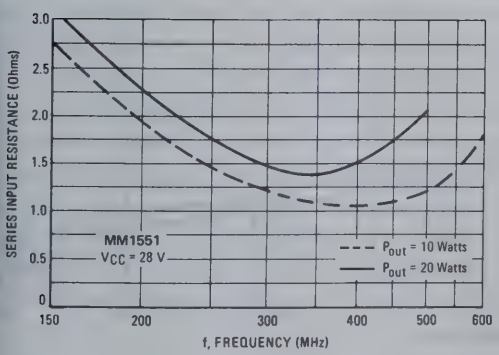
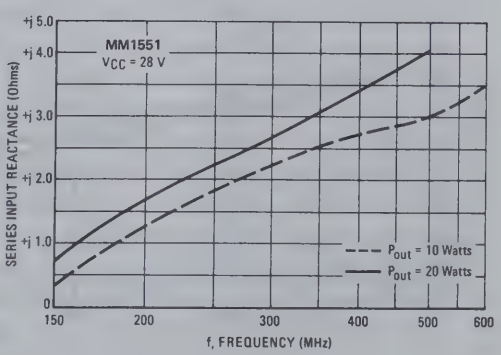


FIGURE 8



CIRCUIT DESIGN DATA

LARGE SIGNAL OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 9

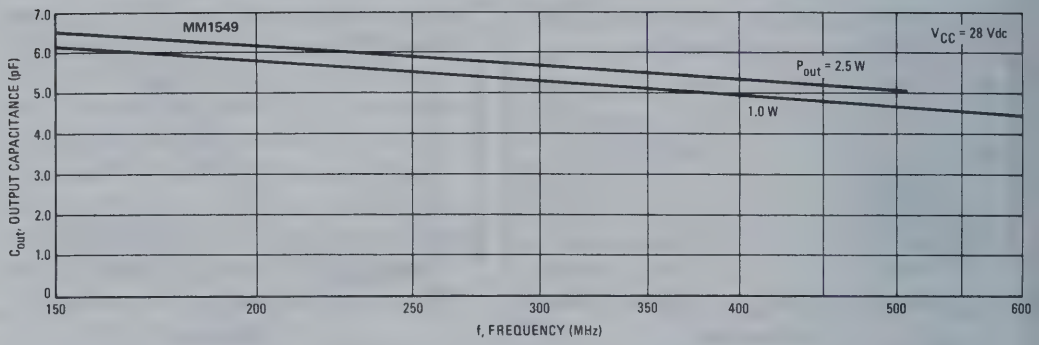


FIGURE 10

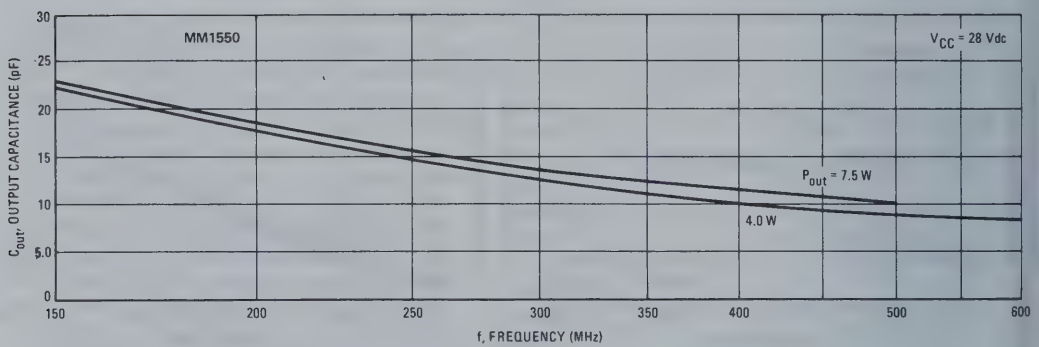
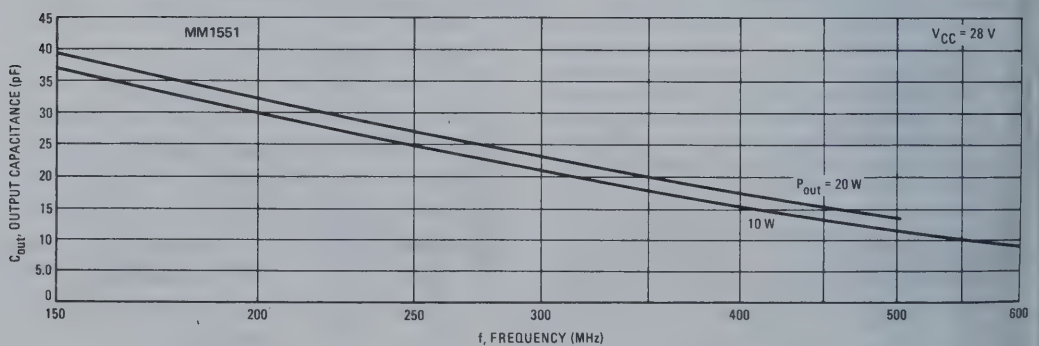


FIGURE 11



TYPICAL PERFORMANCE DATA

POWER OUTPUT versus FREQUENCY

FIGURE 12

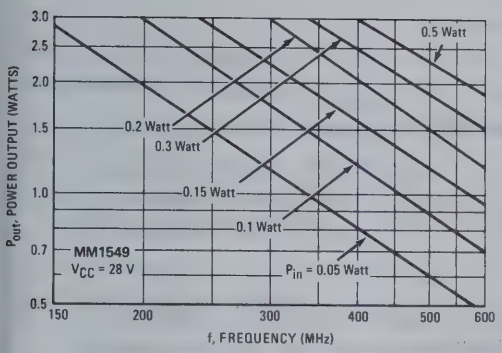


FIGURE 13

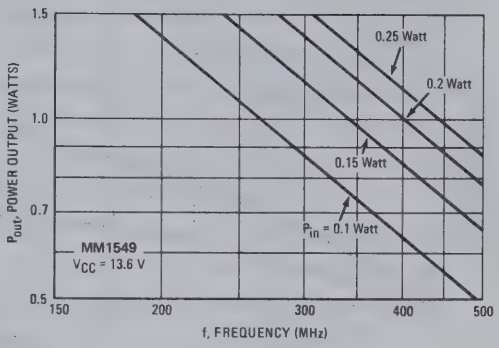


FIGURE 14

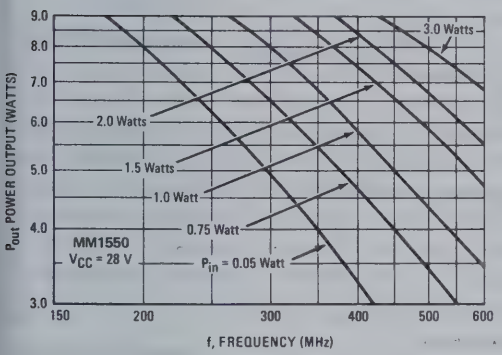


FIGURE 15

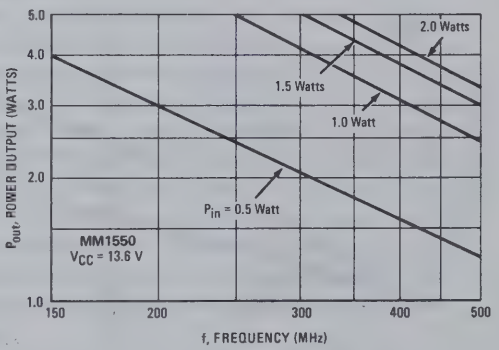


FIGURE 16

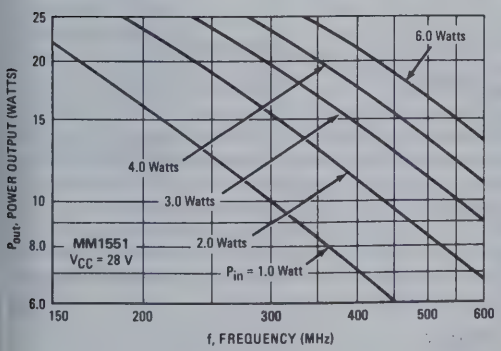
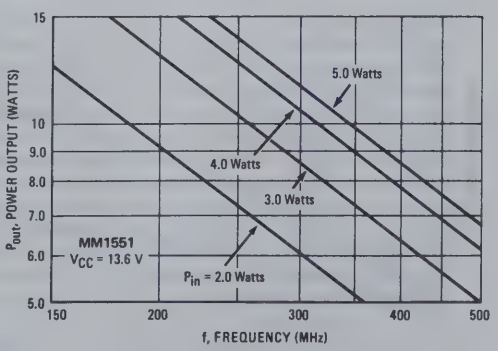


FIGURE 17



TYPICAL PERFORMANCE DATA

POWER OUTPUT versus POWER INPUT

FIGURE 18

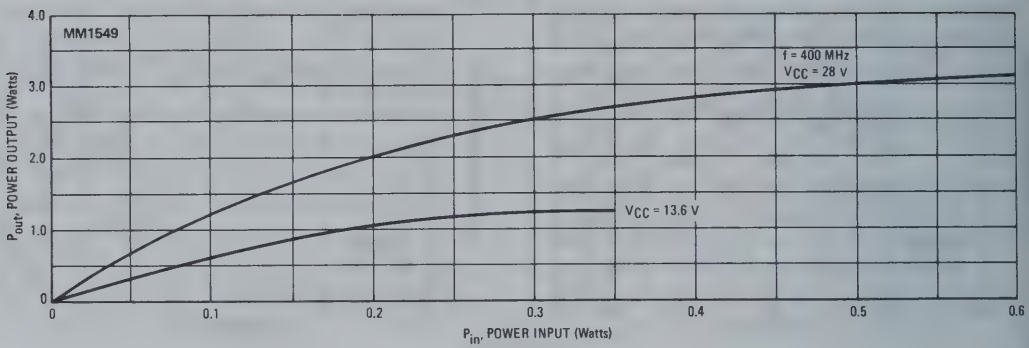


FIGURE 19

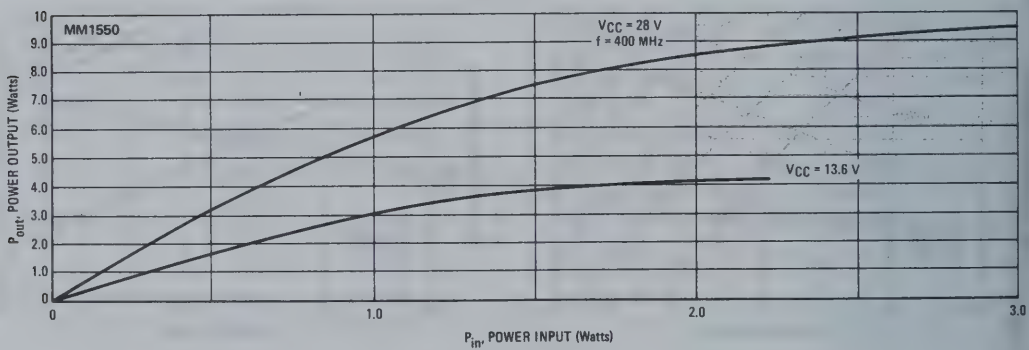
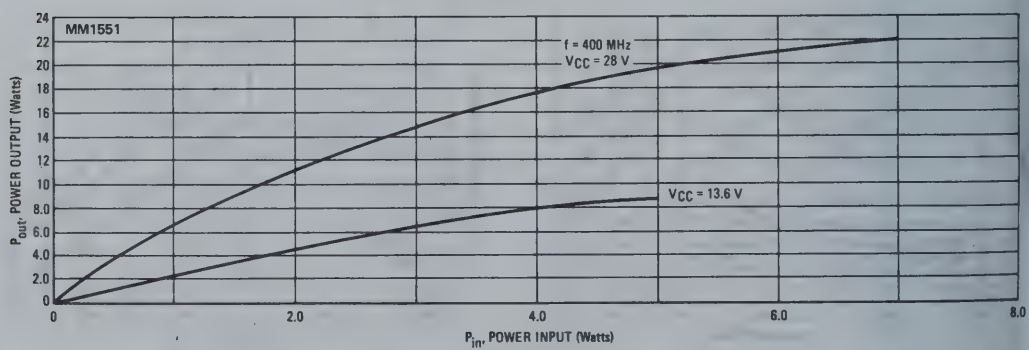


FIGURE 20



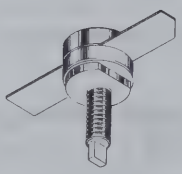
MM1552 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for VHF power amplifier applications in military and industrial equipment. Particularly suited for use in Class AB, B, or C amplifier applications to 175 MHz.

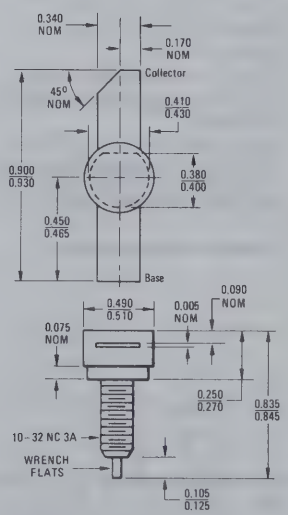
- High Output Power Capability –
  90 Watts Peak Output for 15 Watts (Typ) Input @ f = 150 MHz
- Balanced Emitter Construction to Provide the Designer with the device Technology that Assures Ruggedness and Resists Transistor Damage Caused by Load Mismatch.
- Stripline Packaging for Lower Lead Inductance and Better Broadband Capability

NPN SILICON RF POWER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	8.0	Adc
Total Device Dissipation @ T_C=50°C Derate above 50°C	P_D	80 533	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



Emitter Connected to Stud

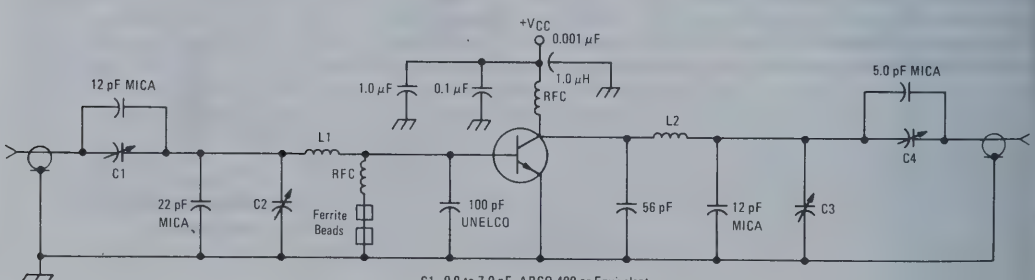
CASE 145C – 01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ① (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	35	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	65	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	90	130	pF
FUNCTIONAL TEST (Circuit Tuned at 90 Watts Peak, V_{CE} = 27 Vdc and not retuned for 13.5 Vdc Carrier Power Test)					
Power Input (P_{out} = 90 W Peak, V_{CE} = 27 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated)	$P_{in(peak)}$	–	15	18	Watts
Power Output CW (Carrier Power) (P_{in} = 7.7 W, V_{CE} = 13.5 Vdc, f = 150 MHz, Circuit Tuned at 90 W Peak, V_{CE} = 27 Vdc)	P_{out}	24	27	–	Watts
Power-Output CW (V_{CE} = 27 Vdc, f = 150 MHz, Saturated CW Output Power)	P_{out}	75	–	–	Watts
Collector Efficiency (P_{out} = 90 W Peak, V_{CE} = 27 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated)	η	60	–	–	%
Load Mismatch (P_{out} = 90 W Peak, V_{CE} = 27 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated. Device Subjected to All Conditions of Load Mismatch from Short-Circuit to Open Circuit)	Less Than 5% Change in Power Readings Before and After Mismatch Tests.				

① Pulsed through 25 mH Inductor.

FIGURE 1 – 150 MHz TEST CIRCUIT



C1 0.9 to 7.0 pF, ARCO 400 or Equivalent
C2, C3, C4 1.5 to 15 pF, ARCO 460 or Equivalent
L1 1" x 3/16" Straight Copper Strap 0.030 Thick
L2 1 1/2 Turns #16 AWG, 1/4" O.D.

FIGURE 2 – POWER OUTPUT versus FREQUENCY

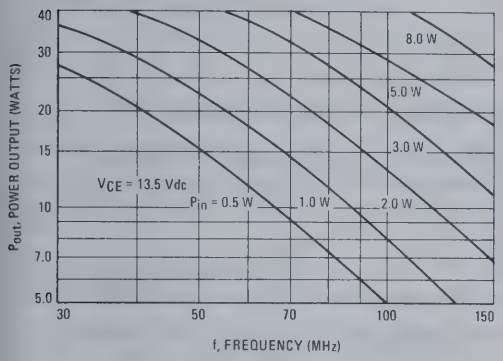


FIGURE 3 – POWER OUTPUT versus FREQUENCY

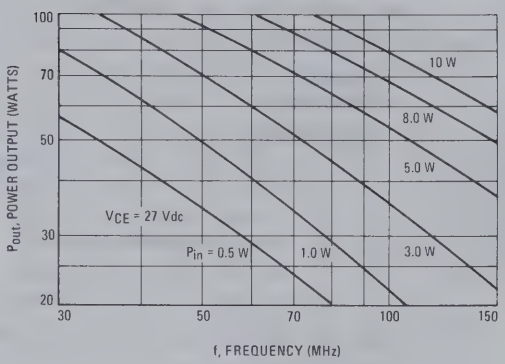


FIGURE 4 – POWER OUTPUT versus POWER INPUT

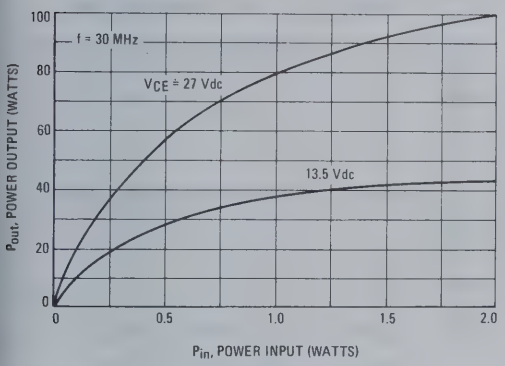


FIGURE 5 – POWER OUTPUT versus POWER INPUT

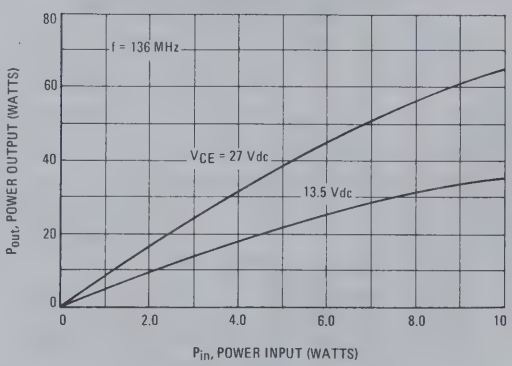


FIGURE 6 – POWER OUTPUT versus POWER INPUT

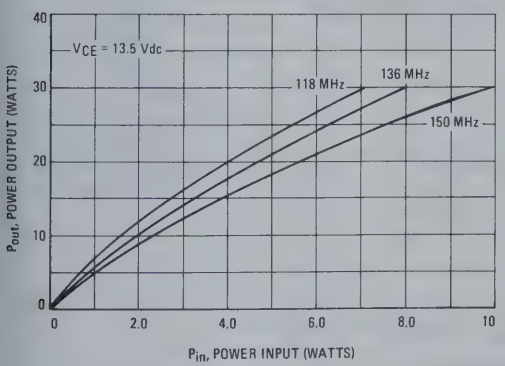


FIGURE 7 – POWER OUTPUT versus COLLECTOR-EMITTER VOLTAGE

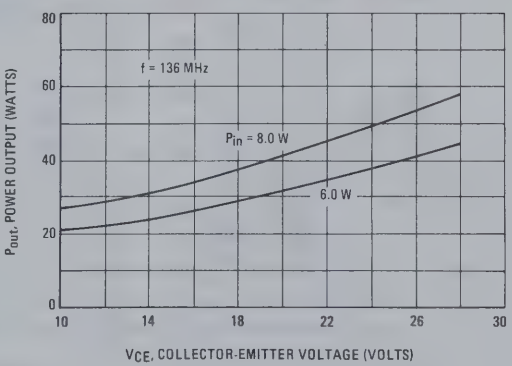


FIGURE 8 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

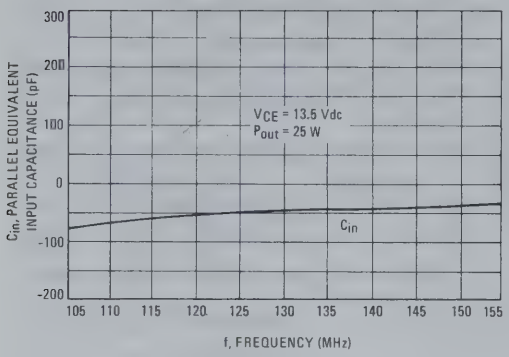


FIGURE 9 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

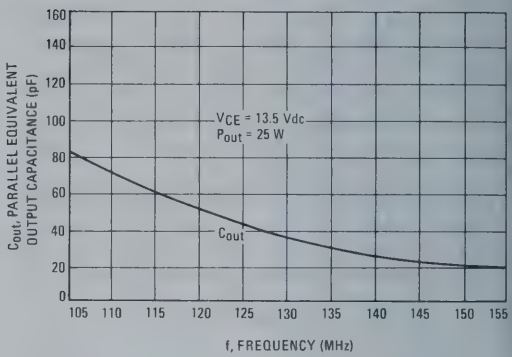


FIGURE 10 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

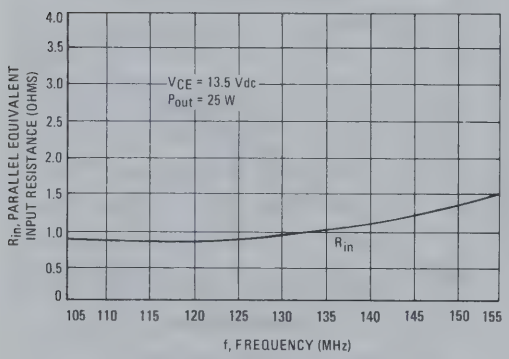


FIGURE 11 – DC SAFE OPERATING AREA

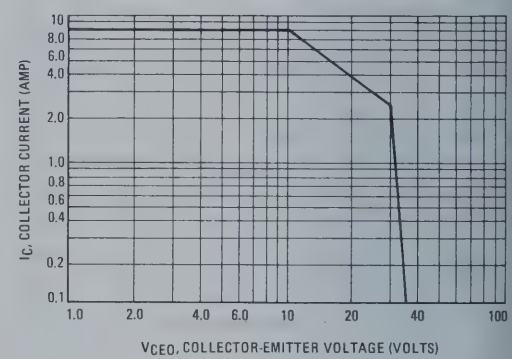
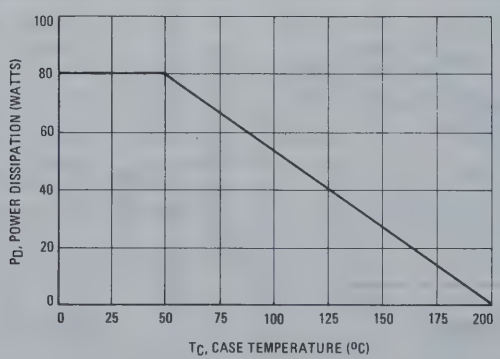


FIGURE 12 – POWER TEMPERATURE DERATING CURVE



MM1553 (SILICON)

NPN SILICON RF POWER TRANSISTOR

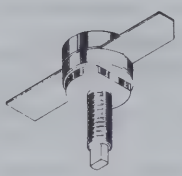
. . . designed for VHF power amplifier applications in military and industrial equipment. Particularly suited for use in Class AB, B, or C amplifier applications to 175 MHz.

- High Output Power Capability –
  90 Watts Peak Output for 13.5 Watts (Max) Input @ f = 150 MHz
- Balanced Emitter Construction to Assure Ruggedness and Resist Transistor Damage Caused by Load Mismatch
- Stripline Packaging for Lower Lead Inductance and Better Broadband Capability

75 W – 150 MHz

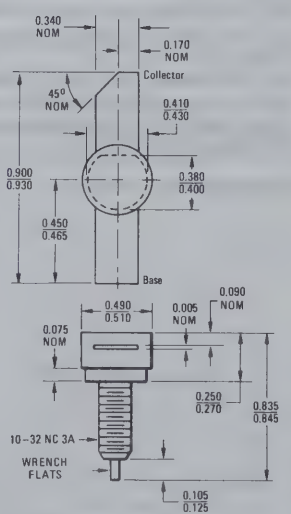
RF POWER TRANSISTOR

NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	70	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	8.0	Adc
Total Device Dissipation @ T_C=50°C Derate above 50°C	P_D	80 533	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



Emitter Connected to Stud

CASE 145C – 01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ① (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	70	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	100	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 2.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	70	85	pF
FUNCTIONAL TEST (Circuit Tuned at 90 Watts Peak, V_{CE} = 44 Vdc and not retuned for 22 Vdc Carrier Power Test)					
Power Input (P_{out} = 90 W Peak, V_{CE} = 44 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated)	$P_{in(peak)}$	–	11	13.5	Watts
Power Output CW (Carrier Power) (P_{in} = 6.0 W, V_{CE} = 22 Vdc, f = 150 MHz, Circuit Tuned at 90 W Peak, V_{CE} = 44 Vdc)	P_{out}	25	28	–	Watts
Power Output CW (V_{CE} = 44 Vdc, f = 150 MHz, Saturated CW Output Power)	P_{out}	75	–	–	Watts
Collector Efficiency (P_{out} = 90 W Peak, V_{CE} = 44 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated)	η	50	–	–	%
Load Mismatch (P_{out} = 90 W Peak, V_{CE} = 44 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated. Device Subjected to All Conditions of Load Mismatch from Short-Circuit to Open Circuit)	Less Than 5% Change in Power Readings Before and After Mismatch Tests.				

① Pulsed through 25 mH Inductor.

FIGURE 1 – POWER OUTPUT versus POWER INPUT

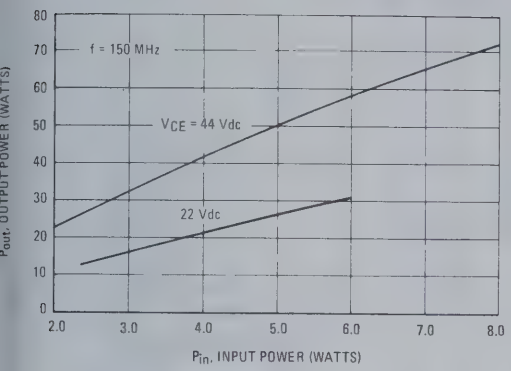


FIGURE 2 – POWER OUTPUT versus POWER INPUT

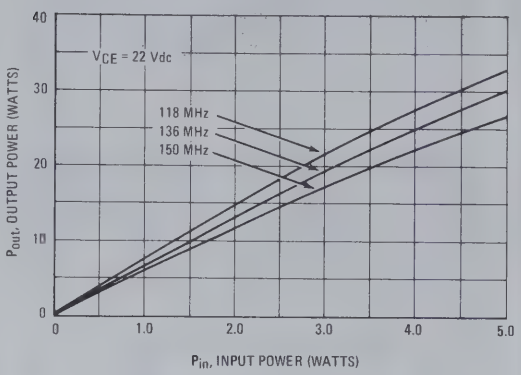


FIGURE 3 – POWER OUTPUT versus COLLECTOR-EMITTER VOLTAGE

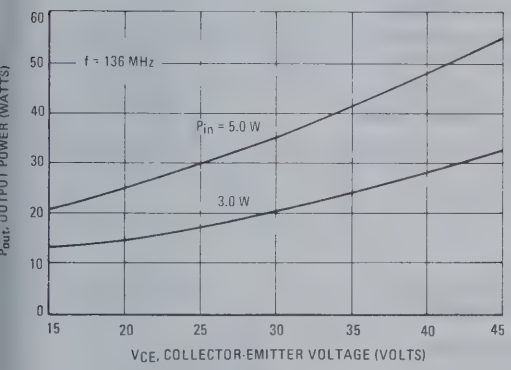


FIGURE 4 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

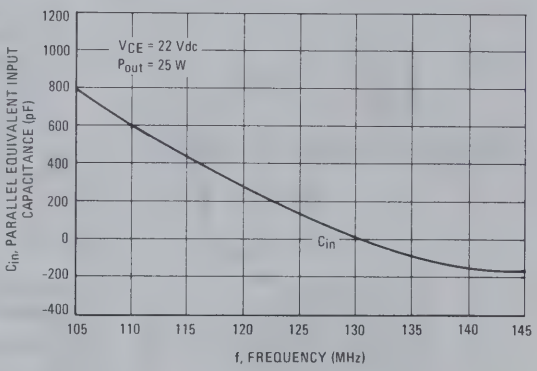


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

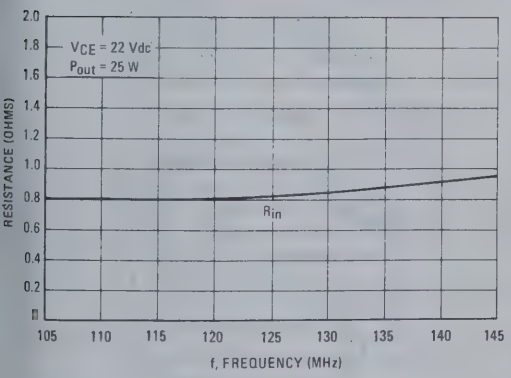


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

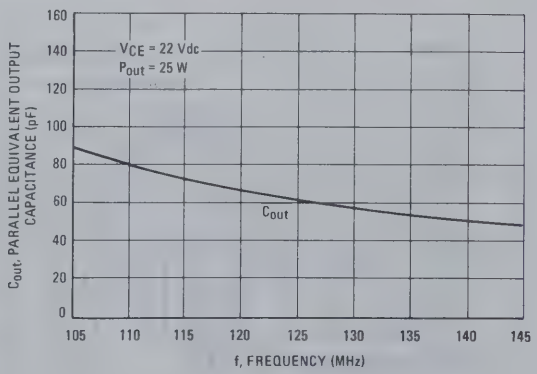


FIGURE 7 – SAFE-OPERATING AREA

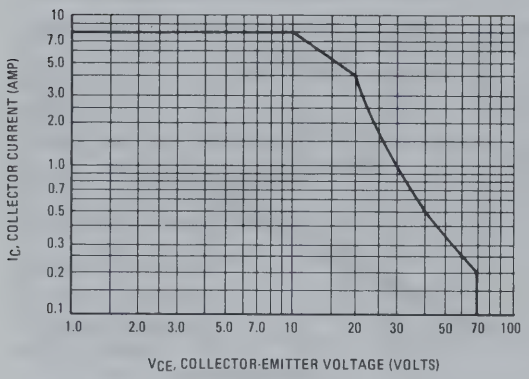


FIGURE 8 – POWER-TEMPERATURE DERATING CURVE

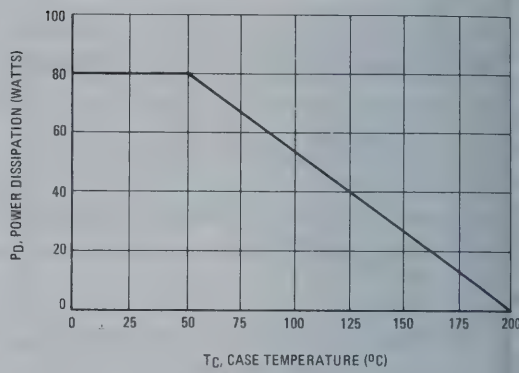
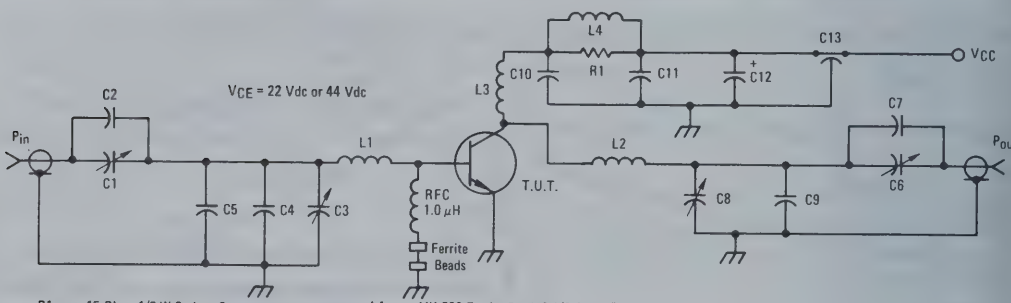
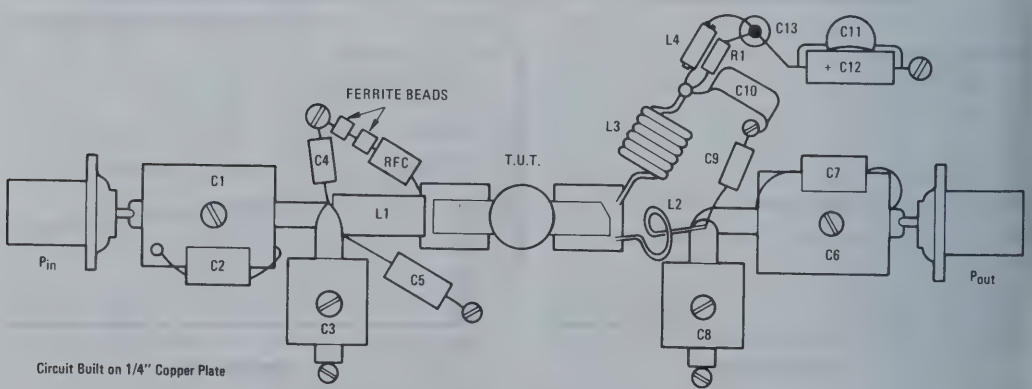


FIGURE 9 – 150 MHz TEST CIRCUIT



R1	15 Ohm, 1/2 W Carbon Comp.	L4	VK 200 Ferrite Bead, 2-1/2 Turns #22 AWG	C6,C8	9.0–180 pF ARCO 463 or Equivalent
L1	3/4" x 1/4" x 0.040" Copper Strap	C1	1.5–15 pF ARCO 460 or Equivalent	C7	4.7 pF Glass
L2	1 Turn #16 AWG Tinned Wire, 1/4" I.D. Closewound (3/4" Total Length)	C2	6.8 pF Glass	C10	2000 pF Mica
		C3	2.7–30 pF ARCO 461 or Equivalent	C11	0.01 μF Ceramic
L3	10 Turns #18 AWG Coated Wire, 5/8" I.D. Closewound (1" Total Length)	C4	12 pF Glass	C12	5.0 μF, 50 V Foil Electrolytic
		C5,C9	22 pF Glass	C13	1200 pF Ceramic Feed-Thru

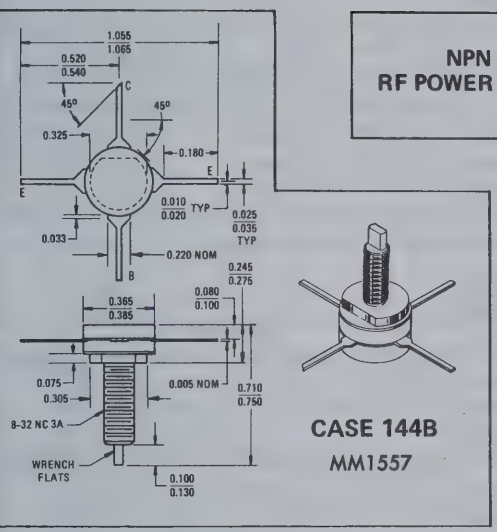
FIGURE 10 – 150 MHz TEST CIRCUIT LAYOUT



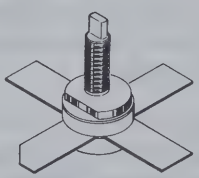
MM1557 (SILICON)
MM1558
MM1559 BEING REPLACED BY 2N5641/2N5643

NPN silicon RF power transistors designed for power amplifier or oscillator applications in military and industrial equipment. Suitable for Class AB, B or C in applications to 400 MHz.

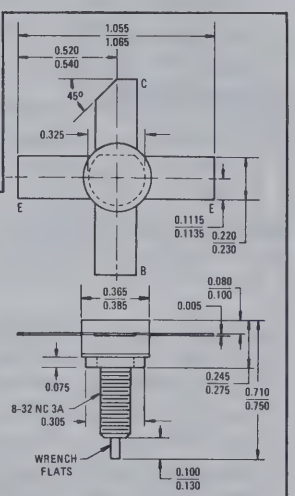
NPN SILICON RF POWER TRANSISTORS



CASE 144B
MM1557



CASE 145A
MM1558
MM1559



MAXIMUM RATINGS

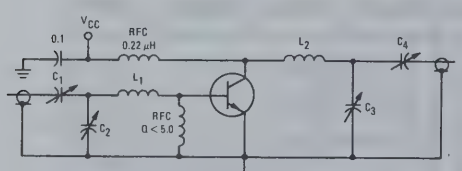
Rating	Symbol	MM1557	MM1558	MM1559	Unit
Collector-Emitter Voltage	V_{CEO}	← 35 →			Vdc
Collector-Base Voltage	V_{CB}	← 65 →			Vdc
Emitter-Base Voltage	V_{EB}	← 4.0 →			Vdc
Collector Current	I_C	1.0	3.0	5.0	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	15 86	30 171	60 342	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	35	-	-	Vdc
Collector-Emitter Sustaining Voltage (I_C = 200 mAdc, R_{BE} = 0)		$BV_{CES(sus)}$	65	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	MM1557	BV_{EBO}	4.0	-	-	Vdc
(I_E = 10 mAdc, I_C = 0)	MM1558, MM1559		4.0	-	-	
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	-	1.0	mAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MM1557	h_{FE}	5.0	-	-	-
(I_C = 200 mAdc, V_{CE} = 5.0 Vdc)	MM1558		5.0	-	-	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	MM1559		5.0	-	-	
DYNAMIC CHARACTERISTICS						
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	MM1557	C_{ob}	-	-	20	pF
	MM1558		-	-	50	
	MM1559		-	-	100	
FUNCTIONAL TEST						
Power Input (P_{out} = 7.0 Watts, V_{CE} = 28 Vdc, f = 175 MHz) (Figure 1)	MM1557	P_{in}	-	0.4	1.0	Watts
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 175 MHz) (Figure 1)	MM1558		-	1.9	3.0	
(P_{out} = 40 Watts, V_{CE} = 28 Vdc, f = 175 MHz) (Figure 2)	MM1559		-	5.0	7.0	
Common-Emitter Amplifier Power Gain (P_{out} = 7.0 Watts, V_{CE} = 28 Vdc, f = 175 MHz) (Figure 1)	MM1557	G_{PE}	8.4	12.5	-	dB
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 175 MHz) (Figure 1)	MM1558		8.2	10.2	-	
(P_{out} = 40 Watts, V_{CE} = 28 Vdc, f = 175 MHz) (Figure 2)	MM1559		7.6	9.1	-	
Collector Efficiency (P_{out} = 7.0 Watts, V_{CE} = 28 Vdc, f = 175 MHz) (Figure 1)	MM1557	η	60	-	-	%
(P_{out} = 20 Watts, V_{CE} = 28 Vdc, f = 175 MHz) (Figure 1)	MM1558		60	-	-	
(P_{out} = 40 Watts, V_{CE} = 28 Vdc, f = 175 MHz) (Figure 2)	MM1559		60	-	-	

* Pulsed through 25 mH inductor

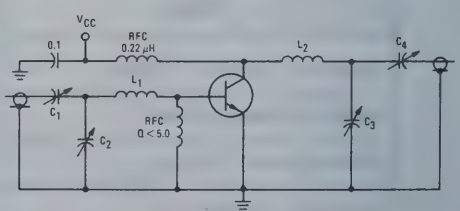
FIGURE 1 – 175 MHz TEST CIRCUIT (MM1557, MM1558)



MM1557
C_1, C_3, C_4 – 5.0 – 80 pF
C_2 – 9.0 – 180 pF
L_1 – 1¼" Straight #14 AWG
L_2 – 3 Turns #16 AWG, 14" I.D.

MM1558
C_1 – 3.0 – 30 pF
C_2, C_3, C_4 – 9.0 – 180 pF
L_1 – 1" Straight #14 AWG
L_2 – 1 Turn #16 AWG, ¼" I.D.

FIGURE 2 – 175 MHz TEST CIRCUIT (MM1559)

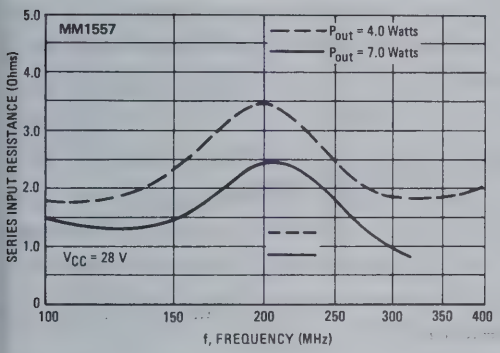


C_1, C_2, C_3, C_4 – ARCO 464 25-280 pF
L_1 – 1" Straight #14 AWG
L_2 – 1 Turn #16 AWG, ¼" I.D.

CIRCUIT DESIGN DATA

REAL INPUT IMPEDANCE versus FREQUENCY

FIGURE 3



IMAGINARY INPUT IMPEDANCE versus FREQUENCY

FIGURE 4

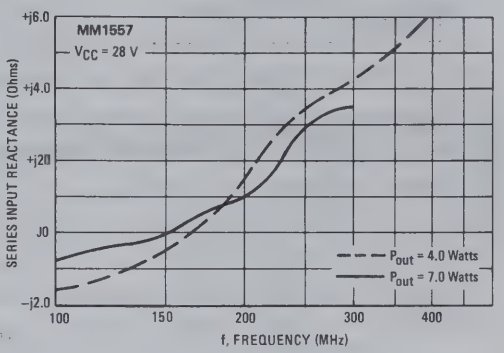


FIGURE 5

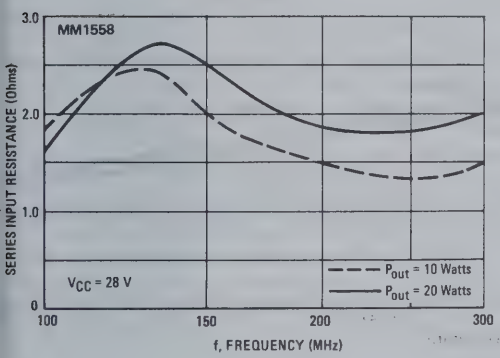


FIGURE 6

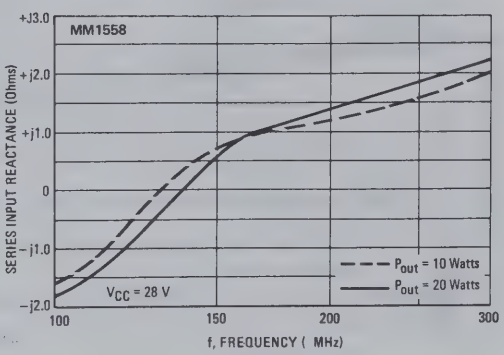


FIGURE 7

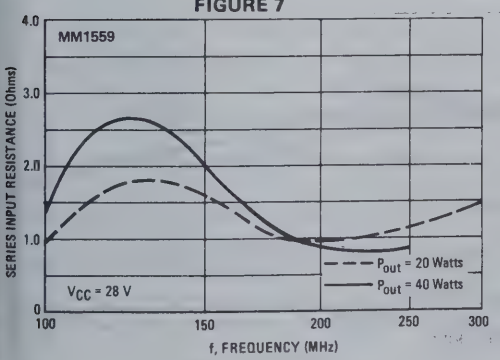
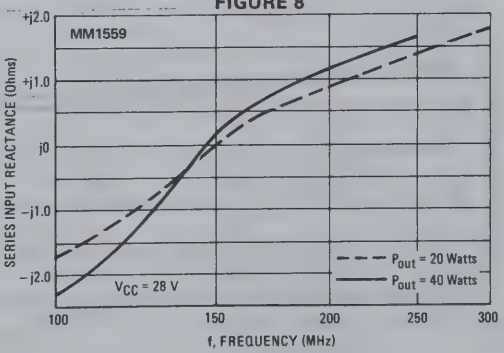


FIGURE 8



CIRCUIT DESIGN DATA

LARGE SIGNAL OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 9

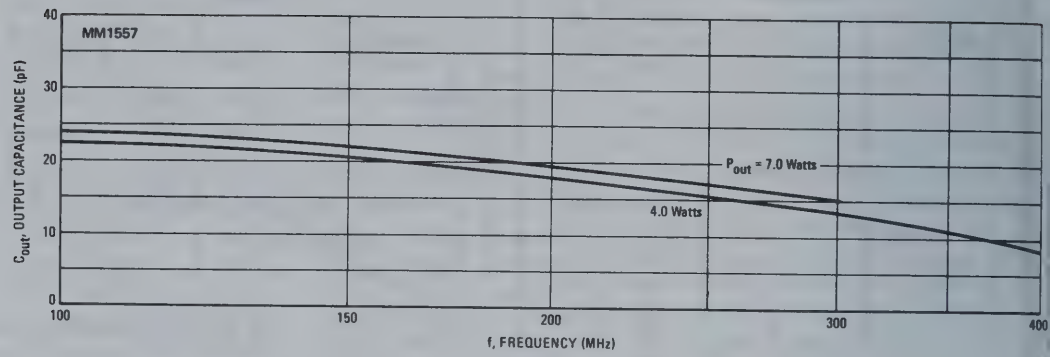


FIGURE 10

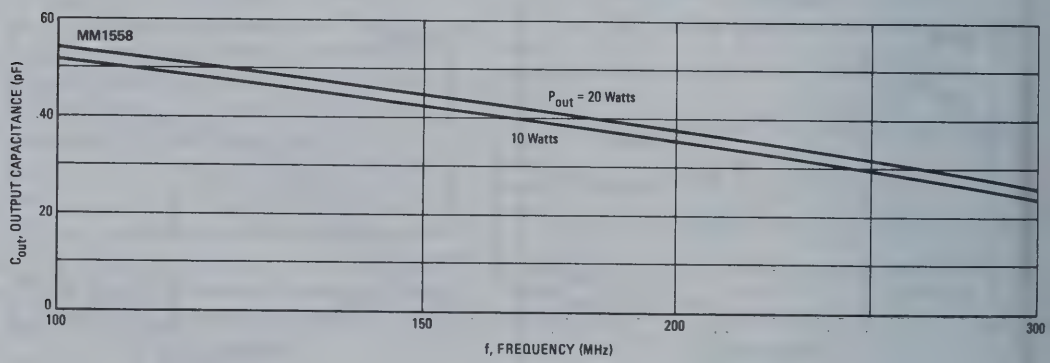
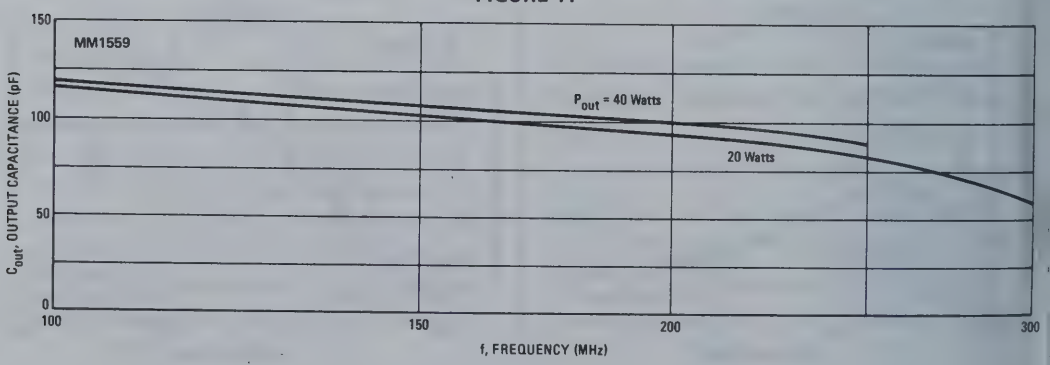


FIGURE 11



PERFORMANCE DATA

POWER OUTPUT versus FREQUENCY

FIGURE 12

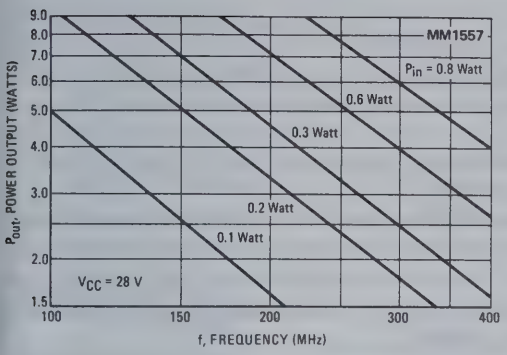


FIGURE 13

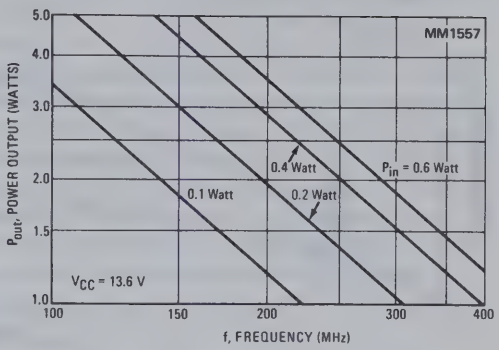


FIGURE 14

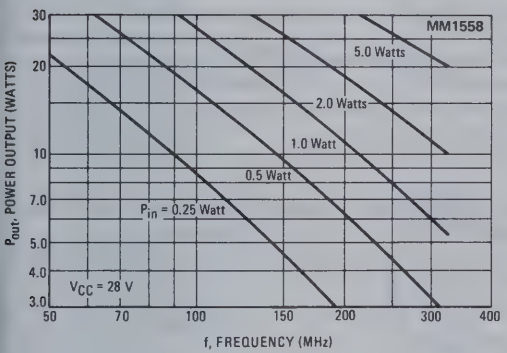


FIGURE 15

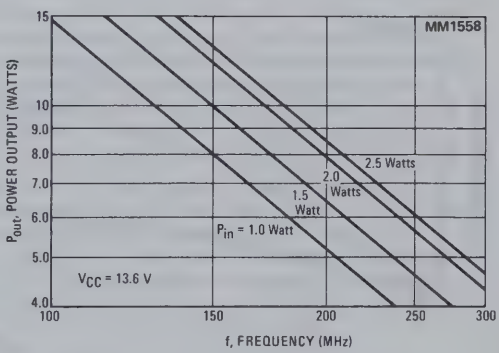


FIGURE 16

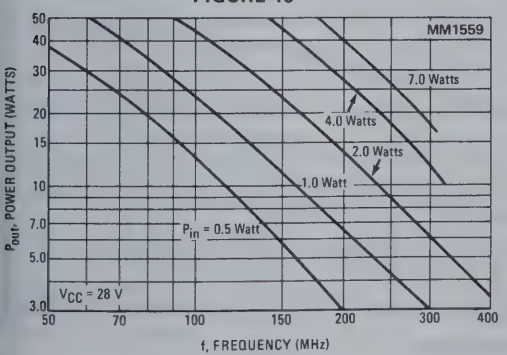
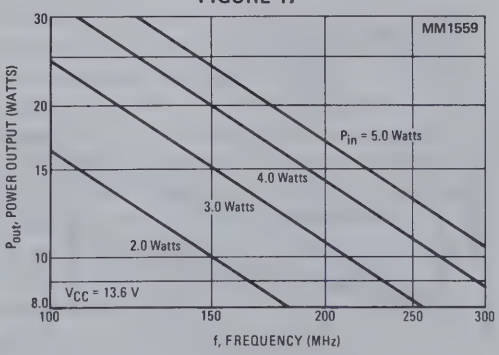


FIGURE 17



PERFORMANCE DATA
POWER OUTPUT versus POWER INPUT

FIGURE 18

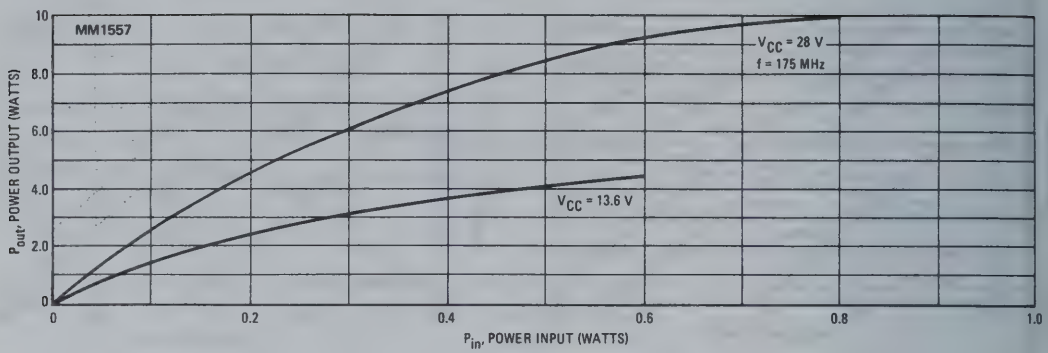


FIGURE 19

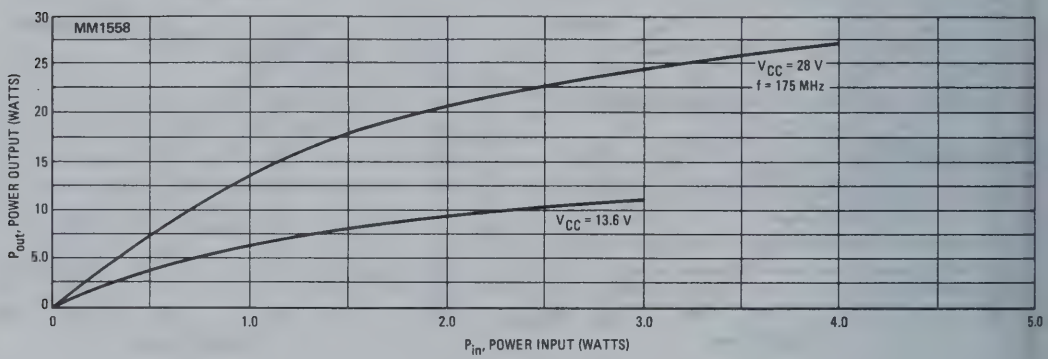
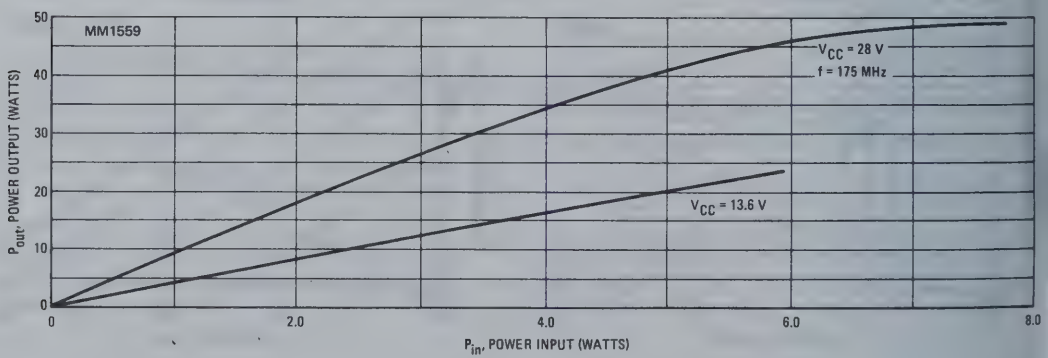


FIGURE 20



MM1603 (SILICON)

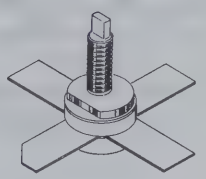
BEING REPLACED BY 2N5591

NPN SILICON RF POWER TRANSISTORS

. . . designed for power amplifier or oscillator applications in military and industrial equipment. Suitable for Class AB, B or C operation in 13.6 V applications to 240 MHz.

- Balanced Emitter Construction for Excellent Safe Operating Area. Designed to Withstand an Open or Shorted Load at Rated Power Output
- Low Profile Stripline Package for Low Lead Inductance and Better Broadband Capability
- 25 Watts Power Output @ 13.6 Volts, 4.4 dB Gain (Min) @ 175 MHz

NPN SILICON RF POWER TRANSISTOR



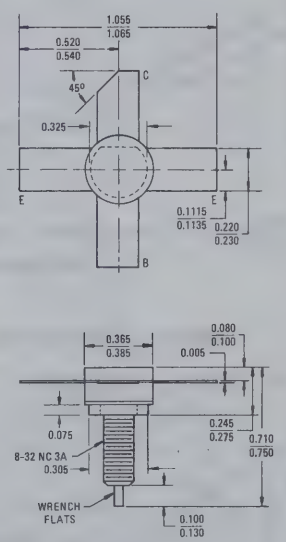
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	70 400	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

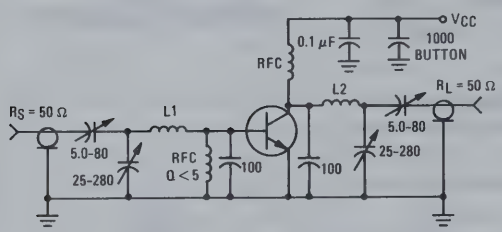
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 200 mAdc, I_B = 0)	BV_{CEO}*	18	-	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 200 mAdc, I_E = 0)	BV_{CES}*	36	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 5.0 mAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	-	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	-	-	-
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	-	80	120	pF
FUNCTIONAL TESTS					
Power Input (P_{out} = 25 Watts, V_{CE} = 13.6 Vdc, f = 175 MHz) (Figure 1)	P_{in}	-	-	9.0	Watts
Common-Emitter Amplifier Power Gain (P_{out} = 25 Watts, V_{CE} = 13.6 Vdc, f = 175 MHz) (Figure 1)	G_{PE}	4.4	-	-	dB
Collector Efficiency (P_{out} = 25 Watts, V_{CE} = 13.6 Vdc, f = 175 MHz) (Figure 1)	η	50	-	-	%

*Pulsed through 25 mH inductor.



CASE 145A

FIGURE 1 – 175 MHZ TEST CIRCUIT



ALL CAPACITORS IN pF UNLESS OTHERWISE INDICATED
L1 – #14 AWG STRAIGHT WIRE, 1–3/8" LONG
L2 – 1 TURN #14 AWG WIRE, 3/8" DIA. 1-1/2" LONG

FIGURE 2 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

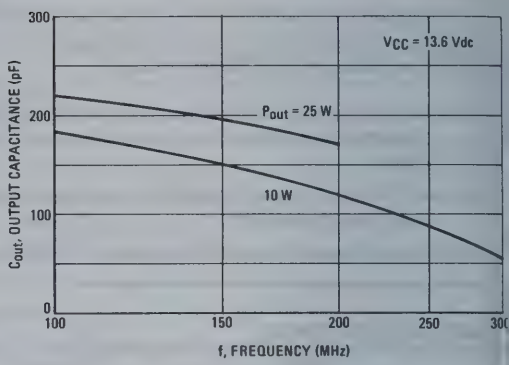


FIGURE 3 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

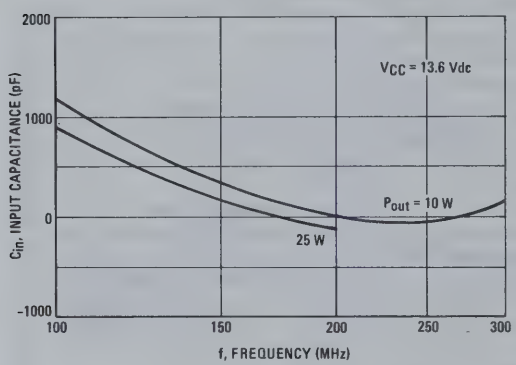


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

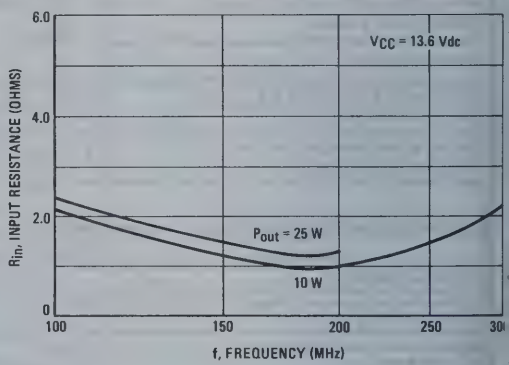


FIGURE 5 – POWER OUTPUT versus FREQUENCY

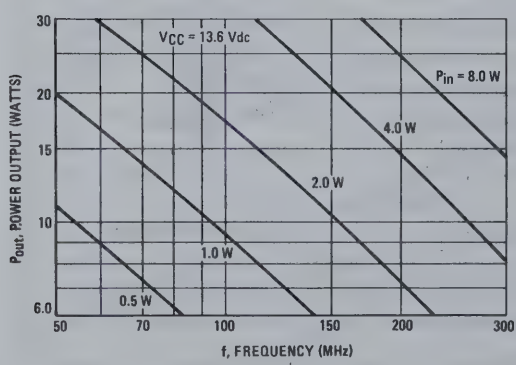
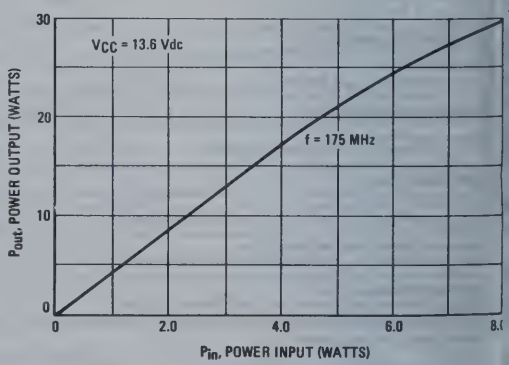


FIGURE 6 – POWER OUTPUT versus POWER INPUT



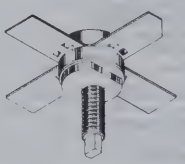
MM1619 (SILICON)
MM1620

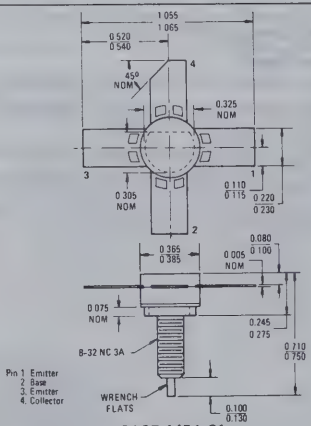
NPN SILICON RF POWER TRANSISTORS

. . . designed primarily for use in large signal low voltage amplifier output stages, the MM1619 and MM1620 are intended for use in industrial communications equipment operating in frequency ranges to 100 MHz.

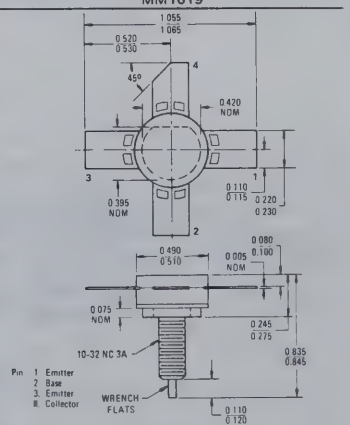
- Low Inductance Ceramic Stripline Packaging
- Designed to Withstand Destruction Under Open or Shorted Load Conditions
- High Power Output @ 12.5 Vdc, 50 MHz —
  MM1619 — 25 W
  MM1620 — 40 W

NPN SILICON RF POWER TRANSISTORS





CASE 145A-01
MM1619



CASE 145A-02
MM1620

MAXIMUM RATINGS

Rating	Symbol	MM1619	MM1620	Unit
Collector-Emitter Voltage	V_{CEO}	24		Vdc
Collector-Base Voltage	V_{CB}	48		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	3.5	7.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	50 285	100 571	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage(1) (I_C = 0.2 Adc, I_B = 0)		$V_{CEO(sus)}$	24	–	–	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 0.1 Adc, R_{BE} = 0)		$V_{CES(sus)}$	48	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	MM1619		3.0	–	–	
(I_C = 2.4 Adc, V_{CE} = 5.0 Vdc)	MM1620		3.0	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	MM1619		–	65	100	
	MM1620		–	150	230	
FUNCTIONAL TEST						
Power Output		P_{out}				Watts
(P_{in} = 3.0 W, V_{CE} = 12.5 Vdc, f = 50 MHz) MM1619, Figure 1			25	–	–	
(P_{in} = 6.0 W, V_{CE} = 12.5 Vdc, f = 50 MHz) MM1620, Figure 2			40	–	–	
Collector Efficiency		η				%
(P_{out} = 25 W, V_{CE} = 12.5 Vdc, f = 50 MHz) MM1619, Figure 1			50	–	–	
(P_{out} = 40 W, V_{CE} = 12.5 Vdc, f = 50 MHz) MM1620, Figure 2			50	–	–	

(1) Pulsed through 25 mH Inductor.

50 MHz TEST CIRCUITS

FIGURE 1 – MM1619

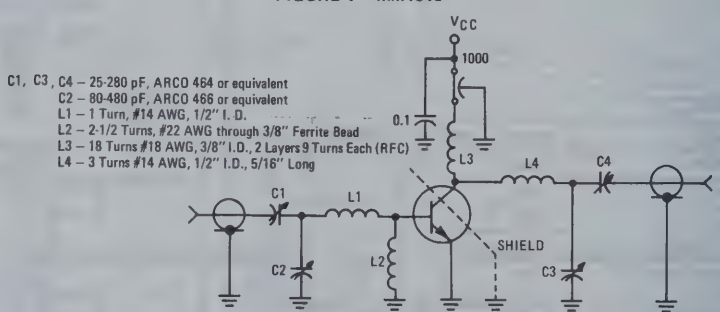
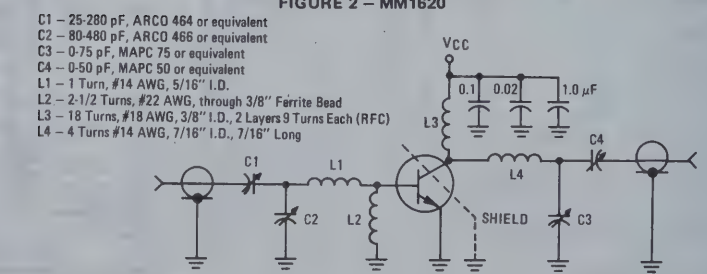


FIGURE 2 – MM1620



POWER OUTPUT versus POWER INPUT

FIGURE 3

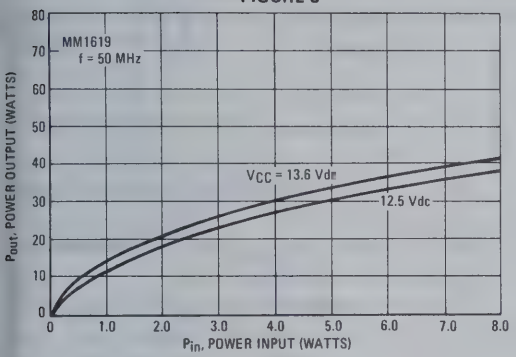
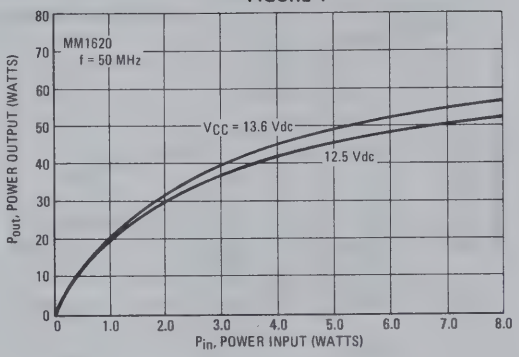


FIGURE 4



POWER OUTPUT versus FREQUENCY

FIGURE 5

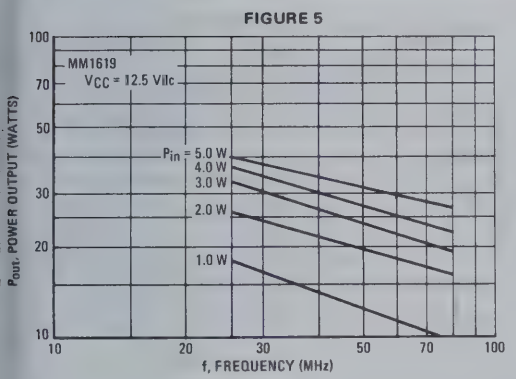
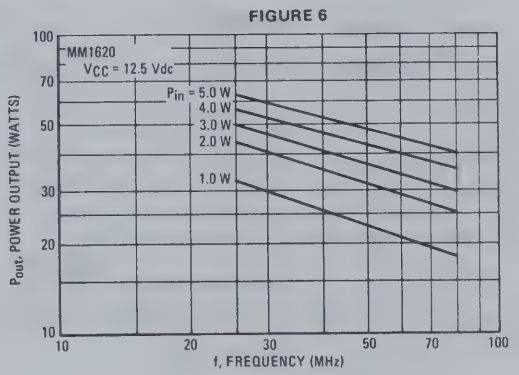


FIGURE 6



POWER OUTPUT versus FREQUENCY

FIGURE 7

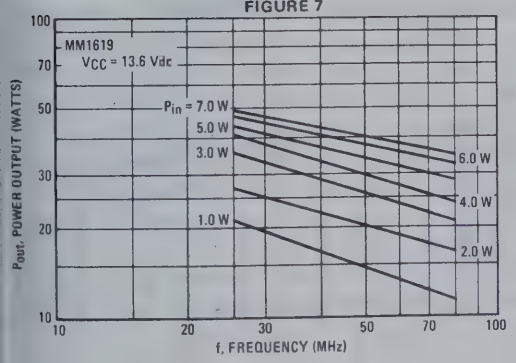
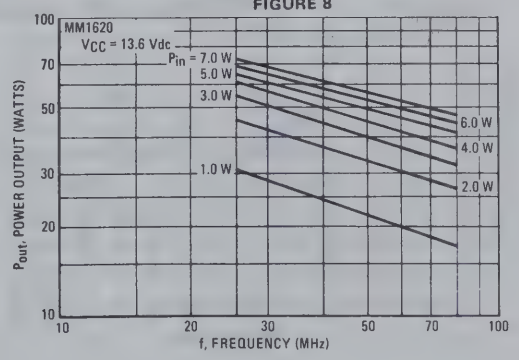


FIGURE 8



PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 9

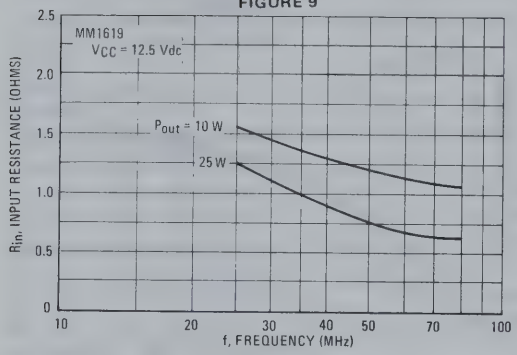
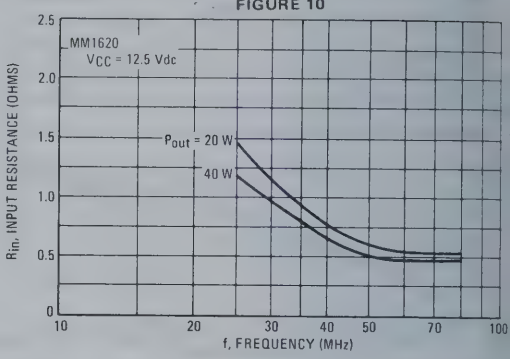


FIGURE 10



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 11

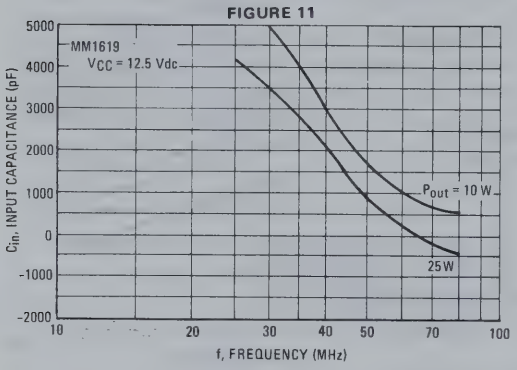
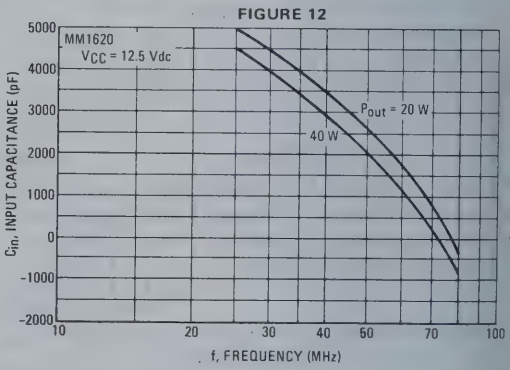


FIGURE 12



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 13

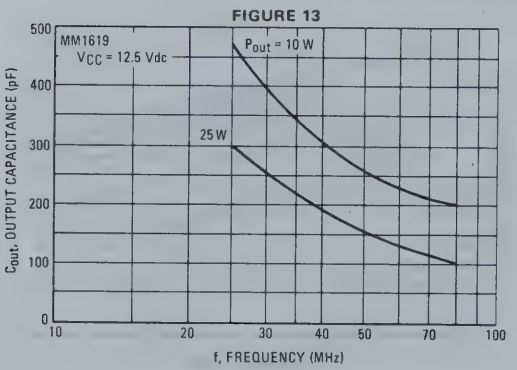
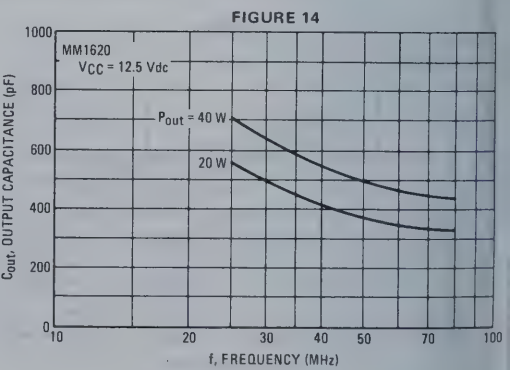


FIGURE 14



MM1748 (SILICON)



CASE 27
(TO-52)

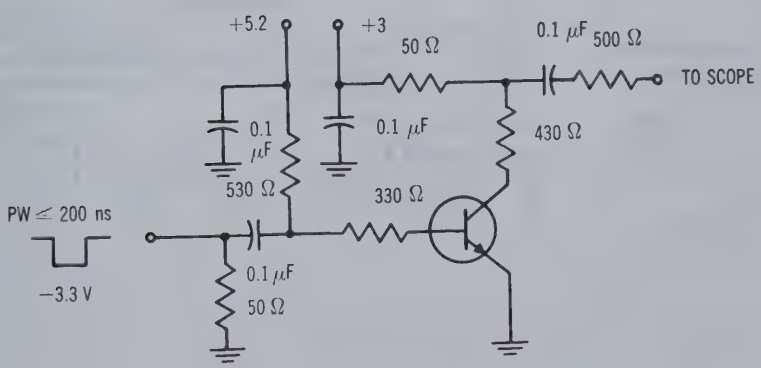
Collector connected to case

NPN silicon annular transistor designed for ultra-high speed switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	6	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation $T_A = 25^oC$ Derate above 25^oC	P_D	300 1.71	mWatts $mW/^oC$
Total Device Dissipation $T_C = 100^oC$ Derate above 100^oC	P_D	500 2.0	mWatts $mW/^oC$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

FIGURE 1 — STORAGE TIME CONSTANT TEST CIRCUIT

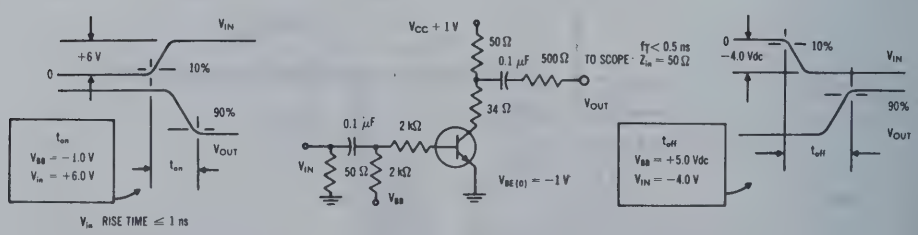


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	6	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4	-	-	Vdc
Collector Cutoff Current (V_{CB} = 5 Vdc, I_E = 0) (V_{CB} = 5 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	- -	0.002 0.5	0.05 5.0	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 0.5 Vdc) (I_C = 10 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C) (I_C = 30 mAdc, V_{CE} = 1 Vdc)	h_{FE}*	20 10 15	- - -	120 - -	-
Collector-Emitter Saturation Voltage (I_C = 3 mAdc, I_B = 0.15 mAdc)	$V_{CE(sat)}$	-	0.2	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 3 mAdc, I_B = 0.15 mAdc)	$V_{BE(sat)}$	0.70	-	0.85	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 5 mAdc, V_{CE} = 4 Vdc, f = 100 MHz)	f_T	600	-	-	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0)	C_{ob}	-	-	3	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0)	C_{ib}	-	-	2	pF
Turn-On Time, Figure 2 (V_{CC} = 1 Vdc, V_{EB} (off) = 1 Vdc, I_C = 10 mAdc, I_{B1} = 2 mAdc, I_{B2} = 1.0 mA)	t_{on}	-	8	15	ns
Turn-Off Time, Figure 2 (V_{CC} = 1 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1 mAdc)	t_{off}	-	6	15	ns
Storage Time, Figure 1 (I_C = 5 mAdc, I_{B1} = I_{B2} = 5 mAdc)	t_s	-	-	6	ns

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

FIGURE 2 — TURN-ON & TURN-OFF TIME TEST CIRCUIT



MM1803

For Specifications, See 2N3137 Data.

MM1812 (SILICON)



CASE 31
(TO-5)

NPN silicon transistor designed for audio power amplifier applications up to 1 watt output.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	175	Vdc
Collector-Emitter Voltage	V_{CEO}	175	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector-Current	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5 28.6	Watts mW/°C
Operating Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —		0.1 100	μAdc
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)	I_{EBO}	—		0.025	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	175		—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	175		—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4		—	Vdc
Collector Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$*	— —		0.3 0.6	Vdc
DC Current Gain * (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}*	25 35 40		— 200 300	—
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{fe}	50		200	—
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{re}	—		4	$X10^{-4}$
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{ie}	0.2		1.25	k ohms
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{oe}	10		200	μmhos
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—		10	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—		100	pF
		Min	Typ	Max	
Power Gain (P_{out} = 1 W, V_{CE} = 85 Vdc, I_C = 30 mAdc, f = 1 kHz R_S = 400 ohms, R_L = 2.9 k ohms)	G_{pe}	36	44	—	dB

*Pulse Test: PW ≤ 300 μs, duty cycle ≤ 2%

FIGURE 1 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

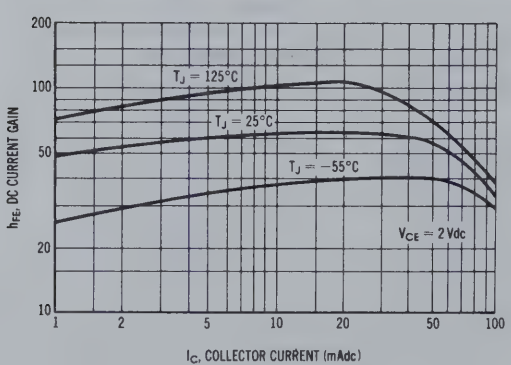
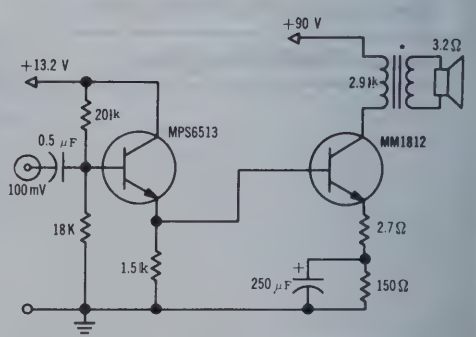


FIGURE 2 — 750 mW CLASS A AUDIO AMPLIFIER



*TRANSFORMER EFFICIENCY ~ 75%

MM1941 (SILICON)



Collector connected to case

CASE 22
(TO-18)

NPN silicon annular transistor for high-frequency power oscillator, multiplier and driver applications.

MAXIMUM RATINGS (Tc = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Volts
Collector-Emitter Voltage	V_{CES}	30	Volts
Emitter-Base Voltage	V_{EB}	3.0	Volts
Base Current	I_B	30	mAdc
Collector Current	I_C	200	mAdc
Input Power	P_{in}	100	mW
Output Power	P_{out}	250	mW
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D*	600 4.0	mW mW/°C
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	300 2.0	mW mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

*See Safe Area Curve

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

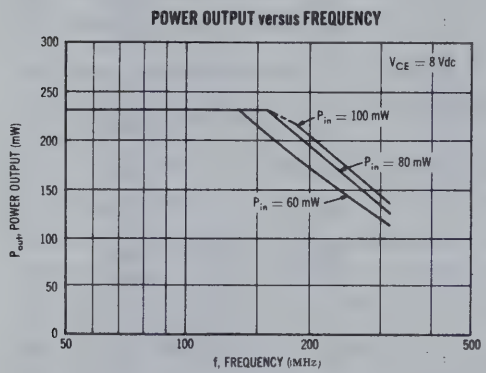
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	I_C = 15 mA, R_{BE} = 0	30	40	-	Volts
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 100 μAdc, I_E = 0	30	40	-	Volts
Collector Emitter-Open Base Sustain Voltage	$BV_{CEO(sus)}$*	I_C = 15 mA, I_B = 0	20	-	-	Volts
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc, I_E = 0 V_{CB} = 15 Vdc, I_E = 0, T_C = 100°C	- -	0.01 -	0.1 25	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 3 Vdc, I_C = 0	-	0.1	10	μAdc
DC Current Gain	h_{FE}	I_C = 10 mAdc, V_{CE} = 10 Vdc	25	50	-	-
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 10 Vdc, I_C = 10 mAdc f = 100 mc	6	8	-	-
Collector Output Capacitance	C_{ob}	V_{CB} = 15 Vdc, I_E = 0, f = 100 kHz	-	-	2.5	pF
Power Output	P_{out}	P_{in} = 20 mW max, f = 175 MHz	100	-	-	mW
Power Gain	G_e	V_{CC} = 13.6 Vdc, $I_{C(max)}$ = 25 mA	7	9	-	dB

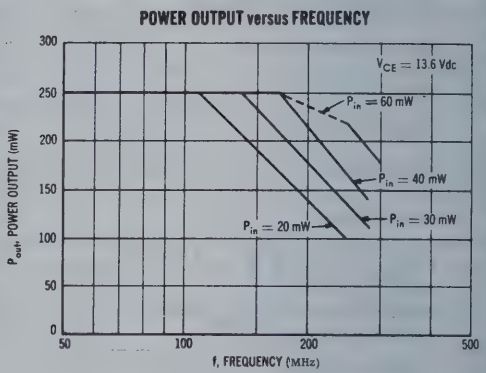
*Pulse Test: PW = 100 μs; DC = 2%

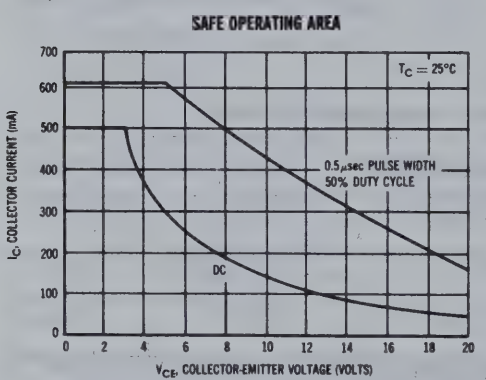
ELECTRICAL CHARACTERISTICS (continued)

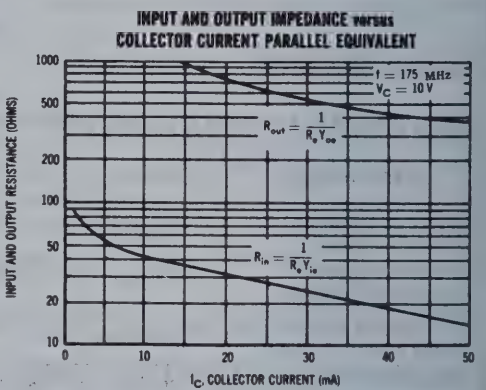
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Power Output (Oscillator)	P_{out}	f = 80 MHz, V_{CC} = 13.6 Vdc, $I_{C(typ)}$ = 20 mAdc	-	50	-	mW
Power Gain (Multiplier)	G_e	f_{in} = 80 MHz, f_{out} = 240 MHz, V_{CC} = 13.6 Vdc, P_{out} ≈ 30 mW, $I_{C(typ)}$ = 25 mAdc	-	3	-	dB

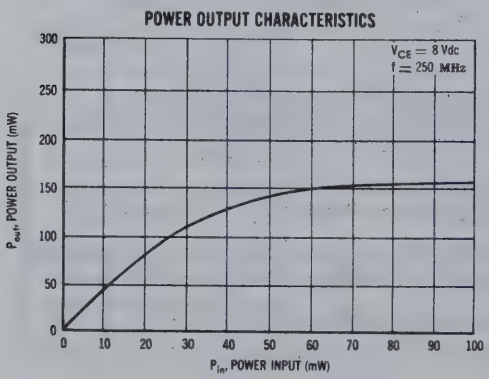
*Pulse Test: PW = 100 μs; DC = 2%

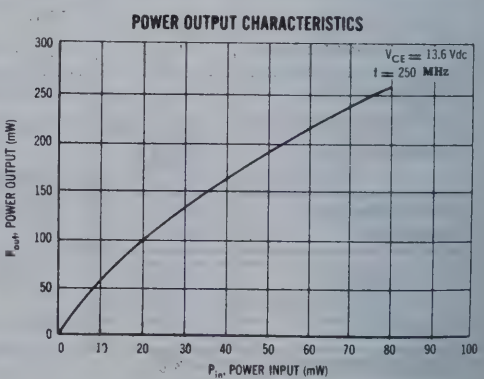












MM2258 (SILICON)
MM2259
MM2260



CASE 31
(TO-5)

NPN silicon transistors designed for video output circuitry in transistorized television receivers.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value		Unit
		MM2258	MM2259 MM2260	
Collector-Base Voltage	V_{CB}	120	175	Vdc
Collector-Emitter Voltage	V_{CEO}	120	175	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	500	300	mAdc
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	5 28.6		Watt mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL RESISTANCE

$\theta_{JA(air)} = 175°C/W$
$\theta_{JC(case)} = 35°C/W$

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	— —	— —	0.050 50	μAdc
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)		I_{EBO}	—	—	25	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MM2258 MM2259, MM2260	BV_{CBO}	120 175	— —	— —	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MM2258 MM2259, MM2260	BV_{CEO}*	120 175	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	—	Vdc
Collector-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)		$V_{CE(sat)}$	—	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)		$V_{BE(sat)}$	—	—	1.0	Vdc
DC Current Gain* (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc)	MM2259 MM2258, MM2260 MM2259 MM2258, MM2260 MM2259 MM2258, MM2260	h_{FE}	25 50 35 50 35 50	— — — — — —	— — — — — —	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	MM2258 MM2259, MM2260	C_{ob}	— —	— —	9 8	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	—	80	pF
Feedback (Miller) Capacitance (V_{CB} = 25 Vdc, I_C = 10 mAdc)	MM2258 MM2259, MM2260	C_{cb}	— —	4.2 3.0	5.0 4.5	pF
Small Signal Current Gain (V_{CE} = 25 Vdc, I_C = 20 mAdc, f = 100 MHz)		$\|h_{fe}\|$	1.5	—	—	—

*Pulse Test: PW ≤ 300 μs, duty cycle ≤ 2%

FIGURE 1 — DC CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

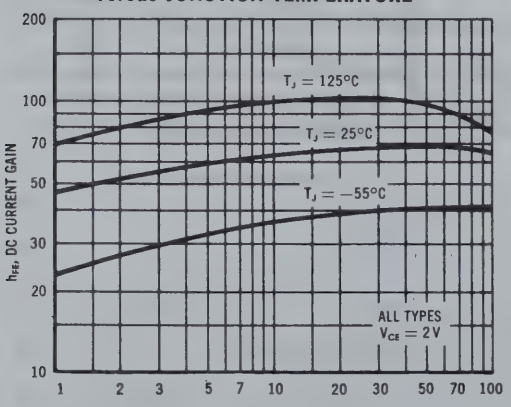
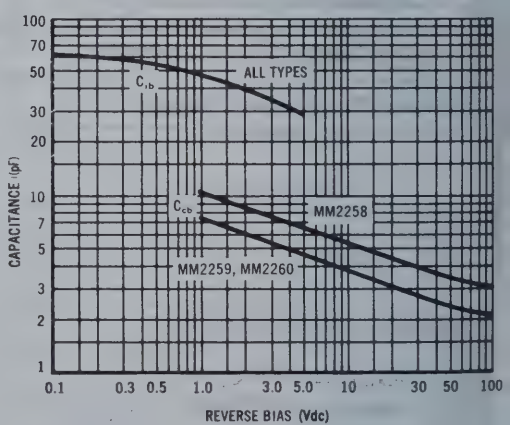


FIGURE 2 — JUNCTION CAPACITANCE VARIATIONS



SMALL SIGNAL h PARAMETER CHARACTERISTICS
(V_{CE} = 10 V, T_A = 25°C, f = 1 kHz)

FIGURE 3 — CURRENT GAIN

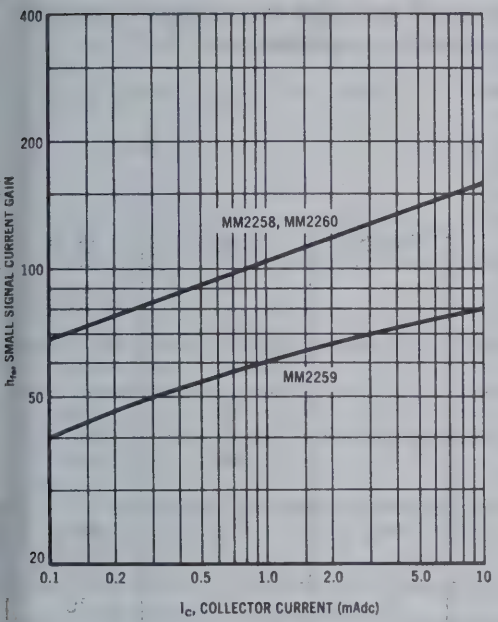


FIGURE 4 — OUTPUT ADMITTANCE

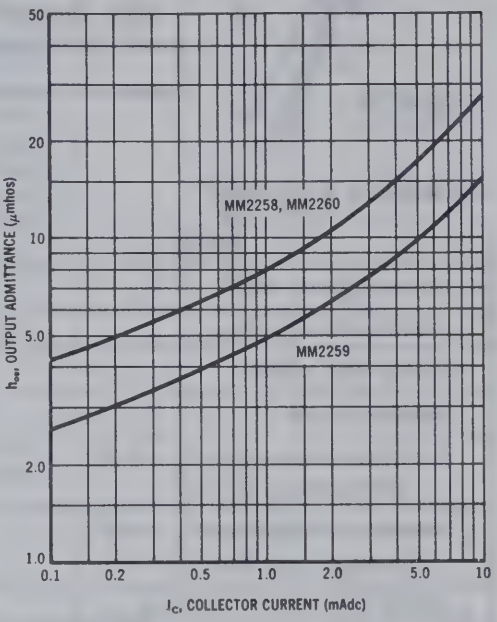


FIGURE 5 — INPUT IMPEDANCE

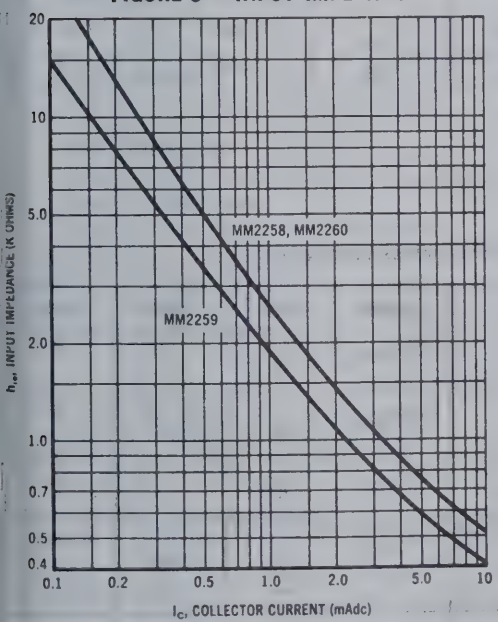
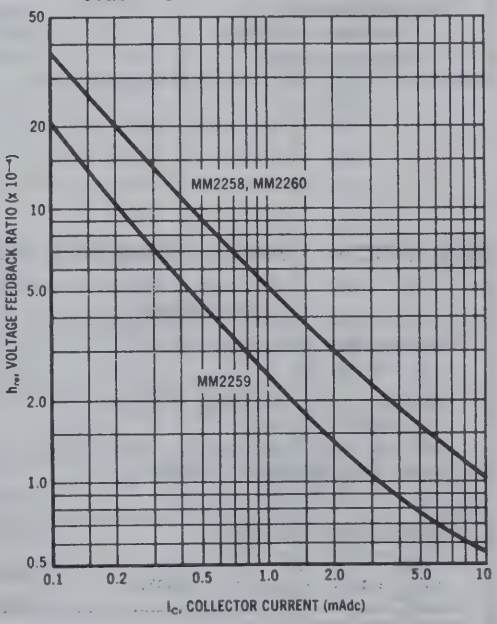


FIGURE 6 — VOLTAGE FEEDBACK RATIO



MM2483 (SILICON)
MM2484



CASE 22
(TO-18)

NPN silicon epitaxial transistors designed for low-level, low-noise amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Emitter-Base Voltage	V_{EB}	6	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derating Factor above 25°C	P_D	360 2.1	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor above 25°C	P_D	1.2 6.9	Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Thermal Resistance: Junction-to Ambient Junction-to-Case	 θ_{JA} θ_{JC}	 486 146	 °C/W °C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)	BV_{CBO}	60	—	V
Collector-Emitter Sustaining Voltage* (I_C = 10 mA, I_B = 0)	$V_{CEO(sus)}$	60	—	V
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	BV_{EBO}	6	—	V
Collector Cutoff Current (V_{CB} = 45 V, I_E = 0) (V_{CB} = 45 V, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.010 10	μA
Emitter Cutoff Current (V_{EB} = 5.0 V, I_C = 0)	I_{EBO}	—	0.010	μA
Collector-Emitter Saturation Voltage (I_C = 1.0 mA, I_B = 0.1 mA)	$V_{CE(sat)}$	—	0.35	V

*Pulse Conditions: Length = 300 μs, Duty Cycle ≤ 2%

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
DC Current Gain		h_{FE}			—
(I_C = 1.0 μA, V_{CE} = 5.0 V)	MM2484		30	—	
(I_C = 10 μA, V_{CE} = 5.0 V)	MM2483		40	120	
	MM2484		100	500	
(I_C = 10 μA, V_{CE} = 5.0 V, -55°C)	MM2483		10	—	
	MM2484		20	—	
(I_C = 100 μA, V_{CE} = 5.0 V)	MM2483		75	—	
	MM2484		175	—	
(I_C = 500 μA, V_{CE} = 5.0 V)	MM2483		100	—	
	MM2484		200	—	
(I_C = 1.0 mA, V_{CE} = 5.0 V)	MM2483		175	—	
	MM2484		250	—	
(I_C = 10 mA, V_{CE} = 5.0 V)*	MM2483		—	500	
	MM2484		—	800	
Emitter-Base On Voltage (I_C = 100 μA, V_{CE} = 5.0 V)		$V_{BE(on)}$	0.5	0.7	V
High-Frequency Current Gain		h_{fe}			—
(I_C = 50 μA, V_{CE} = 5.0 V, f = 5.0 MHz)	MM2483		2.4	—	
	MM2484		3.0		
(I_C = 500 μA, V_{CE} = 5.0 V, f = 30 MHz)			2.0	—	
Output Capacitance (V_{CB} = 5.0 V, I_E = 0)		C_{ob}	—	6.0	pF
Emitter Transition Capacitance (V_{EB} = 0.5 V, I_C = 0)		C_{TE}	—	6.0	pF
Small Signal Current Gain		h_{fe}			—
(I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1 kHz)	MM2483		80	450	
	MM2484		150	900	
Input Impedance (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1 kHz)		h_{ie}	3.5	24	kohms
Output Conductance (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1 kHz)		h_{oe}	—	50	μmhos
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1 kHz)		h_{re}	—	2500	X10-6
Common Base Input Impedance (I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1 kHz)		h_{ib}	25	32	ohms
Wide Band Noise Figure		NF			dB
(I_C = 10 μA, V_{CE} = 5.0 V, R_S = 10 kohms	MM2483		—	4	
	MM2484		—	3	
Power Bandwidth of 15.7 kHz (3 dB points at 10 Hz and 10 kHz)					
Narrow Band Noise Figure		NF			dB
(I_C = 10 μA, V_{CE} = 5.0 V, f = 1 kHz	MM2483		—	4	
R_S = 10 kohms (Power Bandwidth = 200 Hz)	MM2484		—	3	
(I_C = 10 μA, V_{CE} = 5.0 V, f = 10 kHz,	MM2483		—	3	
R_S = 10 kohms (Power Bandwidth = 2 kHz)	MM2484		—	2	
(I_C = 10 μA, V_{CE} = 5 V, f = 10 kHz	MM2483		—	15	
R_S = 10 kohms (Power Bandwidth = 20 Hz)	MM2484		—	10	

*Pulse Conditions: PW ≤ 300 μs, Duty Cycle ≤ 2%

MM2894 (SILICON)



CASE 22
(TO-18)

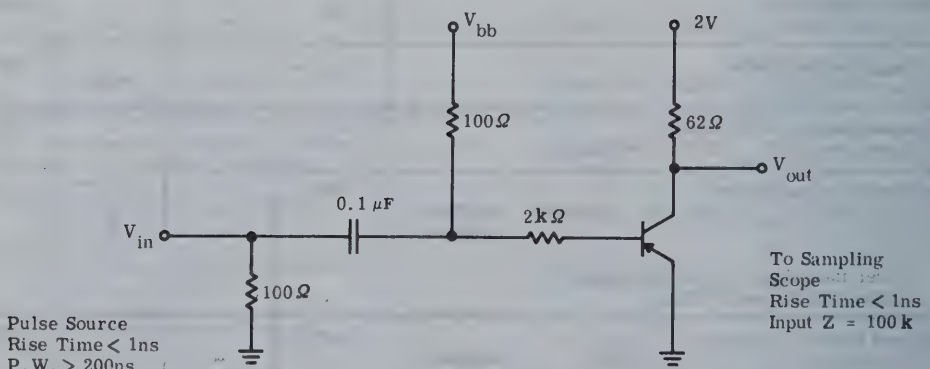
PNP silicon annular transistor for low-level, high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Device Dissipation @ 25° C Ambient Temperature Derate above 25° C	P_D	0.36 2.06	Watt mW/° C
Total Device Dissipation @ 25° C Case Temperature Derate above 25° C	P_D	1.2 6.9	Watts mW/° C
Operating Junction Temperature	T_J	200	° C
Storage Temperature	T_{stg}	-65 to 200	° C

SWITCHING TIME TEST CIRCUIT



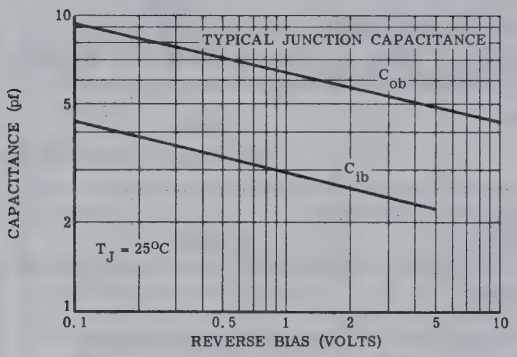
T_{on} V_{bb} = 3V V_{in} = 7V

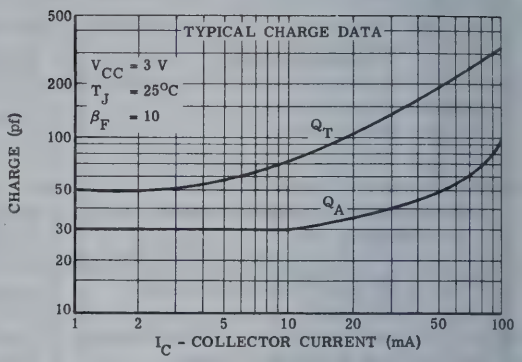
T_{off} V_{bb} = 4V V_{in} = 6V

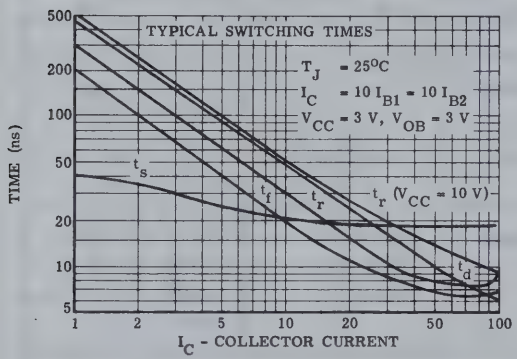
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

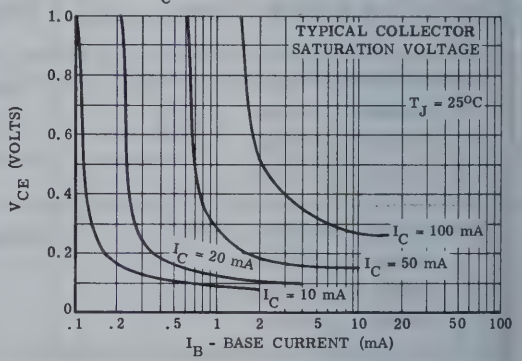
Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current V_{CB} = 6V, I_E = 0 V_{CB} = 6V, I_E = 0, T_A = 125° C	I_{CBO}			0.08 10	μA
Collector-Base Breakdown Voltage I_C = 10μA, I_E = 0	BV_{CBO}	15			Vdc
Collector-Emitter Sustaining Voltage* I_C = 10mA, I_B = 0	$V_{CEO(sust)}$	12			Vdc
Emitter-Base Breakdown Voltage I_E = 100μA, I_C = 0	BV_{EBO}	4.5			Vdc
Collector-Emitter Saturation Voltage I_C = 10mA, I_B = 1.0mA I_C = 30mA, I_B = 3.0mA I_C = 100mA, I_B = 10mA	$V_{CE(sat)}$		 0.1	 0.15 0.2 0.5	Vdc
Base-Emitter Saturation Voltage I_C = 10mA, I_B = 1.0mA I_C = 30mA, I_B = 3.0mA I_C = 100mA, I_B = 10mA	$V_{BE(sat)}$	 0.68 0.74		 0.83 0.89 1.7	Vdc
DC Pulse Current Gain* I_C = 1mA V_{CE} = 0.3v I_C = 10mA V_{CE} = 0.3v I_C = 30mA, V_{CE} = 0.5v I_C = 30mA, V_{CE} = 0.5v (-55° C) I_C = 100mA, V_{CE} = 1.0V	h_{FE}*	 25 30 40 17 25	 70	 150	—
High Frequency Current Gain (f = 100 MHz) VCE = 100 IC = 30mA	h_{fe}	4.0			—
Output Capacitance V_{CB} = 5.0V, I_E = 0, f = 140 kHz)	C_{ob}			6.0	pF
Emitter Transition Capacitance V_{EB} = 0.5V, I_C = 0, f = 140 kHz)	C_{TE}			6.0	pF
Turn On Time I_C = 30mA, I_{B1} = 1.5mA	t_{on}		23	60	ns
Turn Off Time I_C = 30mA, I_{B1} = I_{B2} = 1.5mA	t_{off}		34	60	ns

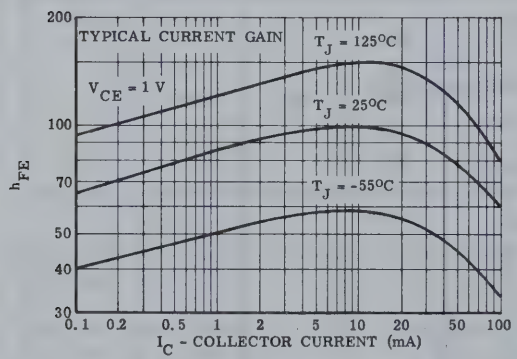
* Pulse Conditions; Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

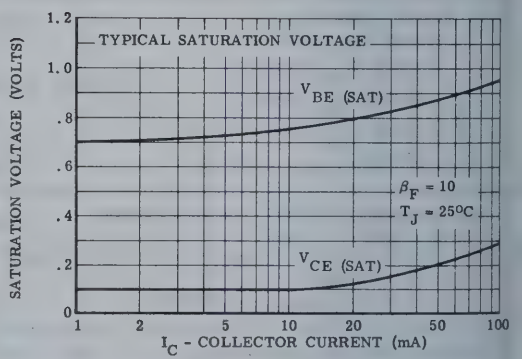

TYPICAL JUNCTION CAPACITANCE
C_{ob}
C_{ib}
T_J = 25°C
CAPACITANCE (pf)
REVERSE BIAS (VOLTS)

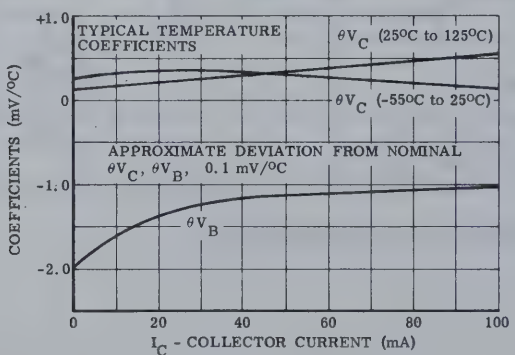

TYPICAL CHARGE DATA
V_{CC} = 3 V
T_J = 25°C
β_F = 10
Q_T
Q_A
CHARGE (pf)
I_C - COLLECTOR CURRENT (mA)


TYPICAL SWITCHING TIMES
T_J = 25°C
I_C = 10 I_{B1} = 10 I_{B2}
V_{CC} = 3 V, V_{OB} = 3 V
t_s
t_f
t_r
t_r (V_{CC} = 10 V)
t_d
TIME (ns)
I_C - COLLECTOR CURRENT


TYPICAL COLLECTOR SATURATION VOLTAGE
T_J = 25°C
I_C = 100 mA
I_C = 50 mA
I_C = 20 mA
I_C = 10 mA
V_{CE} (VOLTS)
I_B - BASE CURRENT (mA)


TYPICAL CURRENT GAIN
T_J = 125°C
V_{CE} = 1 V
T_J = 25°C
T_J = -55°C
h_{FE}
I_C - COLLECTOR CURRENT (mA)


TYPICAL SATURATION VOLTAGE
V_{BE} (SAT)
β_F = 10
T_J = 25°C
V_{CE} (SAT)
SATURATION VOLTAGE (VOLTS)
I_C - COLLECTOR CURRENT (mA)


TYPICAL TEMPERATURE COEFFICIENTS
θV_C (25°C to 125°C)
θV_C (-55°C to 25°C)
APPROXIMATE DEVIATION FROM NOMINAL
θV_C, θV_B, 0.1 mV/°C
θV_B
COEFFICIENTS (mV/°C)
I_C - COLLECTOR CURRENT (mA)

MM3000 thru MM3003 (SILICON)



NPN silicon epitaxial transistors designed for general-purpose, high-voltage applications.

CASE 79
(TO-39)

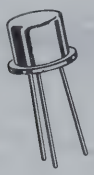
MAXIMUM RATINGS

Rating	Symbol	MM3000	MM3001	MM3002	MM3003	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EB}	5.0				Vdc
Collector Current	I_C	200	200	50	50	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	1.0				Watt
Derate above 25°C		5.71				mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	5.0				Watts
Derate above 25°C		28.6				mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MM3000	BV_{CEO}	100		Vdc
	MM3001		100	-	
	MM3002		150	-	
	MM3003		200	-	
			250	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 50 Vdc, I_E = 0)	MM3000		-	1.0	
(V_{CB} = 75 Vdc, I_E = 0)	MM3001		-	1.0	
(V_{CB} = 100 Vdc, I_E = 0)	MM3002, MM3003		-	5.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	150	-	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	MM3000, MM3001	C_{ob}	-	7.0	pF
	MM3002, MM3003		-	15	

MM3008 (SILICON)
MM3009



CASE 79
(TO-39)

High-voltage NPN silicon transistors designed for video output circuitry in transistorized television receivers.

MAXIMUM RATINGS

Rating	Symbol	MM3008	MM3009	Unit
Collector-Emitter Voltage	V_{CEO}	120	180	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current	I_C	400		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	4.0 22.8		Watts mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MM3008 MM3009	BV_{CEO}*	120 180	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc I_C = 0)		BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CB} = 120 Vdc, I_E = 0) (V_{CB} = 180 Vdc, I_E = 0)	 MM3008 MM3009	I_{CBO}	 - -	 0.1 0.1	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}		0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)		h_{FE}	 30 40 30	 - - -	-
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T	50	-	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	-	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	20	pF

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — CURRENT GAIN

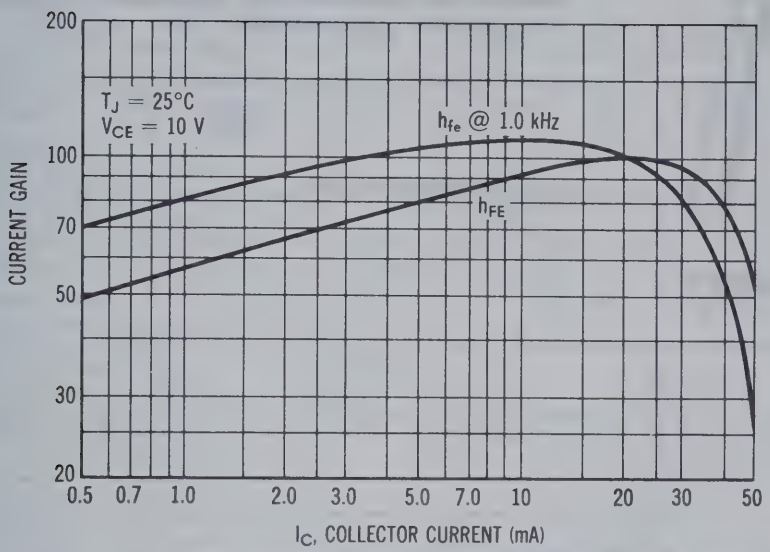
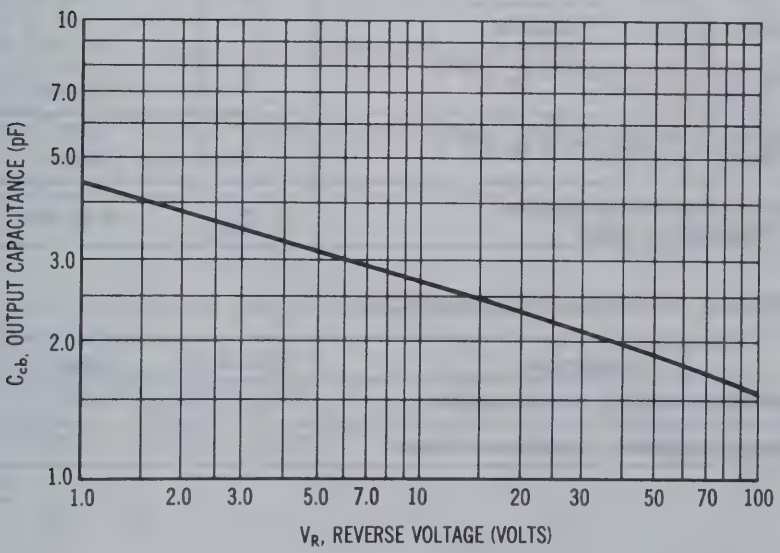


FIGURE 2 — CAPACITANCE



MM3724 (SILICON)
MM3725

NPN silicon annular transistors designed for medium-current, high-speed saturated switching and core driver applications. Type MM3725 is complementary to PNP type MM3726.



Collector connected to case

CASE 31
(TO-5)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	MM3724	MM3725	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Emitter-Base Voltage	V_{EB}	6		Vdc
Collector Current — Continuous	I_C	1.5		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	35	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0) MM3724 / MM3725	—	BV_{CEO}	30 / 50	— / —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	—	BV_{EBO}	6	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	—	I_{CBO}	—	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 2 Vdc)	9	h_{FE}	25	150	—
(I_C = 1 Adc, V_{CE} = 5 Vdc)			15	—	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	10, 11	$V_{CE(sat)}$	—	0.6	Vdc
(I_C = 1 Adc, I_B = 100 mAdc)			—	0.9	
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	11	$V_{BE(sat)}$	0.8	1.0	Vdc
(I_C = 1 Adc, I_B = 100 mAdc)			—	1.3	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	—	f_T	200	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz, emitter guarded)	3	C_{cb}	—	9	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz, collector guarded)	3	C_{eb}	—	80	pF
Turn-On Time (V_{CC} = 30 Vdc, $V_{EB(off)}$ = 2 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc, R_B = 200 ohms, R_L = 60 ohms)	1, 5, 6	t_{on}	—	30	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc, R_B = 200 ohms, R_L = 60 ohms)	2, 6, 7, 8	t_{off}	—	50	ns
Turn-On Time (V_{CC} = 30 Vdc, $V_{EB(off)}$ = 2 Vdc, I_C = 1 Adc, I_{B1} = 100 mAdc, R_B = 100 ohms, R_L = 30 ohms)	1, 5, 6	t_{on}	—	40	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 1 Adc, I_{B1} = I_{B2} = 100 mAdc, R_B = 100 ohms, R_L = 30 ohms)	2, 6, 7, 8	t_{off}	—	50	ns

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

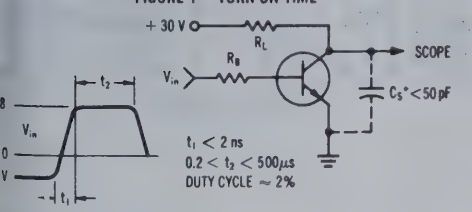
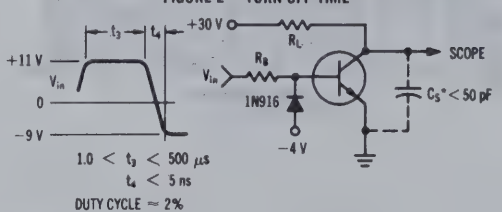


FIGURE 2 — TURN-OFF TIME



*TOTAL SHUNT CAPACITANCE OF TEST JIG, CONNECTORS, AND OSCILLOSCOPE.

TRANSIENT CHARACTERISTICS

——— 25°C - - - 150°C

FIGURE 3 — CAPACITANCES

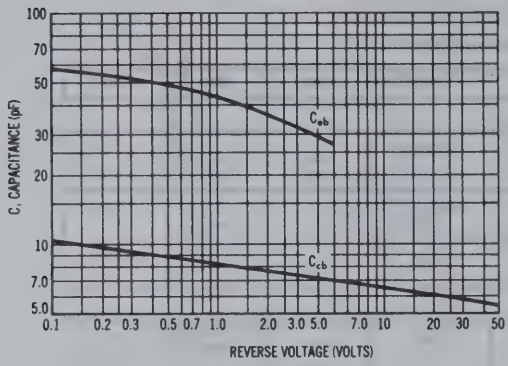


FIGURE 4 — CHARGE DATA

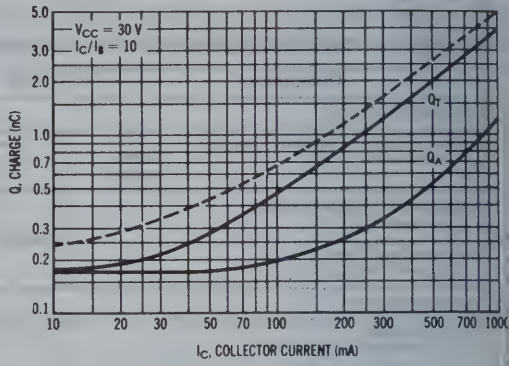


FIGURE 5 — TURN-ON TIME

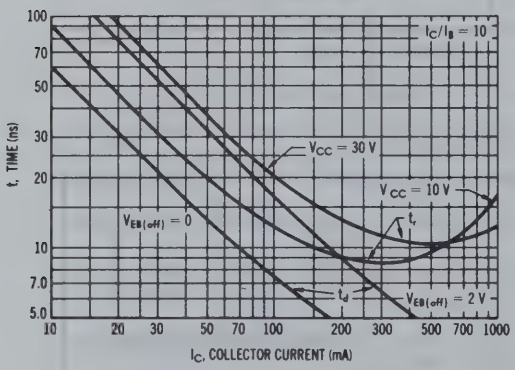


FIGURE 6 — RISE AND FALL TIMES

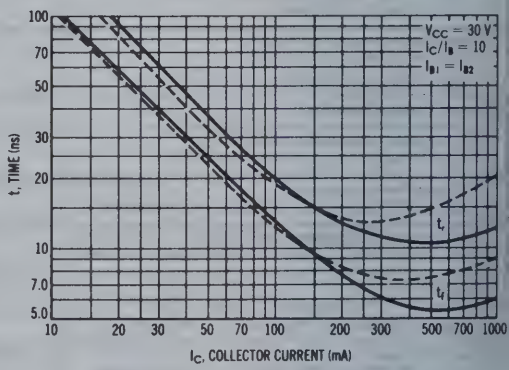


FIGURE 7 — STORAGE TIME

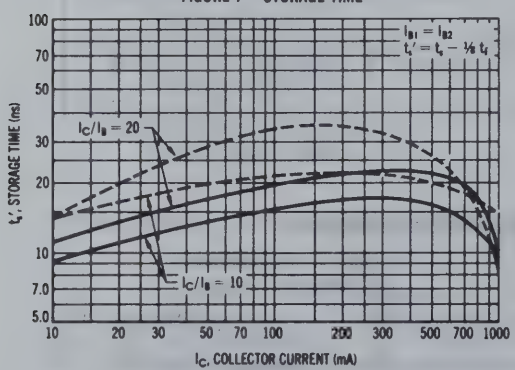
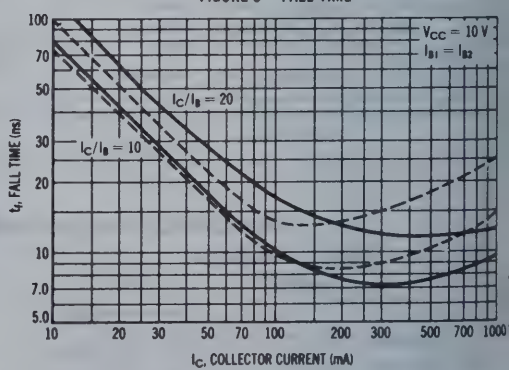


FIGURE 8 — FALL TIME



STATIC CHARACTERISTICS

FIGURE 9 — CURRENT GAIN

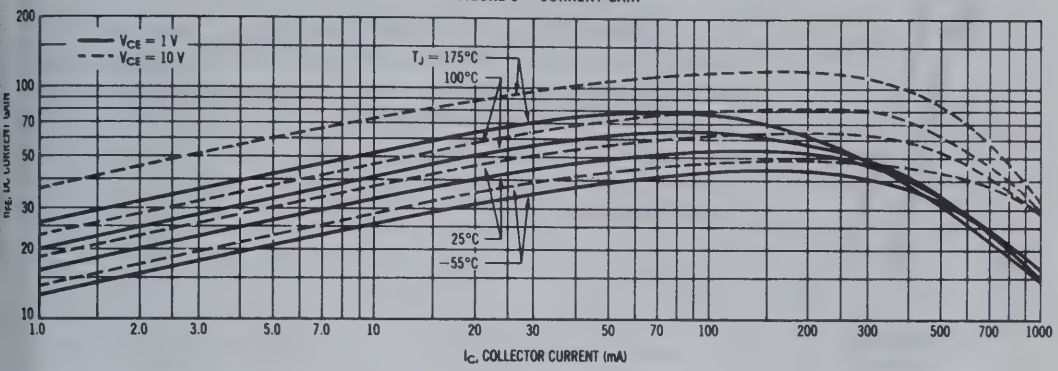


FIGURE 10 — SATURATION REGION

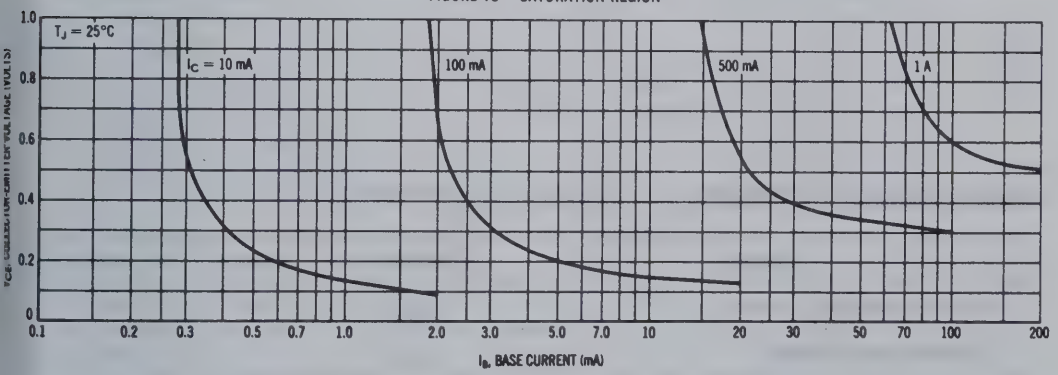


FIGURE 11 — "ON" VOLTAGES

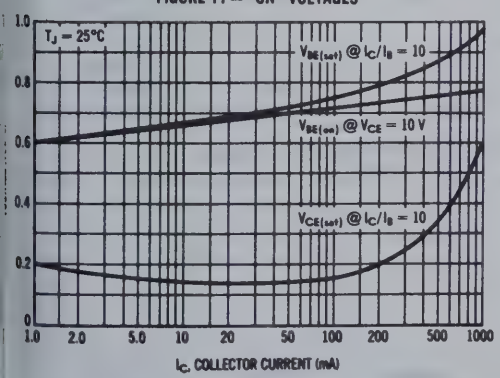
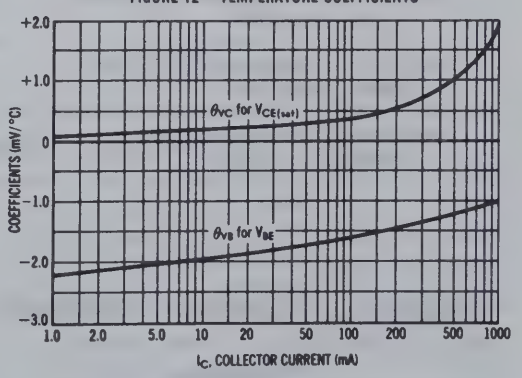


FIGURE 12 — TEMPERATURE COEFFICIENTS



MM3726 (SILICON)



CASE 31
(TO-5)

PNP silicon annular transistor designed for medium-current, high-speed saturated switching and core driver applications, and for complementary circuitry with NPN type MM3725.

Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current — Continuous	I_C	1.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

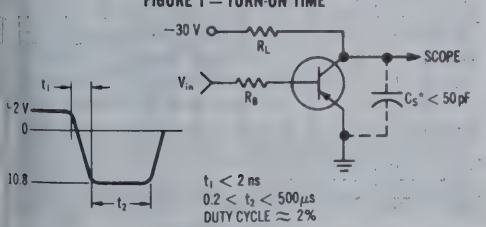
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	35	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	—	BV_{CEO}	50	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	—	BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	—	I_{CBO}	—	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CE} = 2 Vdc)	9	h_{FE}	30	120	—
(I_C = 1 Adc, V_{CE} = 5 Vdc)			15	—	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	10, 11	$V_{CE(sat)}$	—	0.6	Vdc
(I_C = 1 Adc, I_B = 100 mAdc)			—	1.2	
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	11	$V_{BE(sat)}$	0.8	1.1	Vdc
(I_C = 1 Adc, I_B = 100 mAdc)			—	1.3	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	—	f_T	200	—	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz, emitter guarded)	3	C_{cb}	—	10	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz, collector guarded)	3	C_{eb}	—	80	pF
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc, R_B = 200 ohms, R_L = 60 ohms)	1, 5, 6	t_{on}	—	30	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc, R_B = 200 ohms, R_L = 60 ohms)	2, 7, 8	t_{off}	—	90	ns
Turn-On Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2 Vdc, I_C = 1 Adc, I_{B1} = 100 mAdc, R_B = 100 ohms, R_L = 30 ohms)	1, 5, 6	t_{on}	—	35	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 1 Adc, I_{B1} = I_{B2} = 100 mAdc, R_B = 100 ohms, R_L = 30 ohms)	2, 7, 8	t_{off}	—	60	ns

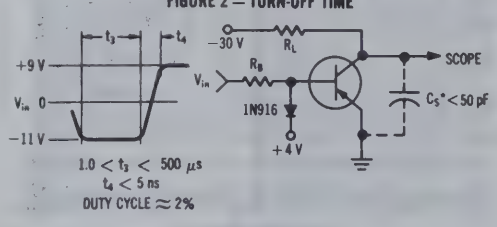
SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME



t_1 < 2 ns
0.2 < t_2 < 500 μs
DUTY CYCLE ≈ 2%

FIGURE 2 — TURN-OFF TIME



1.0 < t_3 < 500 μs
t_4 < 5 ns
DUTY CYCLE ≈ 2%

*TOTAL SHUNT CAPACITANCE OF TEST JIG, CONNECTORS, AND OSCILLOSCOPE.

TRANSIENT CHARACTERISTICS

— 25°C - - - 150°C

FIGURE 3 — CAPACITANCES

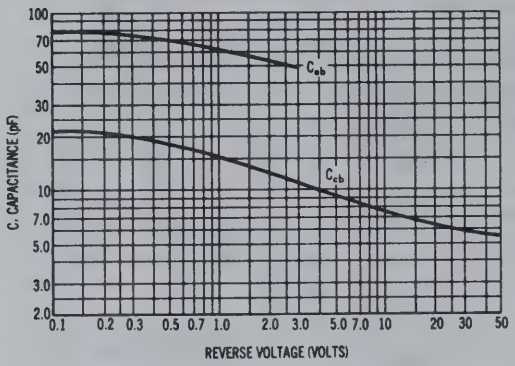


FIGURE 4 — CHARGE DATA

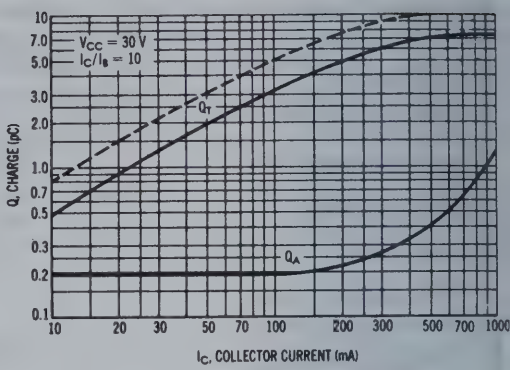


FIGURE 5 — TURN-ON TIME

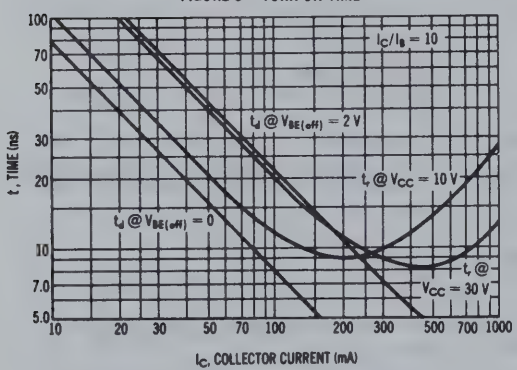


FIGURE 6 — RISE TIME

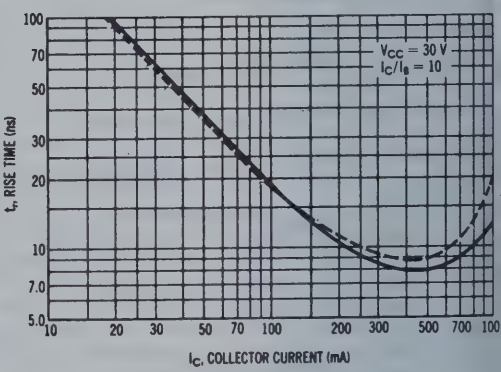


FIGURE 7 — STORAGE TIME

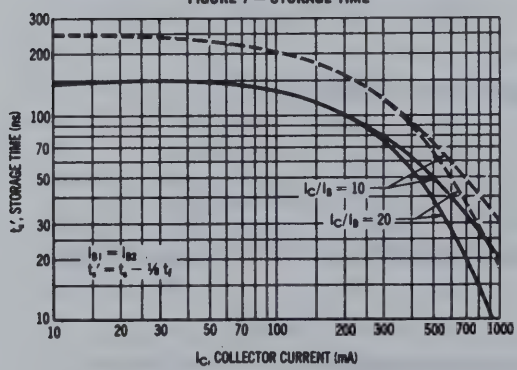
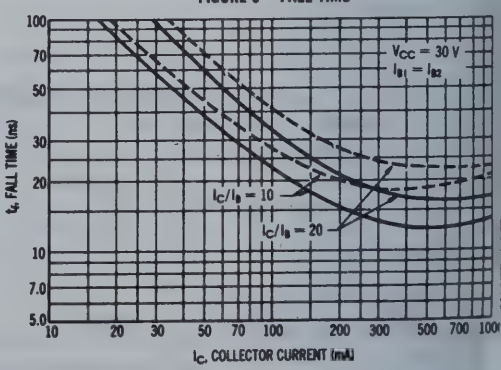


FIGURE 8 — FALL TIME



STATIC CHARACTERISTICS

FIGURE 9 — CURRENT GAIN

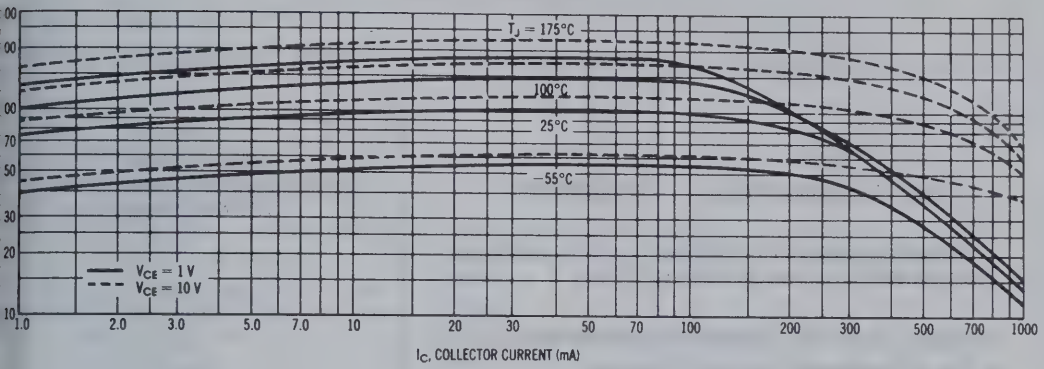


FIGURE 10 — SATURATION REGION

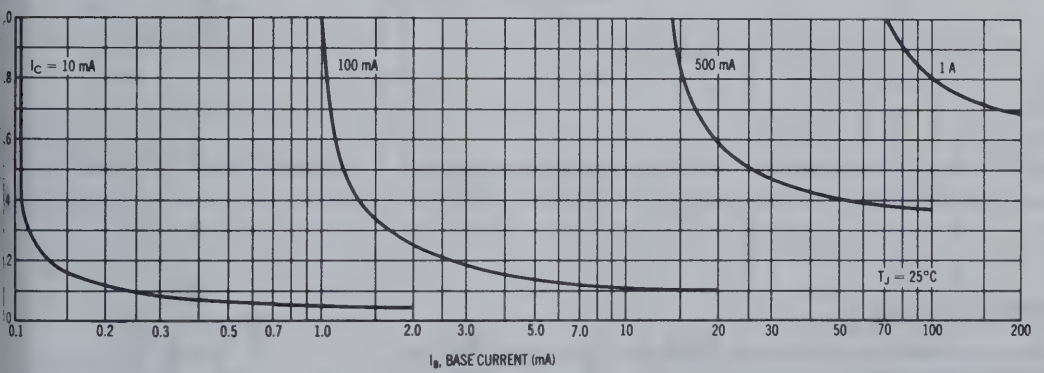


FIGURE 11 — "ON" VOLTAGES

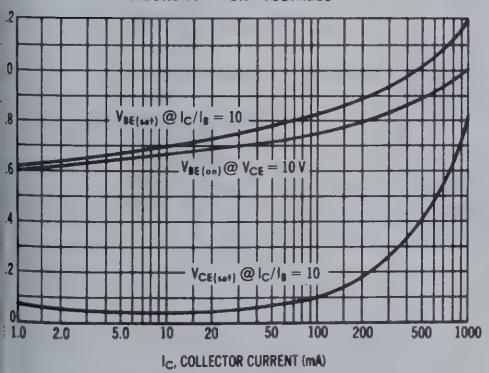
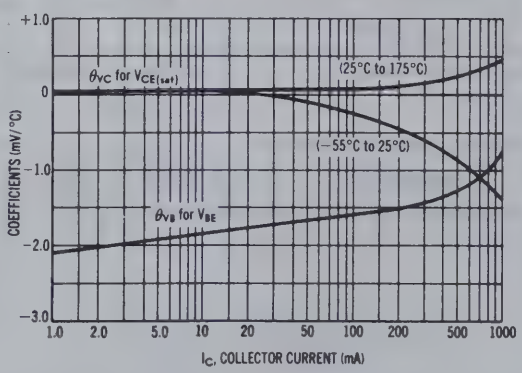


FIGURE 12 — TEMPERATURE COEFFICIENTS



MM3903 (SILICON)
MM3904

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general purpose switching and amplifier applications. Direct replacement for plastic 2N3903 and 2N3904.

- Hermetic Low Profile TO-52 Metal Package for High Reliability
- High Voltage Ratings — BV_{CEO} = 40 Volts (Min)
- Current Gain Specified from 100 μA to 100 mA
- Complete Switching and Amplifier Specifications

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS

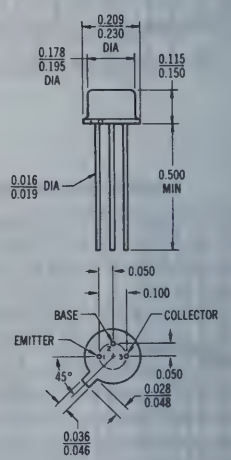


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.49	°C/mW



CASE 27
(TO-52)

MM3903, MM3904 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		-	BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0)		-	BV_{CEO}*	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		-	BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		-	I_{CEX}	-	50	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)		-	I_{BL}	-	50	nAdc
ON CHARACTERISTICS						
DC Current Gain*		15	h_{FE}*			-
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	MM3903			20	-	
	MM3904			40	-	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MM3903			35	-	
	MM3904			70	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MM3903			50	150	
	MM3904			100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	MM3903			30	-	
	MM3904			60	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MM3903			10	-	
	MM3904			15	-	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		16, 17	$V_{CE(sat)}$*	-	0.2	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.3	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		17	$V_{BE(sat)}$*	0.65	0.85	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.95	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MM3903	-	f_T	250	-	MHz
	MM3904			300	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		3	C_{ob}	-	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		3	C_{ib}	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3903	13	h_{ie}	0.5	8.0	k ohms
	MM3904			1.0	10	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3903	14	h_{re}	0.1×10^{-4}	5×10^{-4}	-
	MM3904			0.5×10^{-4}	8×10^{-4}	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3903	11	h_{fe}	50	200	-
	MM3904			100	400	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		12	h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 10 Hz to 15.7 kHz)	MM3903	9, 10	NF	-	6.0	dB
	MM3904			-	5.0	
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	1, 5	t_d	-	35	ns
Rise Time		1, 5, 6	t_r	-	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) MM3903	2, 7	t_s	-	175	ns
	MM3904			-	200	
Fall Time		2, 8	t_f	-	50	ns

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

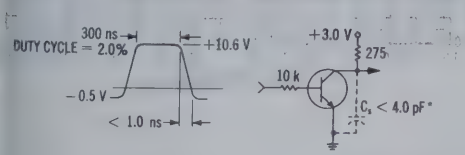
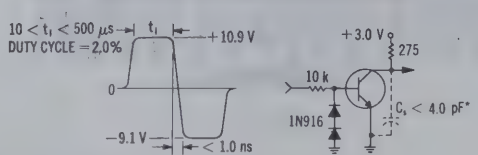


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS

——— $T_J = 25^oC$ ----- $T_J = 125^oC$

FIGURE 3 – CAPACITANCE

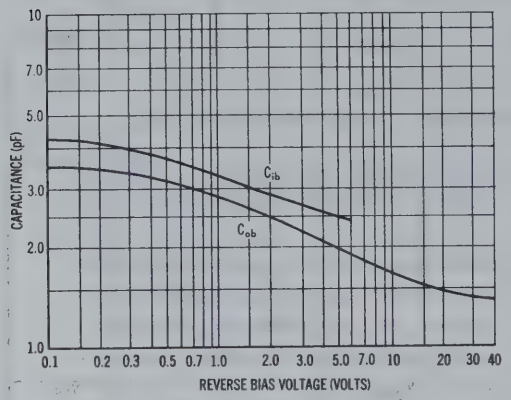


FIGURE 4 – CHARGE DATA

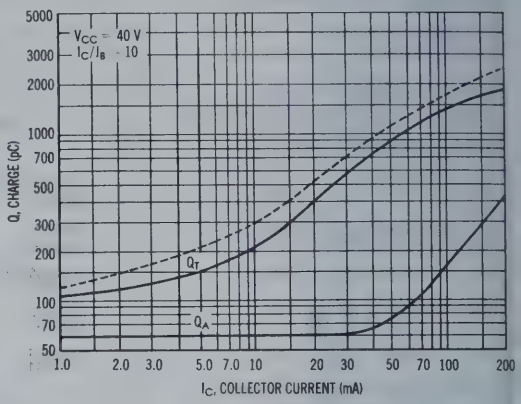


FIGURE 5 – TURN-ON TIME

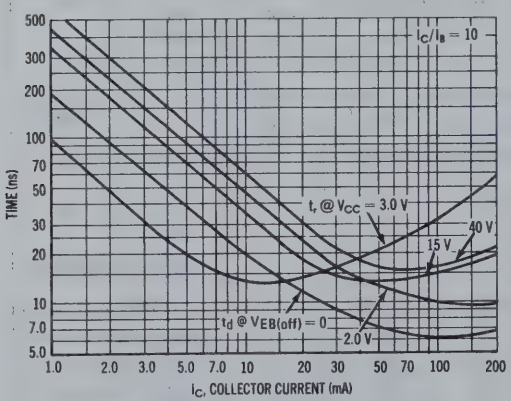


FIGURE 6 – RISE TIME

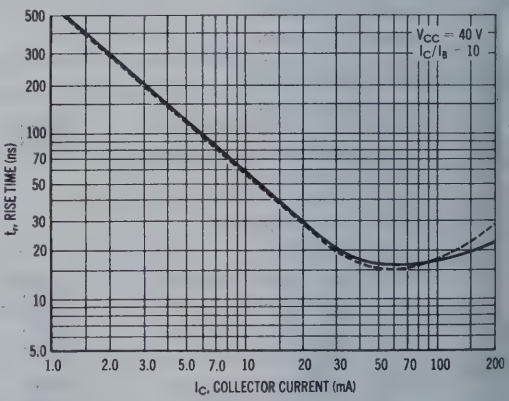


FIGURE 7 – STORAGE TIME

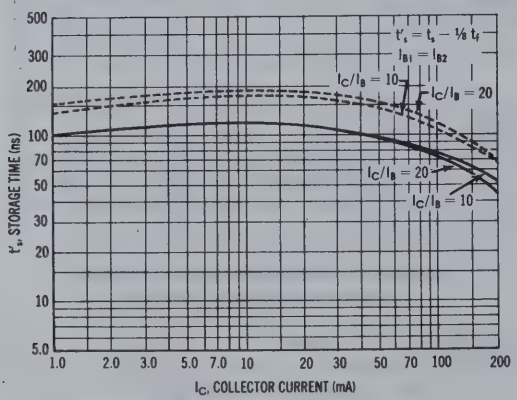
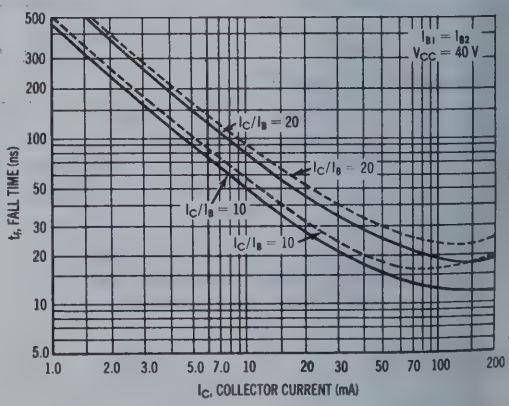


FIGURE 8 – FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C

FIGURE 9

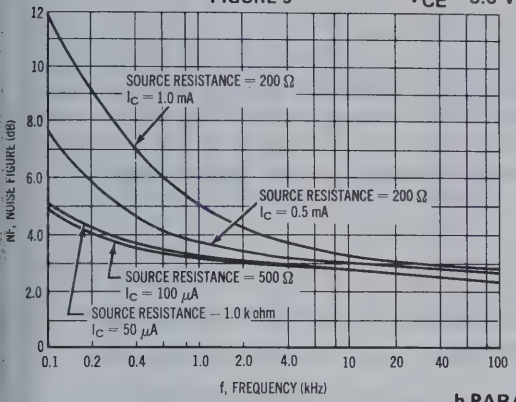
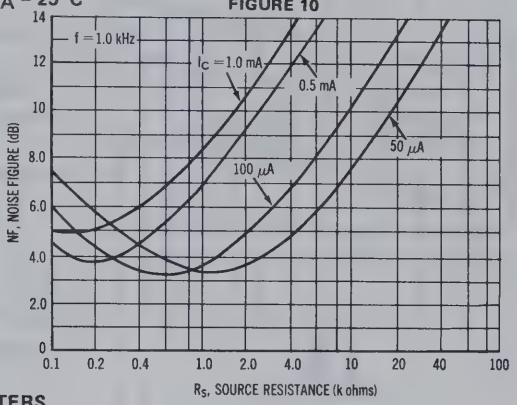


FIGURE 10



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

FIGURE 11 – CURRENT GAIN

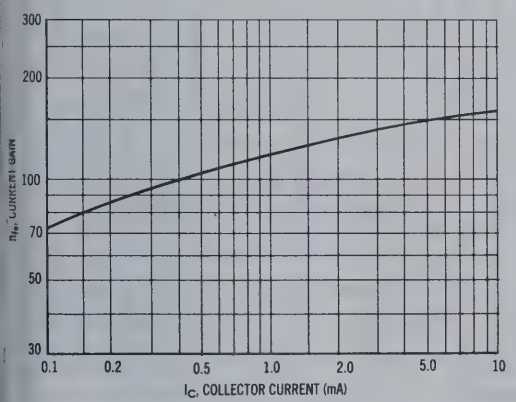


FIGURE 12 – OUTPUT ADMITTANCE

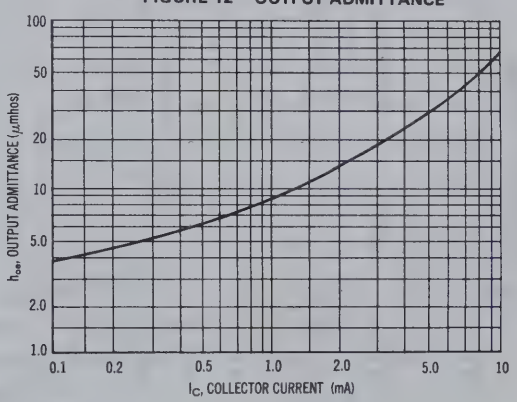


FIGURE 13 – INPUT IMPEDANCE

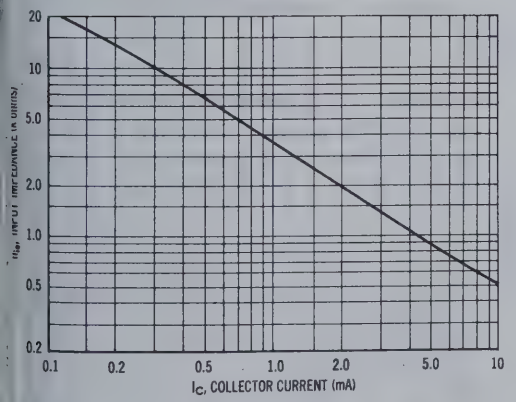
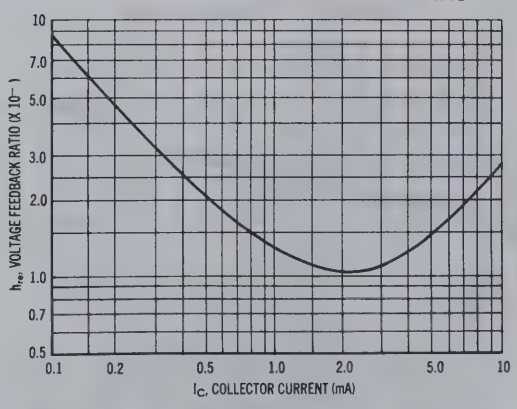


FIGURE 14 – VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 15 – NORMALIZED CURRENT GAIN

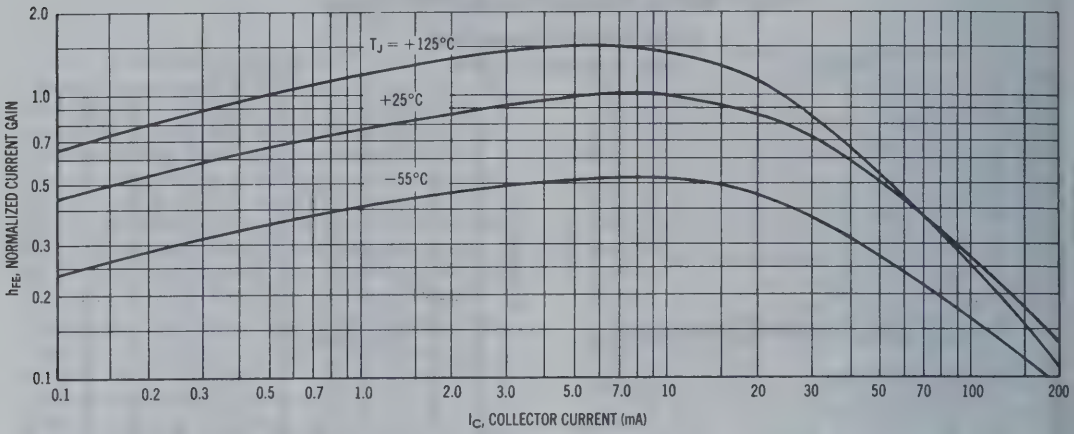


FIGURE 16 – COLLECTOR SATURATION REGION

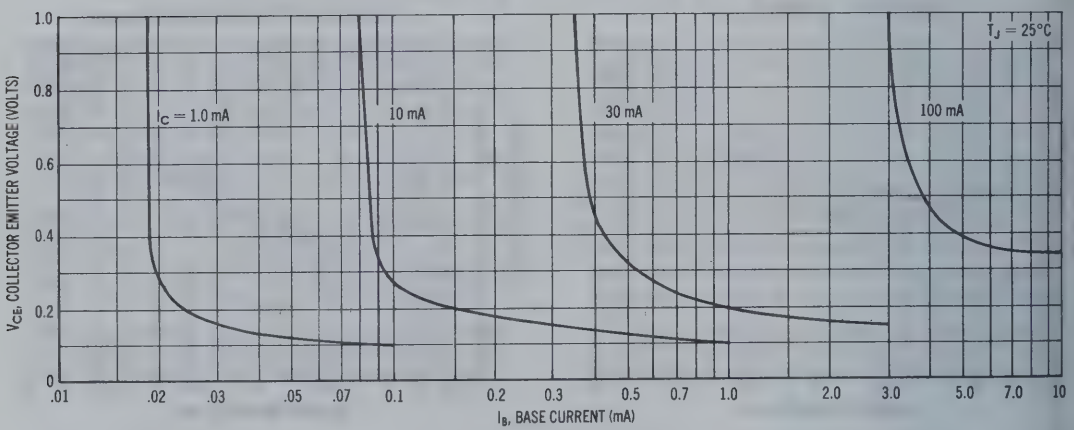


FIGURE 17 – "ON" VOLTAGES

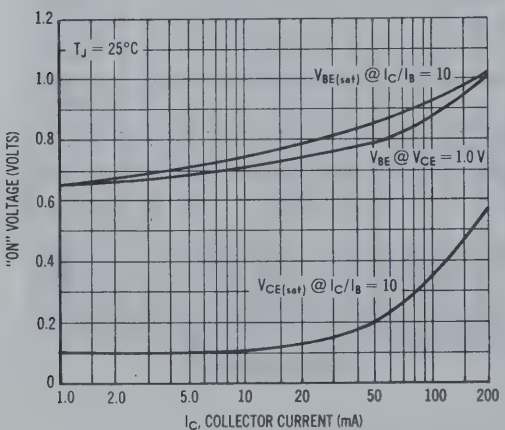
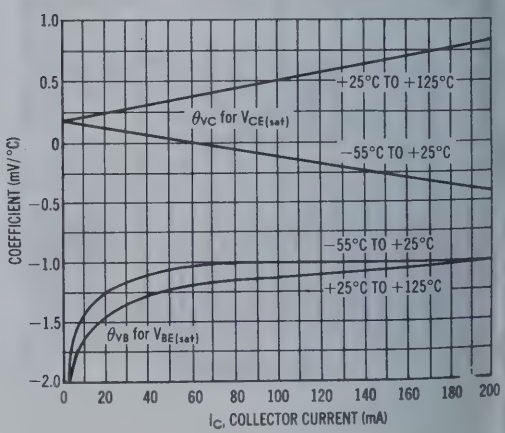


FIGURE 18 – TEMPERATURE COEFFICIENTS



MM3905 (SILICON)
MM3906

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general purpose switching and amplifier applications. Direct replacement for plastic 2N3905 and 2N3906.

- Hermetic Low Profile TO-52 Metal Package for High Reliability
- High Voltage Ratings — BV_{CEO} = 40 Volts (Min)
- Current Gain Specified from 100 μA to 100 mA
- Complete Switching and Amplifier Specifications

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTORS

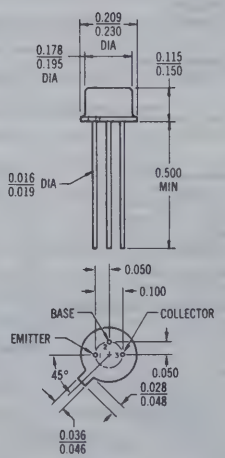


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.49	°C/mW



CASE 27
(TO-52)

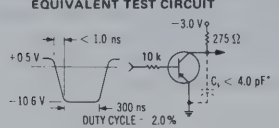
MM3905, MM3906 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		-	BV_{CBO}	40	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0)		-	BV_{CEO}*	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		-	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)		-	I_{CEX}	-	50	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)		-	I_{BL}	-	50	nAdc
ON CHARACTERISTICS						
DC Current Gain*			h_{FE}*			-
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	MM3905	15		30	-	
	MM3906			60	-	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MM3905			40	-	
	MM3906			80	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MM3905			50	150	
	MM3906			100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	MM3905			30	-	
	MM3906			60	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	MM3905			10	-	
	MM3906			15	-	
Collector-Emitter Saturation Voltage*		16, 17	$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)				-	0.25	
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.4	
Base-Emitter Saturation Voltage*		17	$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)				0.65	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.95	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MM3905	-	f_T	200	-	MHz
	MM3906			250	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		3	C_{ob}	-	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		3	C_{ib}	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905	13	h_{ie}	0.5	8.0	k ohms
	MM3906			2.0	12	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905	14	h_{re}	0.1×10^{-4}	5×10^{-4}	-
	MM3906			1×10^{-4}	10×10^{-4}	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905	11	h_{fe}	50	200	-
	MM3906			100	400	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MM3905	12	h_{oe}	1.0	40	μmhos
	MM3906			3.0	60	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, f = 10 Hz to 15.7 kHz)	MM3905	9, 10	NF	-	5.0	dB
	MM3906			-	4.0	
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc,		1, 5	t_d	-	35	ns
Rise Time	I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		1, 5, 6	t_r	-	35	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc,	MM3905	2, 7	t_s	-	200	ns
		MM3906			-	225	
Fall Time	$I_{B1} = I_{B2}$ = 1.0 mAdc)	MM3905	2, 8	t_f	-	60	ns
		MM3906			-	75	

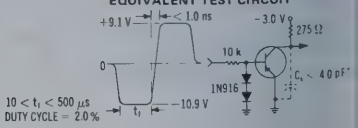
* Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



TRANSIENT CHARACTERISTICS

—T_J = 25°C ---T_J = 125°C

FIGURE 3 – CAPACITANCE

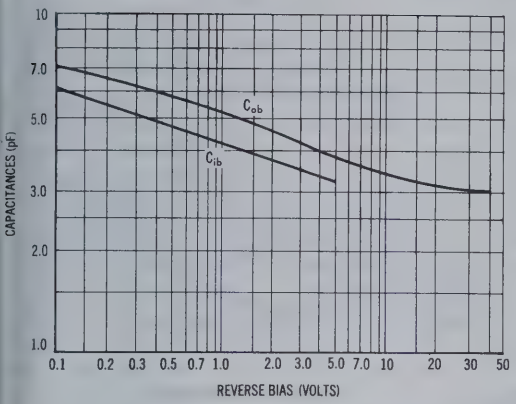


FIGURE 4 – CHARGE DATA

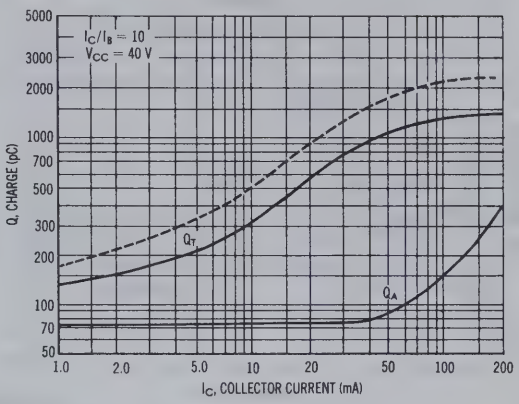


FIGURE 5 – TURN-ON TIME

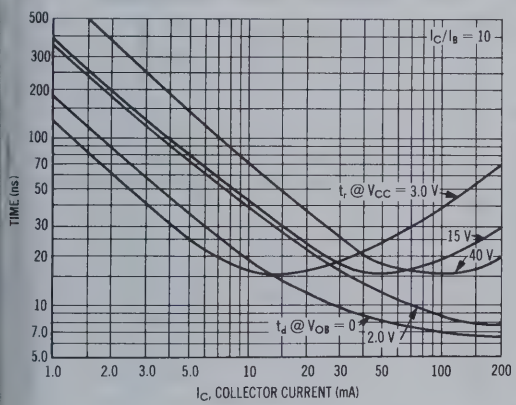


FIGURE 6 – RISE TIME

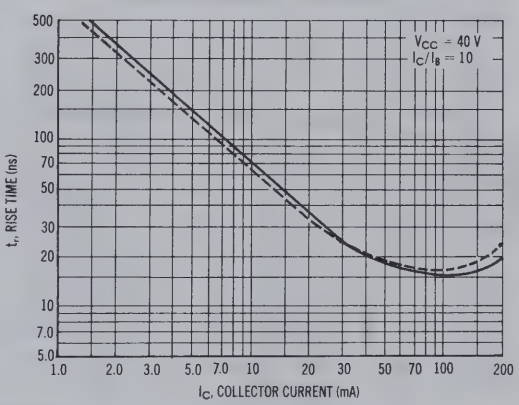


FIGURE 7 – STORAGE TIME

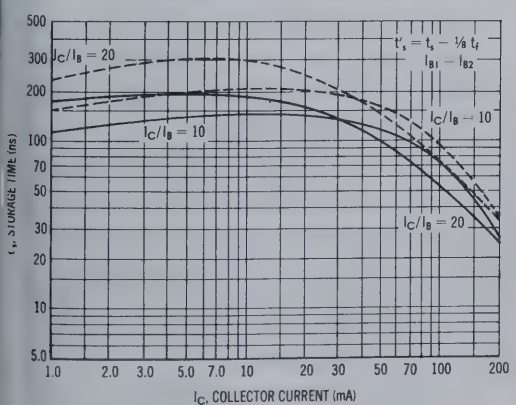
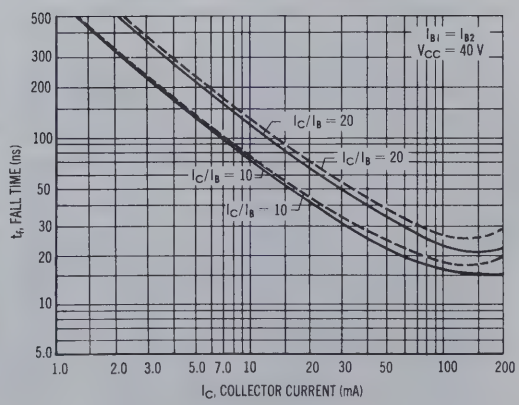


FIGURE 8 – FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C

FIGURE 9

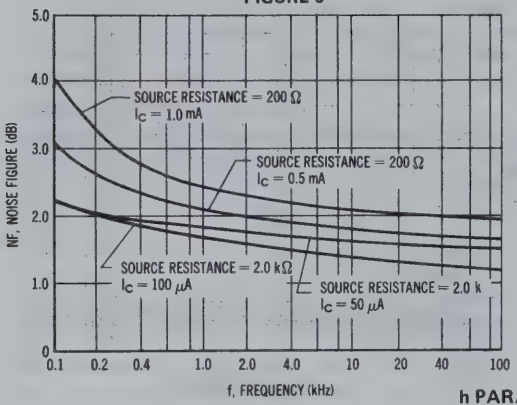
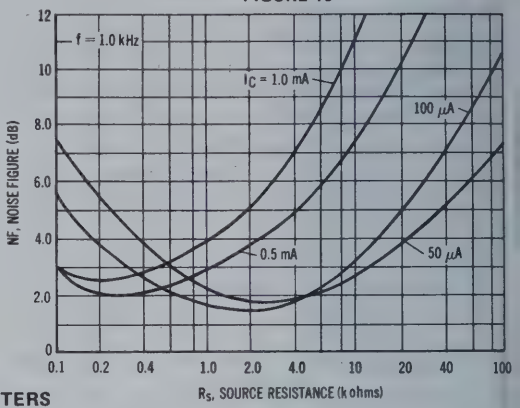


FIGURE 10



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

FIGURE 11 – CURRENT GAIN

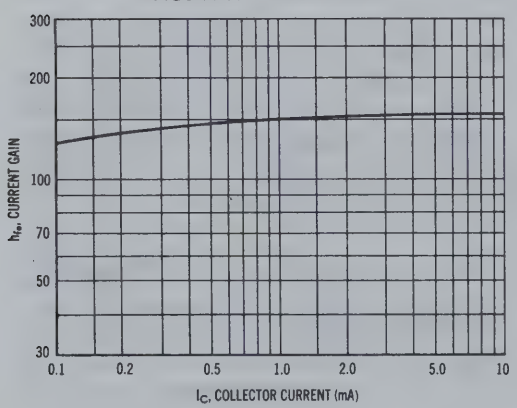


FIGURE 12 – OUTPUT ADMITTANCE

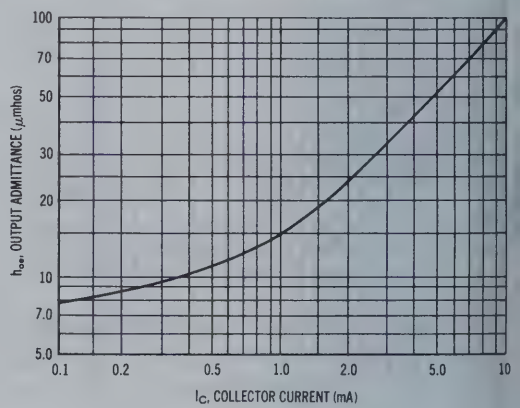


FIGURE 13 – INPUT IMPEDANCE

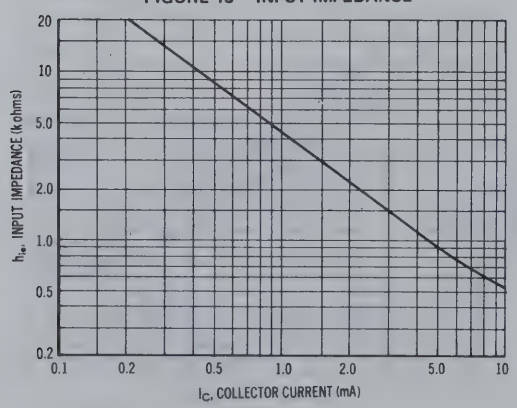
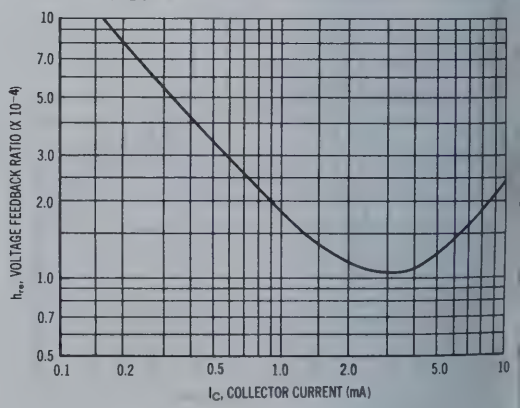


FIGURE 14 – VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 15 – NORMALIZED CURRENT GAIN

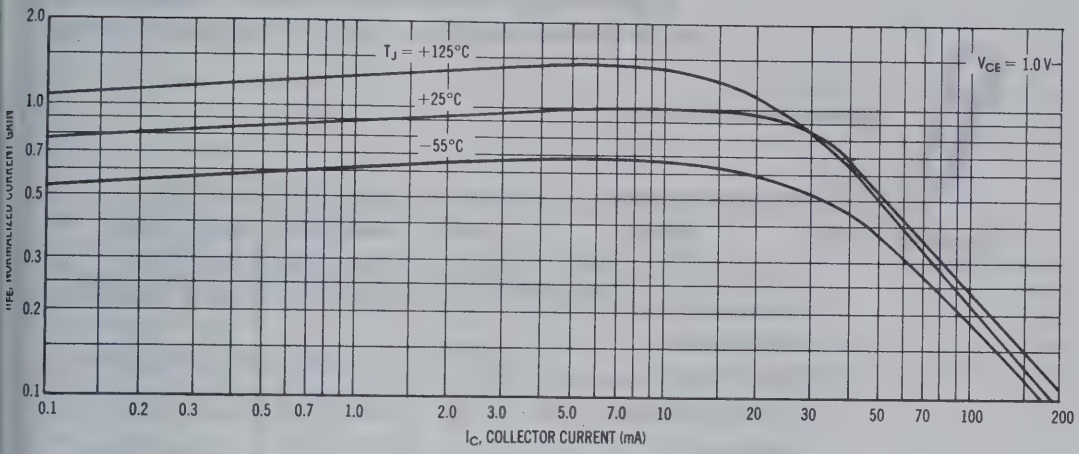


FIGURE 16 – COLLECTOR SATURATION REGION

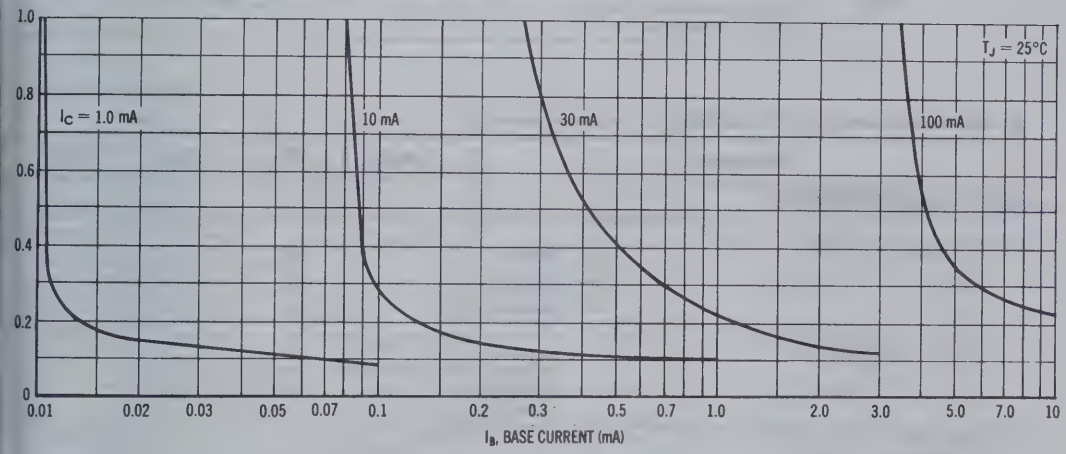


FIGURE 17 – "ON" VOLTAGES

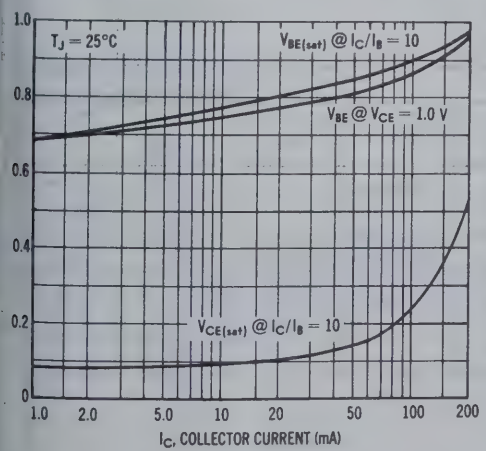
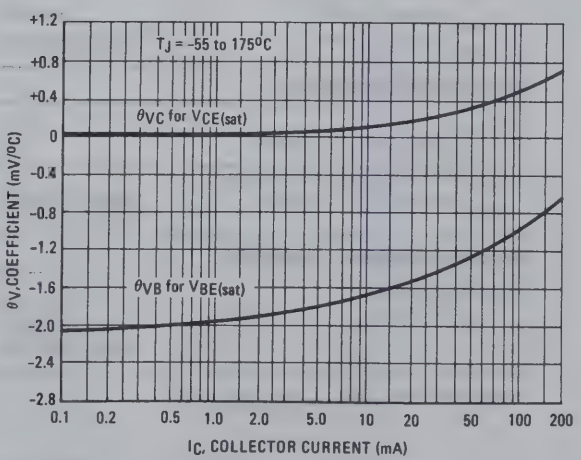


FIGURE 18 – TEMPERATURE COEFFICIENTS



MM4000 thru MM4003 (SILICON)

High-voltage PNP silicon annular transistors for use in general-purpose, high-voltage applications.



Collector connected to case

CASE 79
(TO-5)

MAXIMUM RATINGS

Rating	Symbol	MM4000	MM4001	MM4002	MM4003	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Collector-Base Voltage	V_{CB}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	500	500	500	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	0.6	1.0	1.0	1.0	Watt
Derate above 25°C		3.4	5.71	5.71	5.71	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	3.0	5.0	5.0	5.0	Watts
Derate above 25°C		17.2	28.6	28.6	28.6	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MM4000	BV_{CEO}*	100	-	Vdc
	MM4001		150	-	
	MM4002		200	-	
	MM4003		250	-	
Collector-Base Breakdown Voltage (I_E = 0, I_C = 100 μAdc)	MM4000	BV_{CBO}	100	-	Vdc
	MM4001		150	-	
	MM4002		200	-	
	MM4003		250	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 50 Vdc, I_E = 0)	MM4000		-	1.0	
(V_{CB} = 75 Vdc, I_E = 0)	MM4001		-	1.0	
(V_{CB} = 150 Vdc, I_E = 0)	MM4002, MM4003		-	5.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)*		h_{FE}	20	-	-
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	MM4000, MM4001	$V_{CE(sat)}$*	-	0.6	Vdc
	MM4002, MM4003		-	5.0	
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	MM4000	C_{ob}	-	6.0	pF
	MM4001		-	10	
	MM4002, MM4003		-	20	

* Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

MM4018 (SILICON)

PNP SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency multiplier or oscillator applications in military and industrial equipment. Suitable for use as Class A, B, or C driver, or pre-driver stages in VHF applications.

- Power Output – P_{out} = 0.5 W (Min) @ f = 175 MHz
- High Current-Gain – Bandwidth Product – f_T = 900 MHz (Typ) @ I_C = 50 mAdc

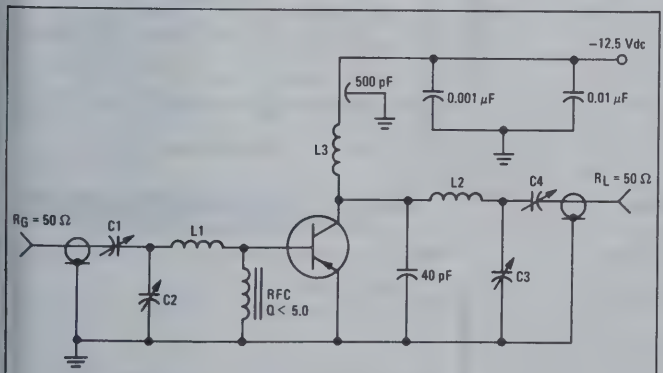
PNP SILICON RF POWER TRANSISTOR



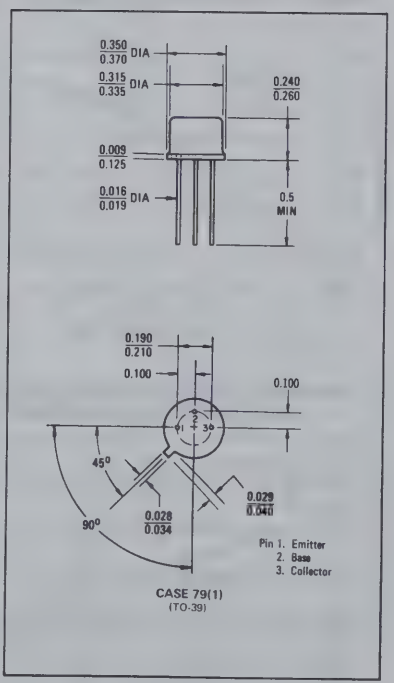
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

FIGURE 1 – 175 MHz OUTPUT POWER TEST CIRCUIT



C1, C2 3.0 – 30 pF, ARCO 461 OR EQUIVALENT
C3, C4 8.0 – 80 pF, ARCO 462 OR EQUIVALENT
L1 100 nH, 4 TURNS NO. 18 AWG, 1/4" I.D., 5/8" LENGTH
L2 40 nH, 2 TURNS NO. 18 AWG, 1/4" I.D., 1/2" LENGTH
L3 200 nH, 8 TURNS NO. 18 AWG, 1/4" I.D., 7/8" LENGTH



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 5.0 mAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–	–	20	μAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0)	I_{CES}	–	–	0.1	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	–	900	–	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	3.5	–	pF
FUNCTIONAL TEST					
Power Output (Figure 1) (P_{in} = 50 mW, V_{CC} = 12.5 Vdc, f = 175 MHz)	P_{out}	0.5	–	–	Watt
Collector Efficiency (Figure 1) (P_{in} = 50 mW, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	45	55	–	%

FIGURE 2 – POWER OUTPUT versus POWER INPUT

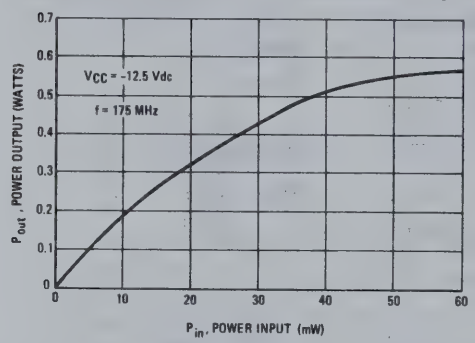


FIGURE 3 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

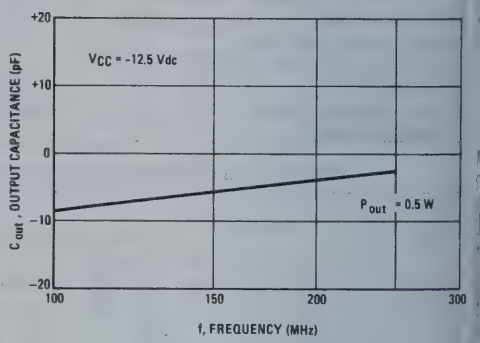


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

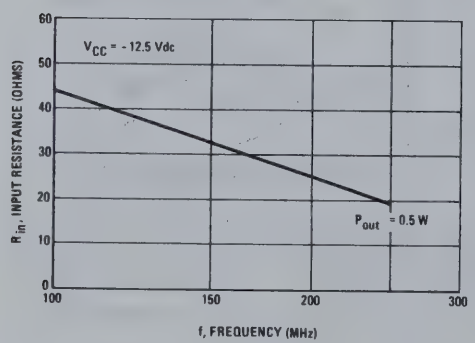
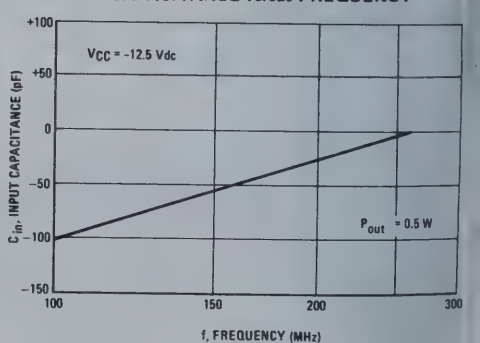


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



MM4019 (SILICON)

PNP SILICON RF POWER TRANSISTOR

. . . designed for use as complement to NPN 2N3553 in VHF and UHF amplifier applications for military and industrial equipment.

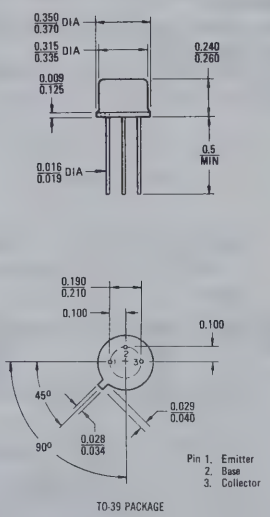
- Power Output – P_{out} = 2.0 W (Typ) @ P_{in} = 0.5 W, f = 400 MHz
- Power Input – P_{in} = 0.25 W (Max) @ P_{out} = 2.5 W, f = 175 MHz

PNP SILICON RF POWER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	5.0 28.6	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC



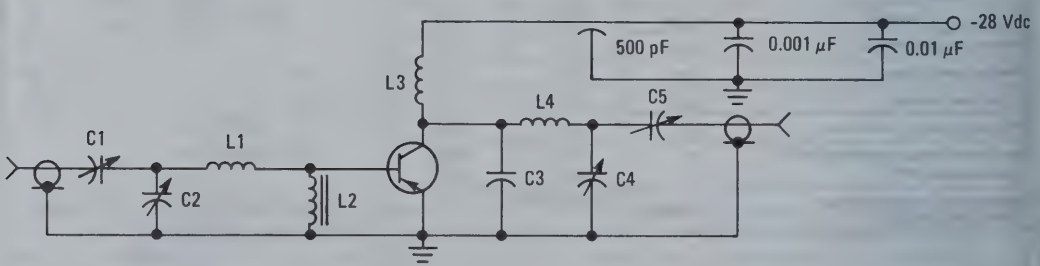
TO-39 PACKAGE

CASE 79(1)
(TO-39)

ELECTRICAL CHARACTERISTICS (T_A = 25° unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 mAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 Adc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	–	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	–	–
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	–	750	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	7.5	–	pF
FUNCTIONAL TEST					
Power Input (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	P_{in}	–	–	0.25	Watt
Power Output (P_{in} = 0.5 W, V_{CC} = 28 Vdc, f = 400 MHz)	P_{out}	–	2.0	–	Watts
Collector Efficiency (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	η	50	–	–	%

FIGURE 1 – 175 MHz TEST CIRCUIT



C1, C2 3.0-30 pF, ARCO 461 or equivalent.
C3 40 pF
C4, C5 5.0-80 pF, ARCO 462 or equivalent.
L1 80 nH, 3 Turns #18 AWG, 1/4" I.D., 1/4" Length
L2 Ferrite Choke, VK-200 Ferroxcube, Q < 5
L3 0.15 μH, RF Choke
L4 27 nH, 2 Turns #18 AWG, 1/4" I.D., 3/8" Length

FIGURE 2 – POWER OUTPUT versus FREQUENCY

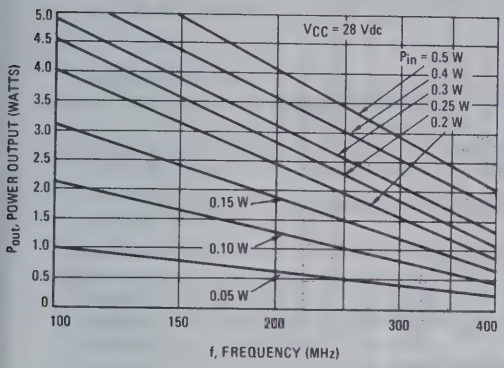


FIGURE 3 – POWER OUTPUT versus POWER INPUT

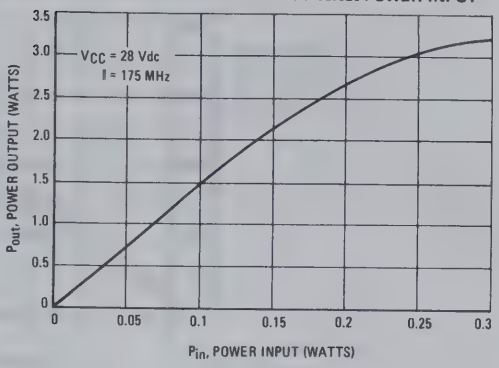


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

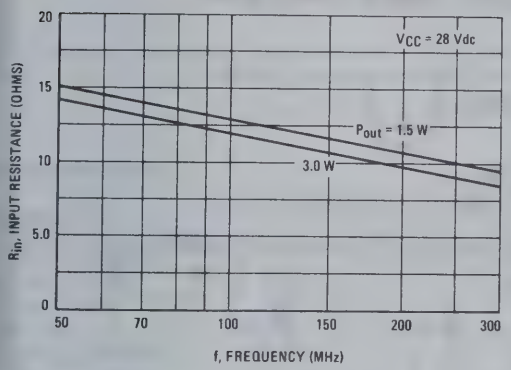


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

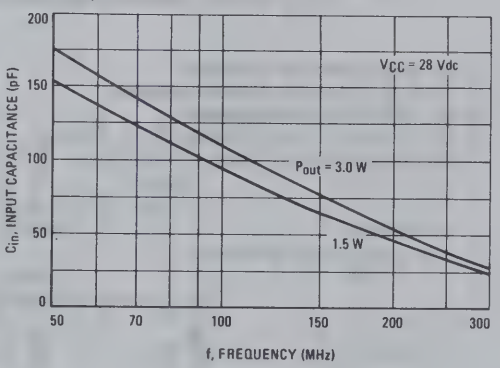


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

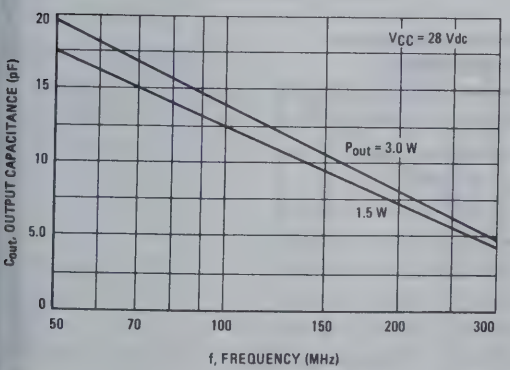


FIGURE 7 – OUTPUT CAPACITANCE versus COLLECTOR VOLTAGE

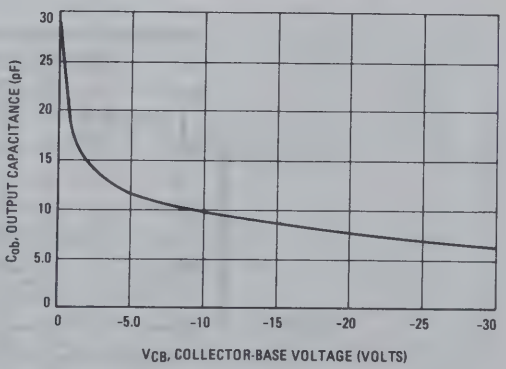


FIGURE 8 – CURRENT-GAIN–BANDWIDTH PRODUCT

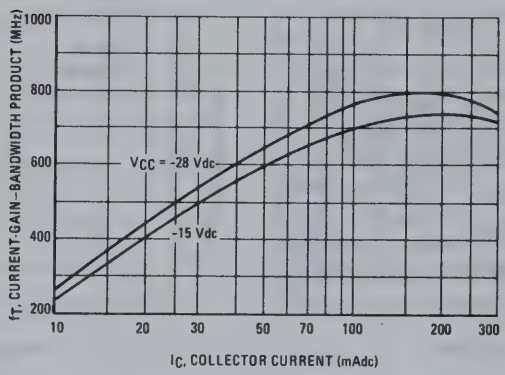


FIGURE 9 – MM4019/2N3553 COMPLEMENTARY 175 MHz AMPLIFIER CIRCUIT

C1, C2 3.0-30 pF, ARCO 461 or equivalent
C3 0.1 μF, ATC-200 Chip Capacitor or equivalent
C4, C5 1.5-15 pF, ARCO 460 or equivalent
L1, L2 1-1/2 Turns #18 AWG, 1/8" Length, 1/4" I.D., 36 nH
L3 7 Turns #18 AWG, 1/2" Length, 1/4" I.D., 140 nH

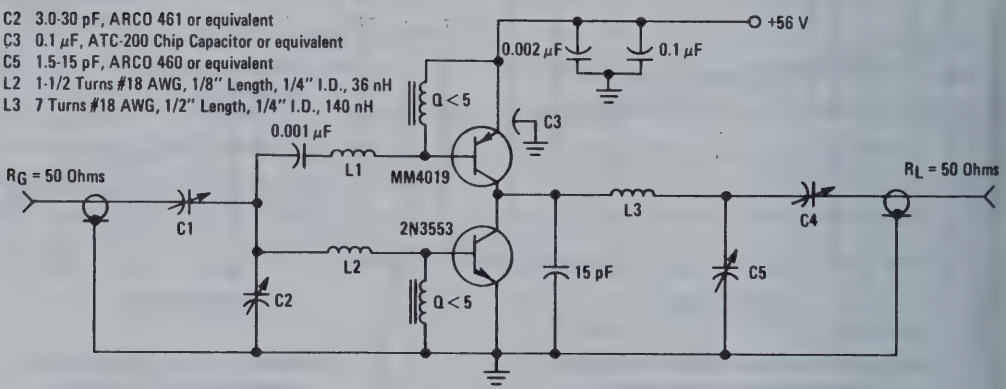
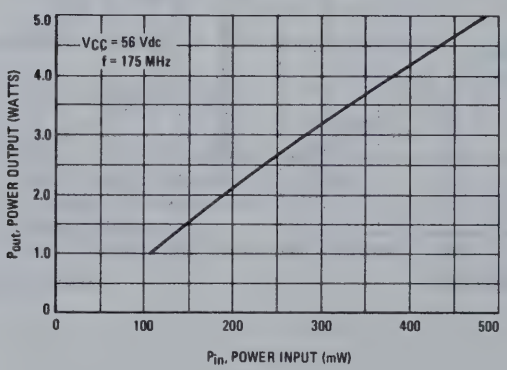


FIGURE 10 – POWER OUTPUT versus POWER INPUT FOR COMPLEMENTARY CIRCUIT



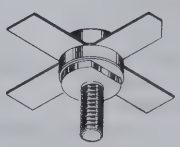
MM4020 (SILICON)
thru
MM4023

PNP SILICON RF POWER TRANSISTORS

. . . designed for 12.5 Volt VHF large-signal amplifier applications required in military and industrial equipment operating to 250 MHz.

- Balanced Emitter Construction to Provide the Designer with the Optimum in Transistor Safe Operating Area
- Low Lead Inductance Stripline Packaging for Easier Design and Increased Broadband Capabilities
- Exceptional Power Output Stability versus Temperature
- Choice of Power Levels at 12.5 Vdc, 175 MHz
  MM4020 – 3.5 Watts @ 11.5 dB Gain (Min)
  MM4021 – 15 Watts @ 7.0 dB Gain (Min)
  MM4022 – 25 Watts @ 5.5 dB Gain (Min)
  MM4023 – 40 Watts @ 4.5 dB Gain (Min)

PNP SILICON RF POWER TRANSISTORS

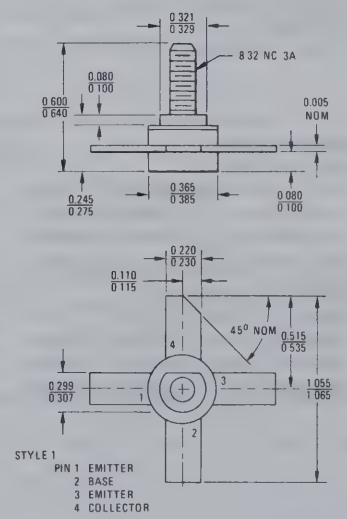


MAXIMUM RATINGS

Rating	Symbol	MM4020	MM4021	MM4022	MM4023	Unit
Collector-Emitter Voltage	V_{CEO}	← 18 →				Vdc
Collector-Base Voltage	V_{CB}	← 36 →				Vdc
Emitter-Base Voltage	V_{EB}	← 4.0 →				Vdc
Collector Current — Continuous	I_C	1.0	2.5	4.0	6.0	Adc
Total Device Dissipation @ $T_C = 25^oC$	P_D	25	29	70	87	Watts
Derate above 25^oC		0.2	0.232	0.56	0.696	W/^{o}C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +150 →				^{o}C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MM4020	MM4021	MM4022	MM4023	Unit
Thermal Resistance, Junction to Case	θ_{JC}	7.0	6.0	2.5	2.0	^{o}C/W

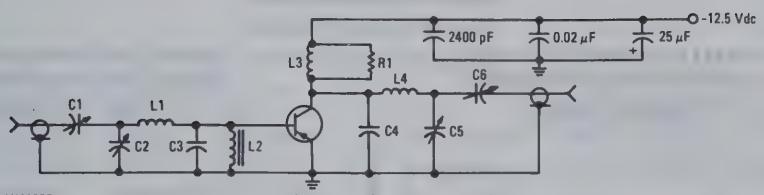


CASE 208-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 10 mAdc, I_B = 0)	MM4020		18	–	–	
(I_C = 20 mAdc, I_B = 0)	MM4021		18	–	–	
(I_C = 50 mAdc, I_B = 0)	MM4022		18	–	–	
(I_C = 100 mAdc, I_B = 0)	MM4023		18	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 5.0 mAdc, I_E = 0)	MM4020		36	–	–	
(I_C = 10 mAdc, I_E = 0)	MM4021		36	–	–	
(I_C = 15 mAdc, I_E = 0)	MM4022		36	–	–	
(I_C = 20 mAdc, I_E = 0)	MM4023		36	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	MM4020		4.0	–	–	
(I_E = 2.0 mAdc, I_C = 0)	MM4021		4.0	–	–	
(I_E = 5.0 mAdc, I_C = 0)	MM4022		4.0	–	–	
(I_E = 10 mAdc, I_C = 0)	MM4023		4.0	–	–	
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 15 Vdc, I_E = 0)	MM4020		–	–	50	
	MM4021		–	–	100	
	MM4022		–	–	250	
	MM4023		–	–	500	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 0.25 Adc, V_{CE} = 5.0 Vdc)	MM4020		15	–	–	
(I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	MM4021,MM4022,MM4023		15	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 12.5 Vdc, I_E = 0, f = 100 kHz)	MM4020		–	15.5	–	
	MM4021		–	90	–	
	MM4022		–	130	–	
	MM4023		–	180	–	
FUNCTIONAL TEST						
Power Output (Figure 1)		P_{out}				Watts
(P_{in} = 0.25 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4020		3.5	–	–	
(P_{in} = 3.0 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4021		15	–	–	
(P_{in} = 7.0 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4022		25	–	–	
(P_{in} = 14 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4023		40	–	–	
Collector Efficiency (Figure 1)		η				%
(P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4020		50	–	–	
(P_{out} = 15 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4021		55	–	–	
(P_{out} = 25 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4022		60	–	–	
(P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4023		50	–	–	

FIGURE 1 – 175 MHz TEST CIRCUIT



MM4020
C1,C2,C5,C6 5.0-80 pF, ARCO 462 or equivalent
C3 7.0 pF
C4 7.0 pF
L1 25 nH, 1 Turn #18 AWG, 1/4" Length, 1/4" I.D.
L2 Ferrite Choke VK-200 Ferroxcube.
L3 150 nH, 8 Turns #18 AWG, 3/4" Length, 3/16" I.D.
L4 36 nH, 1-1/2 Turns, #18 AWG, 1/4" Length, 1/4" I.D.
R1 330 Ohms

MM4021
C1,C2,C5,C6 9.0-180 pF, ARCO 463 or equivalent
C3 120 pF
C4 40 pF
L1 18 nH, 1-1/4" Straight #16 AWG
L2 Ferrite Choke VK-200 Ferroxcube.
L3 150 nH, 8 Turns #18 AWG, 3/4" Length, 3/16" I.D.
L4 25 nH, 1 Turn, #18 AWG, 14" Length, 1/4" I.D.
R1 330 Ohms

MM4022, MM4023
C1,C2,C5,C6 5.0-80 pF, ARCO 462 or equivalent
C3 100 pF
C4 100 pF
L1 18 nH, 1-1/4" Straight #16 AWG
L2 Ferrite Choke VK-200, Ferroxcube.
L3 150 nH, 8 Turns #18 AWG, 3/4" Length, 3/16" I.D.
L4 25 nH, 1 Turn #18 AWG, 1/4" Length, 1/4" I.D.
R1 330 Ohms

TYPICAL PERFORMANCE DATA

POWER OUTPUT versus POWER INPUT

(T_A = 25°C, V_{CC} = 12.5 Vdc, f = 175 MHz)

FIGURE 2 – MM4020

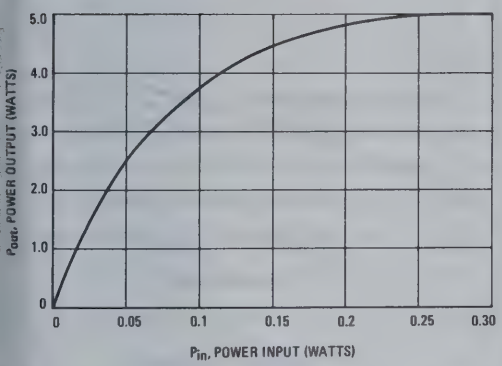


FIGURE 3 – MM4021

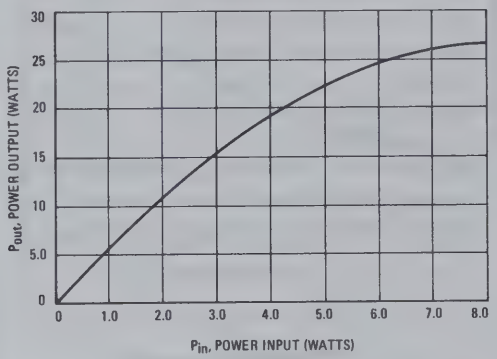


FIGURE 4 - MM4022

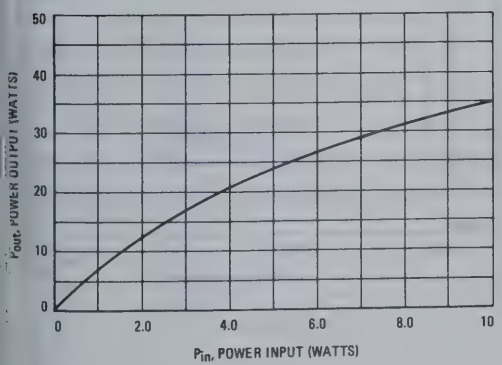
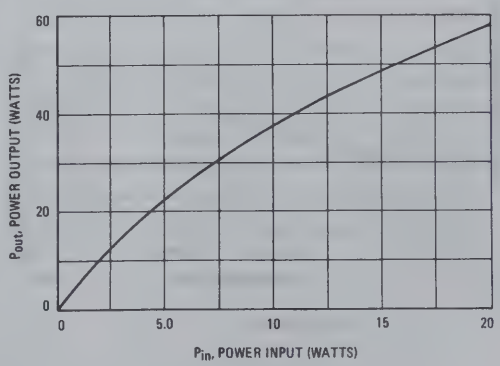


FIGURE 5 – MM4023

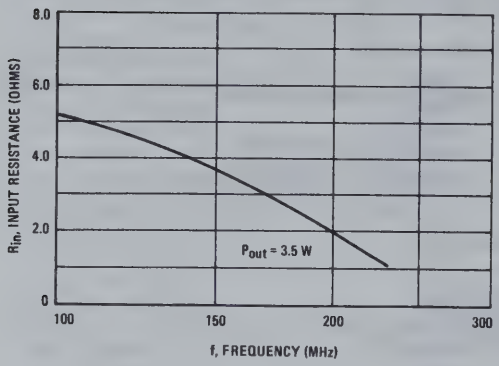


CIRCUIT DESIGN DATA

(T_A = 25°C, V_{CC} = 12.5 Vdc)

PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 6 – MM4020



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 7 – MM4020

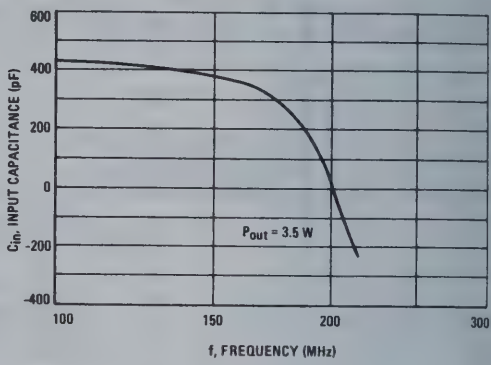


FIGURE 8 – MM4021

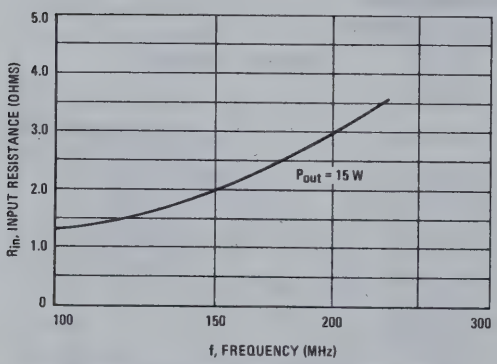


FIGURE 9 – MM4021

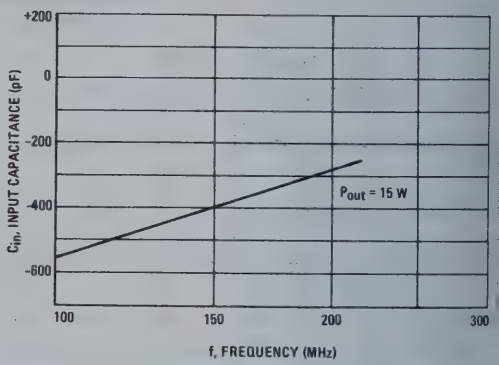


FIGURE 10 – MM4022

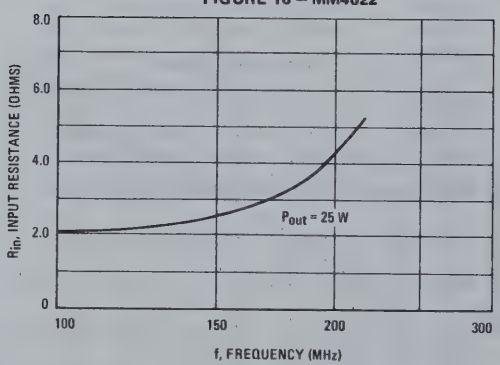
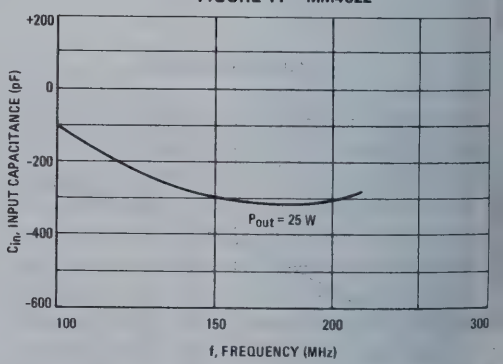


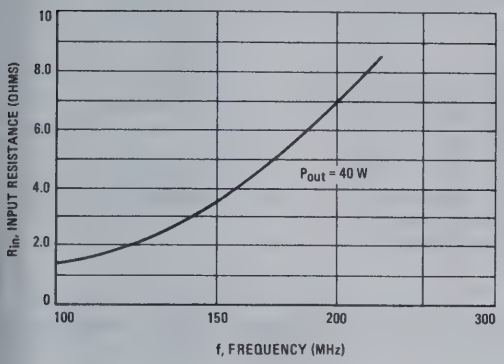
FIGURE 11 – MM4022



CIRCUIT DESIGN DATA

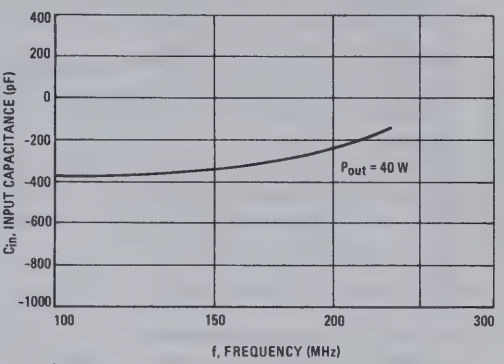
PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 12 – MM4023



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 13 – MM4023



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

(T_A = 25°C, V_{CC} = 12.5 Vdc)

FIGURE 14 – MM4020

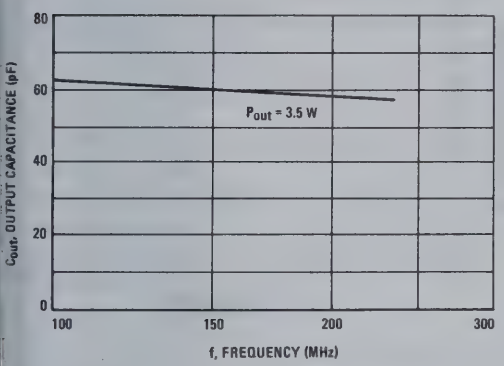


FIGURE 15 – MM4021

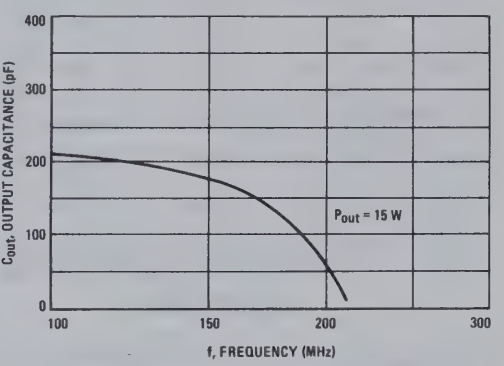


FIGURE 16 – MM4022

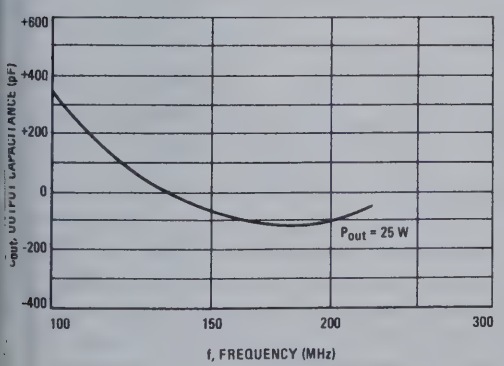
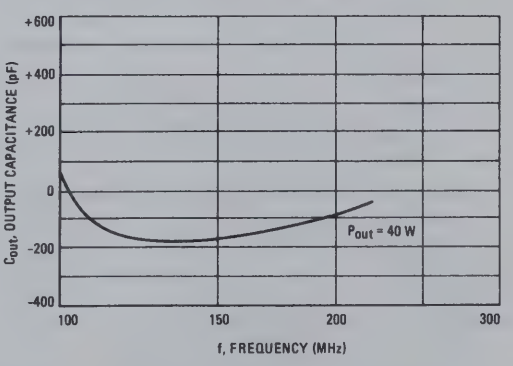


FIGURE 17 – MM4023



TYPICAL POWER SLUMP versus STUD TEMPERATURE

(T_A = 25°C, V_{CC} = 12.5 Vdc, f = 175 MHz)

FIGURE 18 – MM4020

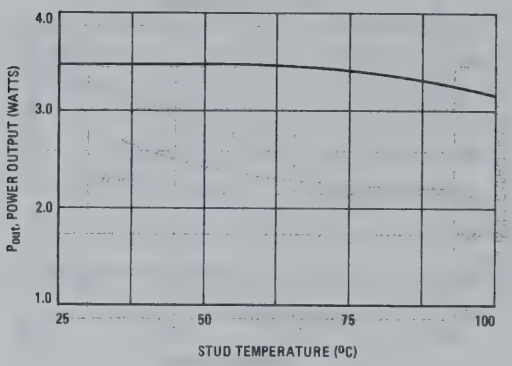


FIGURE 19 – MM4021

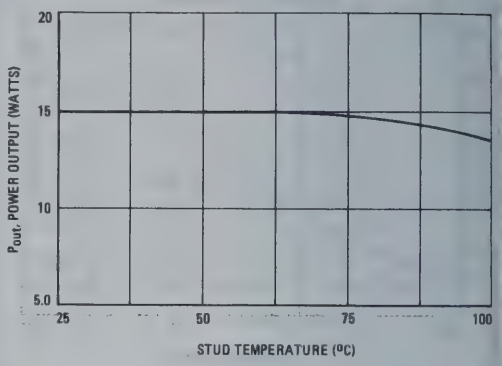


FIGURE 20 – MM4022

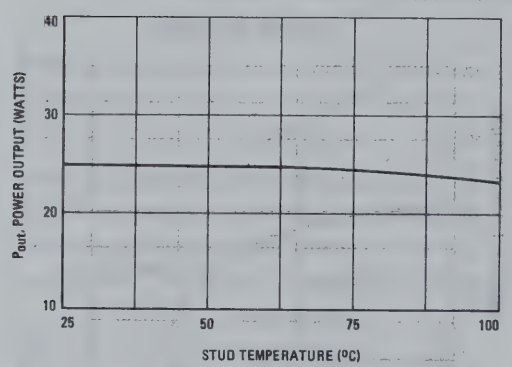
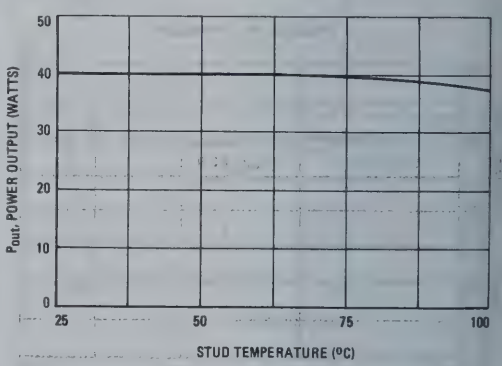


FIGURE 21 – MM4023



MM4048 (SILICON)

PNP silicon annular transistor designed for low frequency, low noise, low level amplifier applications.



CASE 22
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	45	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	45	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	10	nAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	20	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) (I_C = 500 μAdc, V_{CE} = 5.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 150 150 150	 - 450 -	-
Collector-Emitter Saturation Voltage (I_C = 500 μAdc, I_B = 50 μAdc)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter On Voltage (I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	-	0.8	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	100	500	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	-	8.0	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 10 Hz) (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 100 Hz) (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz) (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 10 kHz) (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 10 Hz to 15.7 Hz)	NF	 - - - - -	 6.0 3.0 2.0 1.0 3.0	dB

MM4049 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for use as a high-frequency current mode switch. Because of the extremely high Current-Gain–Bandwidth this transistor also makes an excellent RF amplifier and oscillator.

- High Current-Gain–Bandwidth Product –
  f_T = 4.0 GHz (Min) @ I_C = 12 mAdc
- Low Output Capacitance –
  C_{ob} = 0.8 pF (Typ) @ V_{CB} = 5.0 Vdc

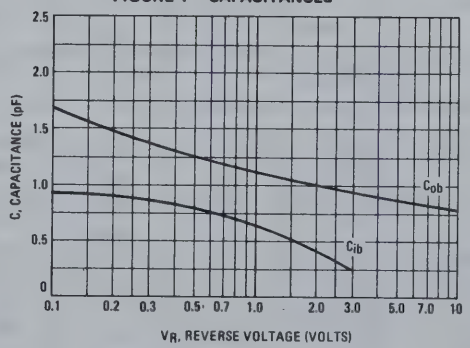
PNP SILICON SWITCHING TRANSISTOR

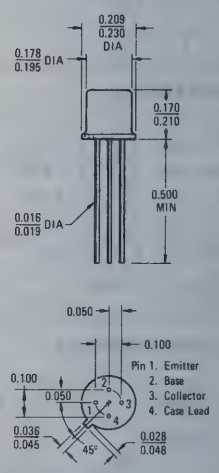


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current – Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

FIGURE 1 – CAPACITANCES





CASE 20 (10)
TO–72

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	BV_{CEO}	10	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.5	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 25 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	20	80	–
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (Figure 2) (I_C = 20 mAdc, V_{CE} = 5.0 Vdc, f = 500 MHz)	f_T	4.0	–	GHz
Output Capacitance (Figure 1) (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	1.25	pF
Input Capacitance (Figure 1) (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	1.25	pF
Collector-Base Time Constant (Figure 3) (I_E = 15 mAdc, V_{CB} = 5.0 Vdc, f = 63.6 Hz)	$r_b'C_c$	–	15	ps

FIGURE 2 – CURRENT-GAIN–BANDWIDTH PRODUCT

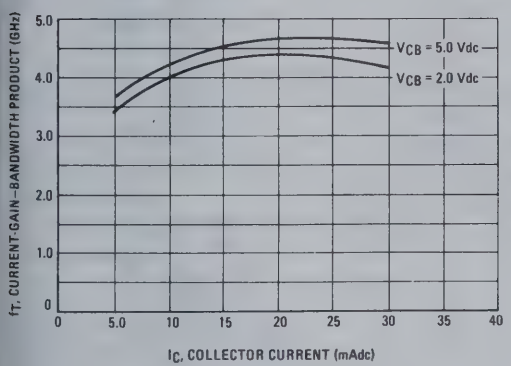
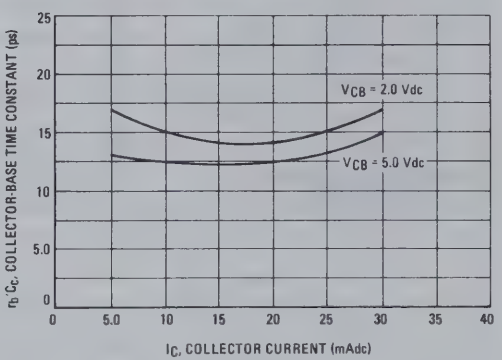


FIGURE 3 – COLLECTOR-BASE TIME CONSTANT



MM4052 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for bilateral switching and high-level chopper applications such as servo-loop circuitry and control amplifiers for motor drive systems. These transistors can also be used as replacement devices for alloy-type transistors where high BV_{EBO} is required.

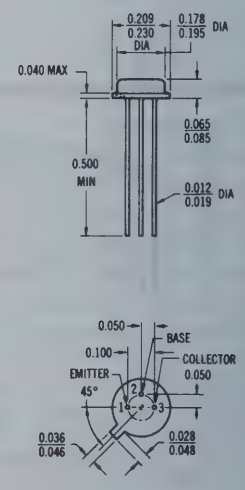
- High Emitter–Base Breakdown Voltage –
  BV_{EBO} = 30 Vdc (Min) @ I_E = 100 μAdc
- Inverted DC Current Gain – 3.0 (Min) @ I_C = 150 mAdc
- Low Emitter-Collector Offset Voltage –
  $V_{EC(ofs)}$ = 2.0 mVdc (Max) @ I_B = 1.0 mAdc
- Low "ON" Series Resistance –
  $r_{ec(ON)}$ = 2.0 Ohms (Max) @ I_B = 10 mAdc

PNP SILICON CHOPPER AND SWITCHING TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Collector Voltage	V_{EC}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.8	Watt mW/°C
Total Device Dissipation @ T_C = 25 C Derate above 25 C	P_D	1.75 10	Watts mW/ C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



CASE 26
TO-46 PACKAGE

ELECTRICAL CHARACTERISTICS (T_A = 25° C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	30	–	Vdc
Emitter-Collector Breakdown Voltage* (I_E = 10 mAdc, I_B = 0)	BV_{ECO}*	30	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	30	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.5	nAdc
Emitter Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)	I_{EBO}	–	0.5	nAdc
ON CHARACTERISTICS				
DC Current Gain*	h_{FE}*			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		20	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		15	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (Inverted)		3.0	–	
Offset Voltage (I_B = 1.0 mAdc, I_E = 0)	$V_{EC(ofs)}$	–	2.0	mVdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{ob}	–	10	pF
Input Capacitance (V_{EB} = 10 Vdc, I_C = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{ib}	–	5.0	pF
Small-Signal Current Gain	h_{fe}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 kHz)		20	–	–
(I_C = 10 mAdc, V_{CE} - 1.0 Vdc, f = 4.0 MHz)		3.0	–	–
"ON" Series Resistance (I_B = 10 mAdc, f = 1.0 kHz)	$r_{ec(ON)}$	–	2.0	Ohms

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 20%



MM4261H (SILICON)

High Reliability Products

PNP SILICON ANNULAR TRANSISTOR

. . . designed for high reliability, low-level switching applications and general usage for radiation resistant requirements.

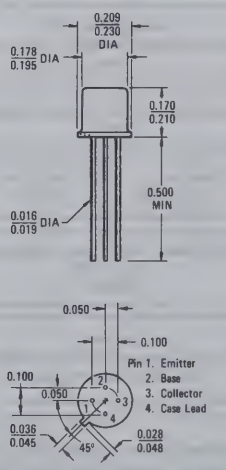
- Off-the-Shelf Availability of Extensive High Reliability Processing
- High Tolerance to Neutron Radiation @ I_C = 10 mA, h_{FE} Degradation Typically Less Than 50% after 5 x 10^{14} Neutrons/cm^2 (Figure 13)
- High Current-Gain—Bandwidth Product — f_T = 3500 MHz (Typ) @ I_C = 10 mA
- Low Input and Output Capacitance — C_{ib} and C_{ob} = 2.5 pF (Max)
- Excellent Current-Mode Performance — t_r = 0.5 ns (Typ) @ I_C = 10 mA
  1.1 ns (Typ) @ I_C = 30 mA

PNP SILICON SWITCHING TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current — Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



CASE 20 (10)
TO-72

HIGH RELIABILITY PROCESSING SEQUENCE

The lot is 100% inspected in the sequence shown below

↓

INTERNAL VISUAL INSPECTION
Note 1

SCREEN ELECTRICAL PARAMETERS
Table I
G,R

HIGH TEMPERATURE STORAGE
$T_A \geq 200^{o}C$, $t \geq 24$ hours

TEMPERATURE CYCLING
MIL-STD-202, Method 102, Condition C
10 cycles, t (extreme) ≥15 minutes

CONSTANT ACCELERATION
MIL-STD-750, Method 2006
Y1 axis 20,000 G

FINE LEAK
MIL-STD-202, Method 112, Procedure IIIa
Condition C, P = 50 psig, t = 4 hours
Leak rate $\leq 1 \times 10^{-8}$ atm. cc/sec
R

GROSS LEAK
MIL-STD-202, Method 112, Condition A
Ethylene Glycol, $T = 100^{o}C$, t ≥15 sec.
R

MARK DEVICES
Motorola Symbol, MM4261H, seal date code

ELECTRICAL TEST Table II (initial)
RR,R

BURN-IN $T_A = 25^{o}C$, t = 168 hours
$P_D = 200$ mW, $V_{CB} \leq 5.0$ V

ELECTRICAL TEST Table II (end points)
$P_{DA} = 10$
RR,R

Option 1
Burn-In Data with Delta Calculations
(see Option Data Provisions)

Samples are randomly selected from the lot for Group A, Group B, and Group C inspection. Sample size for each Subgroup shall be determined from Sampling Plan Table and shall meet the specified LTPD or lambda requirements.

NOTE 1: Internal Visual Inspection

Each device will be inspected under magnification for defects in material and workmanship which do not comply with Motorola's visual inspection procedures.

GROUP A INSPECTION

SAMPLE INSPECT ELECTRICAL PARAMETERS per TABLE I
summary data provided

SUBGROUP 1
LTPD = 5

VISUAL and MECHANICAL
MIL-STD-750
Method 2071
R

SUBGROUP 2
LTPD = 2

ELECTRICAL TEST
Table I
G,R

SUBGROUP 3
LTPD = 3

ELECTRICAL TEST
Table I
G,R

SUBGROUP 4
LTPD = 5

ELECTRICAL TEST
Table I
G,R

SUBGROUP 5
LTPD = 5

ELECTRICAL TEST
Table I
G,R

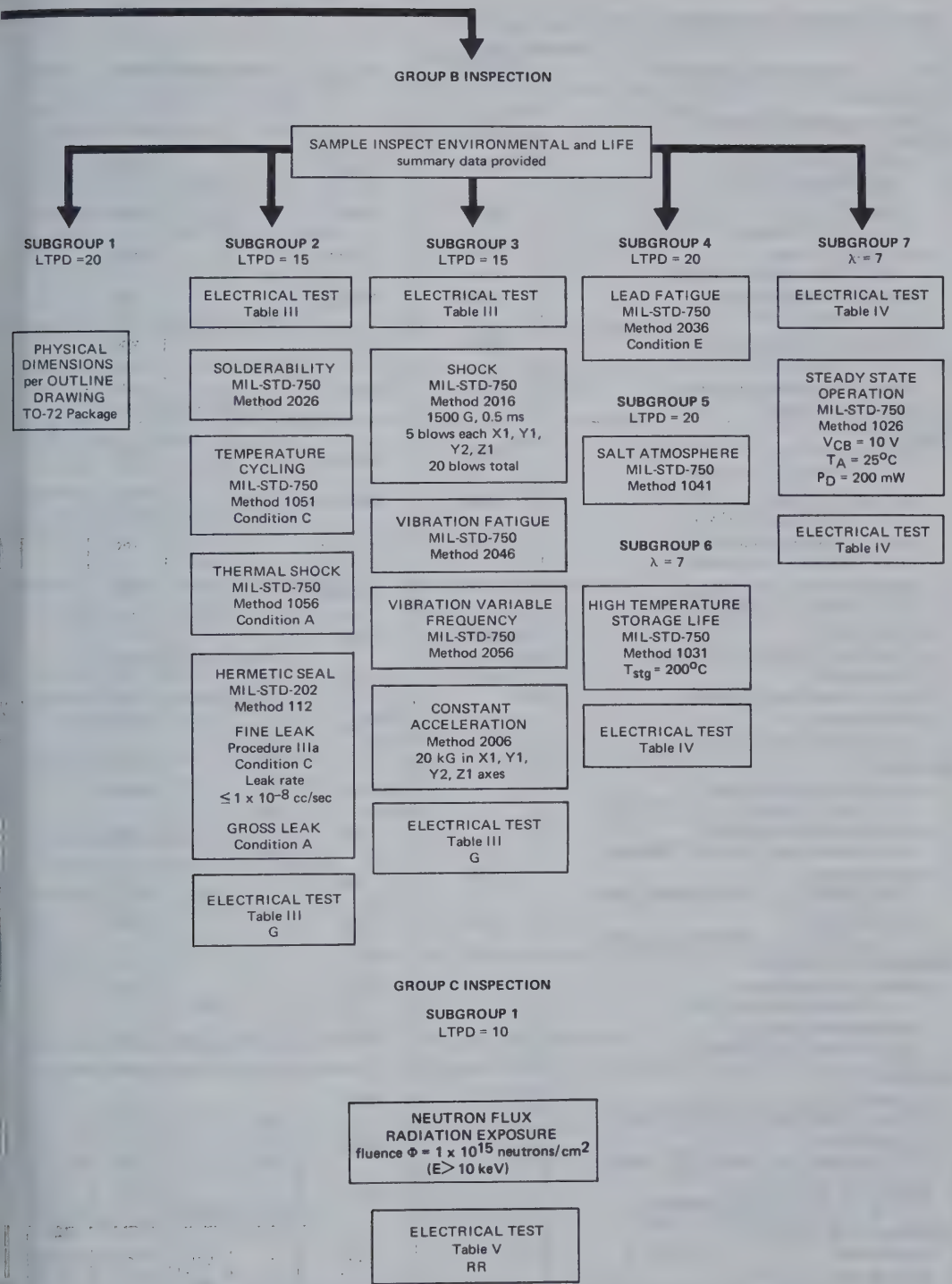
SUBGROUP 6
LTPD = 7

ELECTRICAL TEST
Table I
G,R

SUBGROUP 7
LTPD = 7

ELECTRICAL TEST
Table I
G,R

R — Remove Rejects
G — Go-No-Go
RR — Read and Record



– Go-No-Go

R – Read and Record

TABLE I: GROUP A INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit	LTPD
SUBGROUP 1						
Visual and Mechanical Examination	2071	–	–	–	–	5
SUBGROUP 2						2
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036D	I_{CBO1}	–	5.0	nAdc	
Collector-Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	3041A	I_{CEX1}	–	5.0	nAdc	
Collector-Cutoff Current (V_{CE} = 10 Vdc, $V_{EB(on)}$ = 0.4 Vdc)	3041A	I_{CEX2}	–	50	nAdc	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	3026D	BV_{EBO}	4.5	–	Vdc	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	3001D	BV_{CBO}	15	–	Vdc	
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	3011D	BV_{CEO}*	15	–	Vdc	
SUBGROUP 3						3
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	3066B	$V_{BE(on)1}$	–	0.8	Vdc	
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3066B	$V_{BE(on)2}$	–	1.0	Vdc	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)	3071	$V_{CE(sat)1}$	–	0.15	Vdc	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	3071	$V_{CE(sat)2}$	–	0.35	Vdc	
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE1}	25	–	–	
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}	30	150	–	
DC Current Gain (I_C = 30 mAdc, V_{CE} = 2.0 Vdc)	3076	h_{FE3}	20	–	–	
SUBGROUP 4						5
Current-Gain–Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)		f_{T1}	1500	–	MHz	
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_{T2}	2000	–	MHz	
Output Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, 100 kHz ≤ f ≤ 1.0 MHz)	3236	C_{ob}	–	2.5	pF	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, 100 kHz ≤ f ≤ 1.0 MHz)	3240	C_{ib}	–	2.5	pF	
SUBGROUP 5 (See Figure 1)						5
Collector-Base Time Constant (I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc)		$r_b'C_{c1}$	–	60	ps	
Collector-Base Time Constant (I_C = 10 mAdc, V_{CE} = 10 Vdc)		$r_b'C_{c2}$	–	50	ps	
SUBGROUP 6						7
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc, T_A = –55°C)		h_{FE4}	15	–	–	
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = –55°C)		h_{FE5}	15	–	–	
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)		I_{CBO2}	–	5.0	μAdc	
SUBGROUP 7 (See Figure 2)						7
Turn-On Time		t_{on}	–	5.0	ns	
Turn-Off Time		t_{off}	–	5.0	ns	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TABLE II: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036D	I_{CBO1}	–	5.0	nAdc
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}*	30	150	–
Collector-Base Cutoff Current 100% or 5.0 nAdc whichever is greater		ΔI_{CBO1}	–	–	–
DC Current Gain		Δh_{FE2}	–	±20%	–

TABLE III: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036D	I_{CBO1}	–	5.0	nAdc
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}*	30	150	–

TABLE IV: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

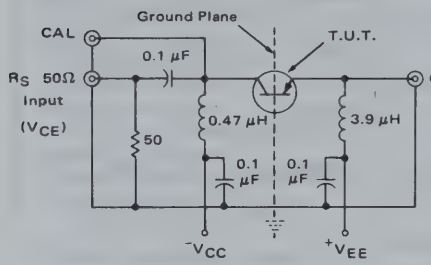
Examination or Test		MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	Initial	3036D	I_{CBO1}	–	5.0	nAdc
	End Point			–	10	
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	Initial	3076	h_{FE2}*	30	150	–
	End Point			20	180	
Collector-Base Cutoff Current 100% or 5.0 nAdc whichever is greater			ΔI_{CBO1}	–	–	–
DC Current Gain			Δh_{FE2}		±20%	–

TABLE V: ELECTRICAL INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	3036D	I_{CBO1}	–	10	μAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	3071	$V_{CE(sat)2}$*	–	0.5	Vdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	3076	h_{FE2}*	12	–	–

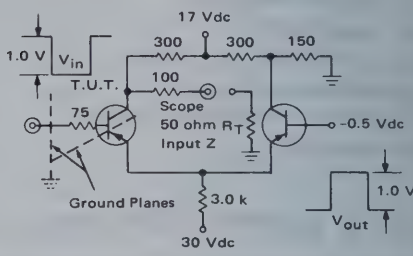
*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – COLLECTOR-BASE TIME CONSTANT TEST CIRCUIT



1. With transistor under test removed from socket, set input level at "CAL" jack to 500 mV at 31.8 MHz. Insert transistor in socket.
2. After putting VTVM probe on "OUT" jack, adjust bias on transistor under test.
3. Reading on VTVB in millivolts multiplied by 10 equals $r_b'C_c$

FIGURE 2 – TURN-ON TIME AND TURN-OFF TIME TEST CIRCUIT



The test circuit is designed to simulate a series of cascaded identic circuits with input Z equal to output Z.

FIGURE 3 – DC CURRENT GAIN

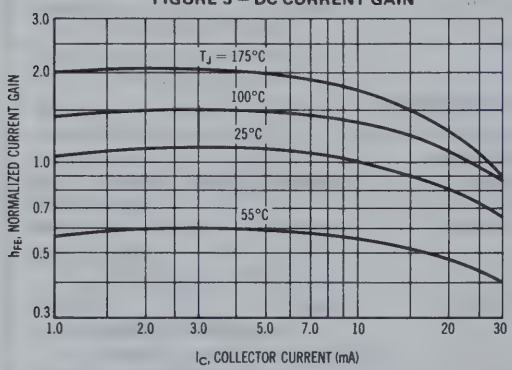


FIGURE 4 – COLLECTOR SATURATION REGION

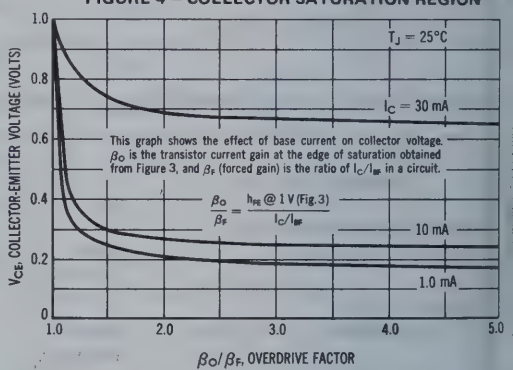


FIGURE 5 – "ON" VOLTAGES

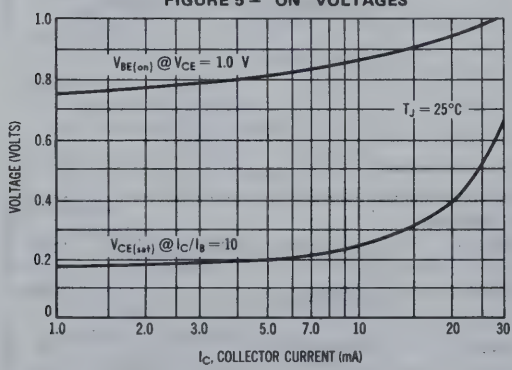


FIGURE 6 – TEMPERATURE COEFFICIENTS

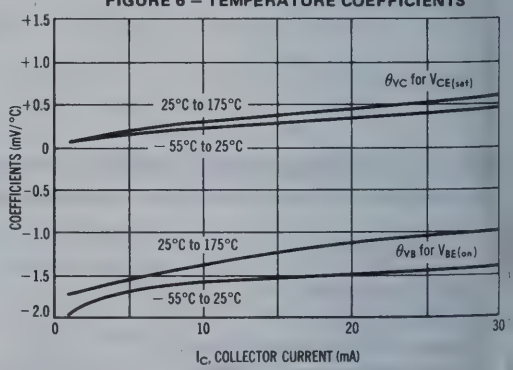


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

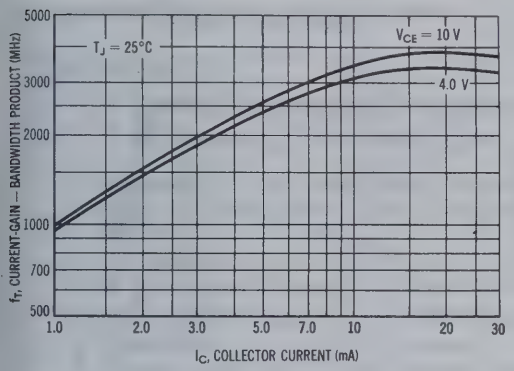


FIGURE 8 – COLLECTOR-BASE TIME CONSTANT

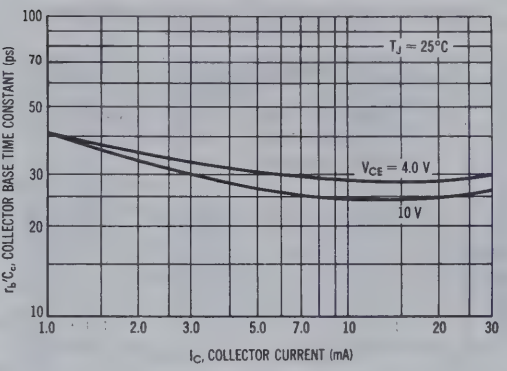


FIGURE 9 – CAPACITANCE

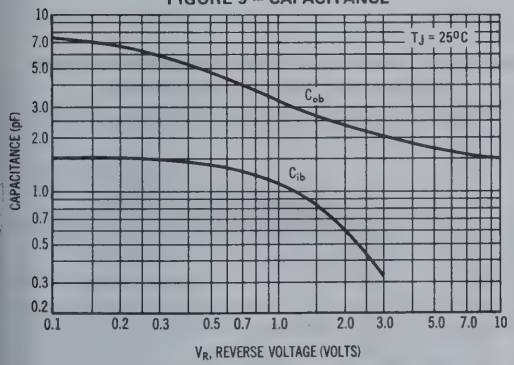


FIGURE 10 – SWITCHING TIMES

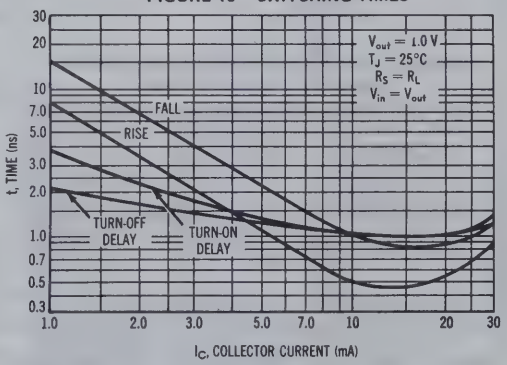
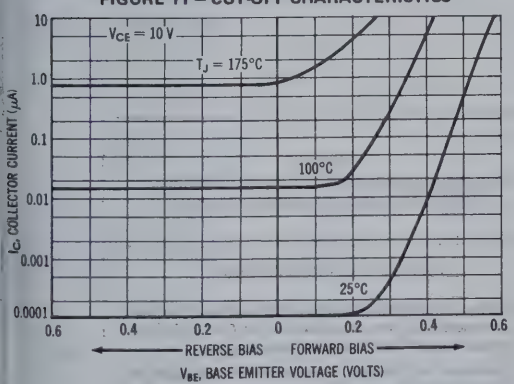


FIGURE 11 – CUT-OFF CHARACTERISTICS



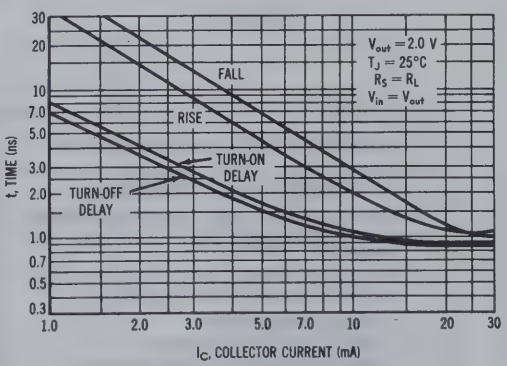


FIGURE 12 – NORMALIZED DC CURRENT GAIN versus FAST NEUTRON DOSAGE

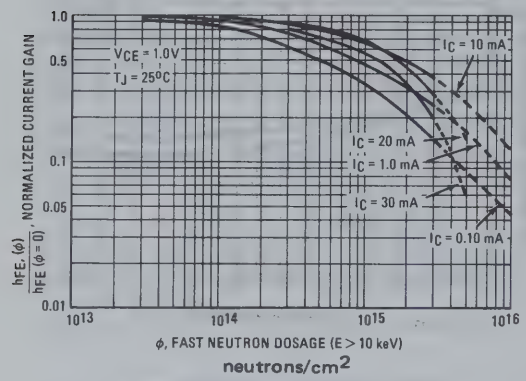


FIGURE 13 – TYPICAL DC CURRENT GAIN versus FAST NEUTRON DOSAGE

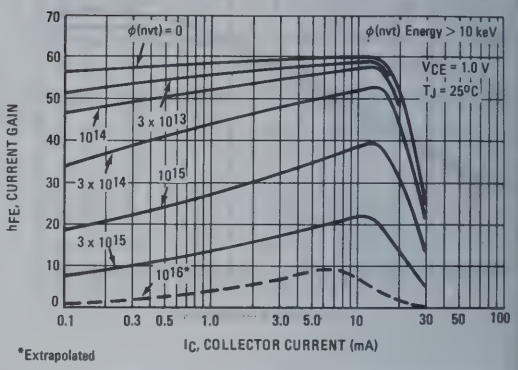


FIGURE 14 – COLLECTOR-BASE LEAKAGE CURRENT versus FAST NEUTRON DOSAGE

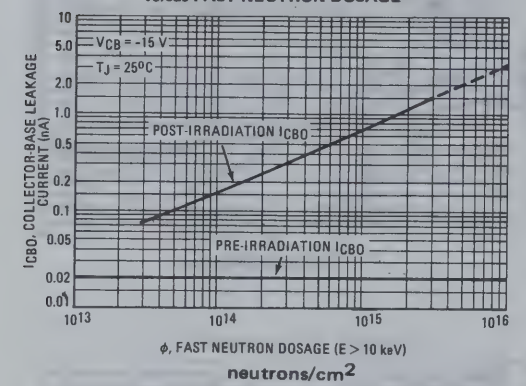
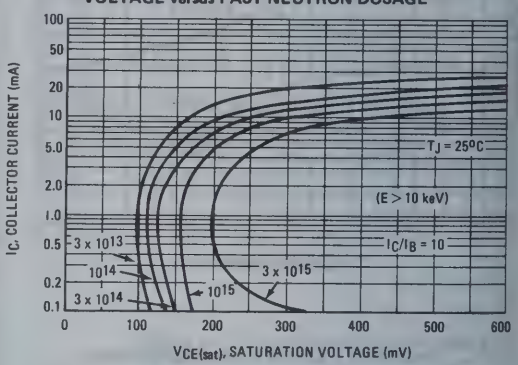


FIGURE 15 – TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGE versus FAST NEUTRON DOSAGE



Devices Stocked in Motorola Bonded Warehouse	Option 2 100% Radiographic Inspection per MIL-STD-202, Method 209 (see Option Data Provisions)
STANDARD DATA PROVISIONS 1. Motorola will keep on file 1 copy of all associated data for a minimum of 3 years from date of purchase order. 2. One copy of Summary data shall accompany each shipment of devices from following steps. a. Burn-In Test per Table II b. Group A Inspection per Table I c. Group B Inspection per Tables III and IV d. Group C Inspection per Table V Foam Tray Packaging per MIL-S-19491	OPTION DATA PROVISIONS 1. Motorola will provide burn-in delta data on control parameters for the lot as well as for Group B, Subgroup 6 and 7, and Group C, Subgroup 1. 2. Motorola will X-ray the serialized devices prior to shipping and provide films only if this is required by purchase order.

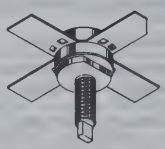
MM4429 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed primarily for use in large signal VHF, UHF and microwave frequency amplifier output stages in military and industrial communications applications.

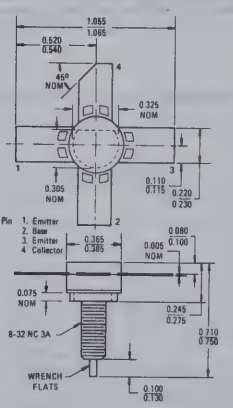
- High Power Output – P_{out} = 1.0 W with 5.2 dB Gain @ f = 1.0 GHz
- Multiple Emitter Construction for Excellent High Frequency Performance
- Low Profile Ceramic Stripline Package for Low Lead Inductance and Ease in Design

NPN SILICON RF POWER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current — Continuous	I_C	250	mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	5.0 28.6	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC



CASE 145A-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	35	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	BV_{CBO}	55	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	–	1.0	mAdc
Collector Cutoff Current (V_{CB} = 55 Vdc, I_E = 0)	I_{CBO}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)	h_{FE}	20	–	200	–
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	–	0.25	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	600	800	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.9	3.5	pF
FUNCTIONAL TEST					
Power Output (Figure 1) (P_{in} = 300 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	P_{out}	1.0	1.3	–	Watt
Collector Efficiency (P_{out} = 1.0 W, V_{CE} = 28 Vdc, f = 1.0 GHz)	η	–	45	–	%

FIGURE 1 – 1.0 GHz TEST SET UP

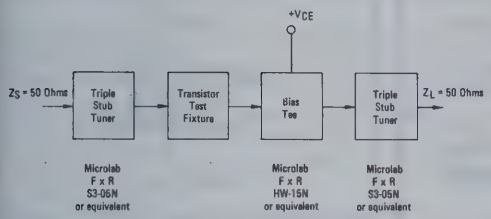


FIGURE 2 – CURRENT-GAIN–BANDWIDTH PRODUCT

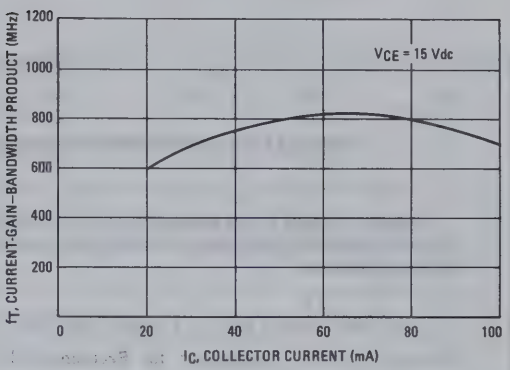


FIGURE 3 – OUTPUT CAPACITANCE versus VOLTAGE

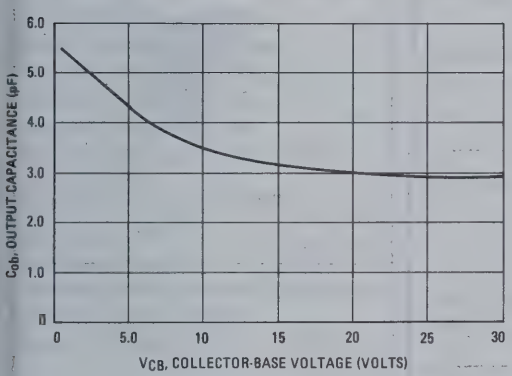


FIGURE 4 – POWER OUTPUT versus VOLTAGE

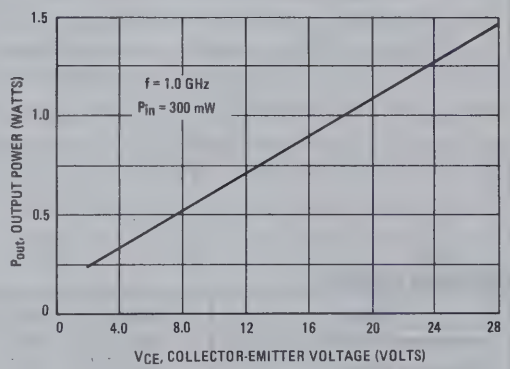


FIGURE 5 – POWER OUTPUT versus POWER INPUT

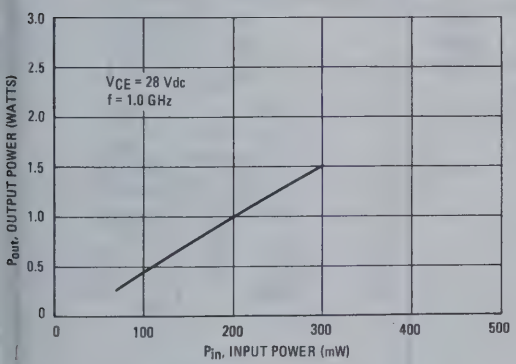
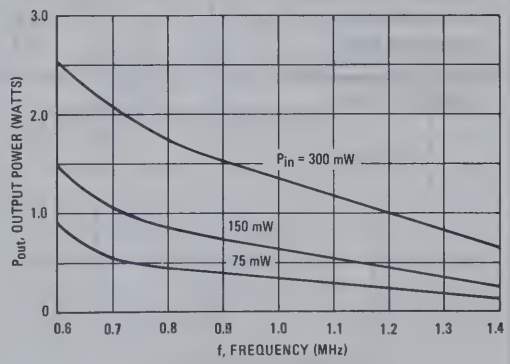


FIGURE 6 – POWER OUTPUT versus FREQUENCY



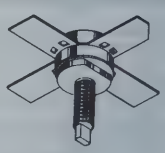
MM4430 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed primarily for use in large signal VHF, UHF and microwave frequency amplifier output stages in military and industrial communications applications.

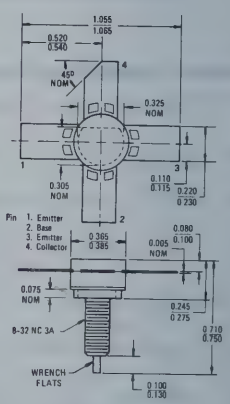
- High Power Output — P_{out} = 2.5 W with 5 dB Gain @ f = 1.0 GHz
- Multiple Emitter Construction for Excellent High Frequency Performance
- Low Profile Ceramic Stripline Package for Low Lead Inductance and Ease in Design

NPN SILICON RF POWER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current — Continuous	I_C	250	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



CASE 145A-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	35	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	BV_{CBO}	55	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	–	1.0	mAdc
Collector Cutoff Current (V_{CB} = 55 Vdc, I_E = 0)	I_{CBO}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)	h_{FE}	20	–	200	–
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	–	0.25	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	600	–	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.8	3.5	pF
FUNCTIONAL TEST					
Power Output (Figure 1) (P_{in} = 750 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	P_{out}	2.5	2.8	–	Watt
Collector Efficiency (Figure 1) (P_{out} = 2.5 W, V_{CE} = 28 Vdc, f = 1.0 GHz)	η	–	45	–	%

FIGURE 1 – 1.0 GHz TEST SET UP

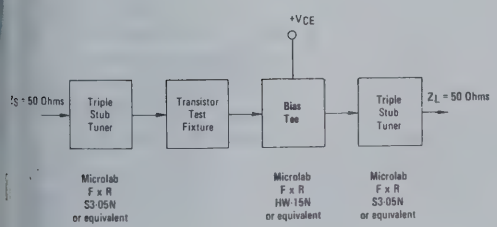


FIGURE 2 – CURRENT-GAIN–BANDWIDTH PRODUCT

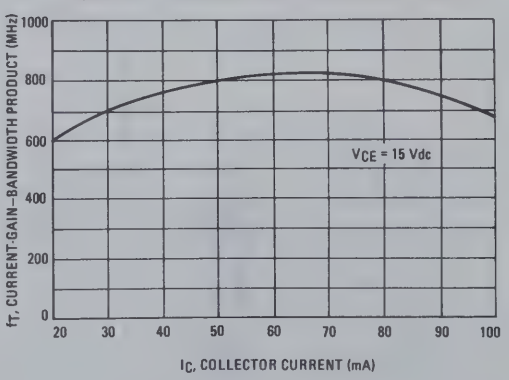


FIGURE 3 – OUTPUT CAPACITANCE versus VOLTAGE

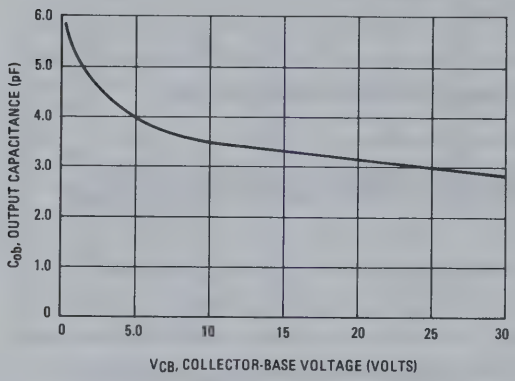


FIGURE 4 – POWER OUTPUT versus VOLTAGE

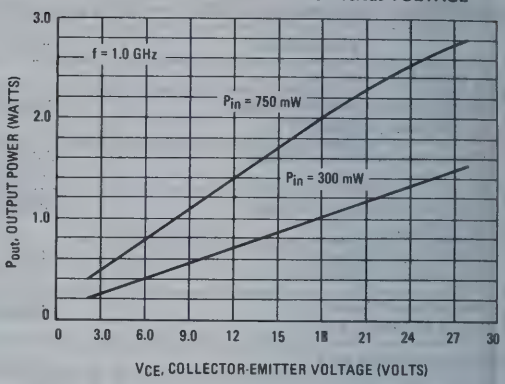


FIGURE 5 – POWER OUTPUT versus POWER INPUT

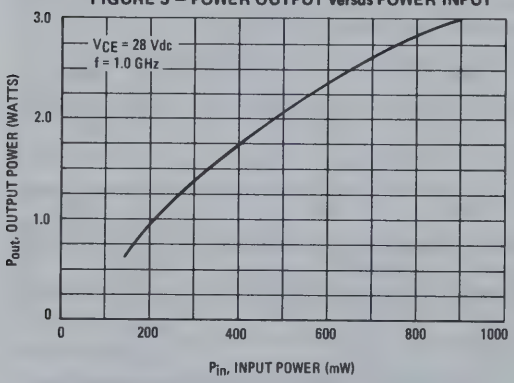
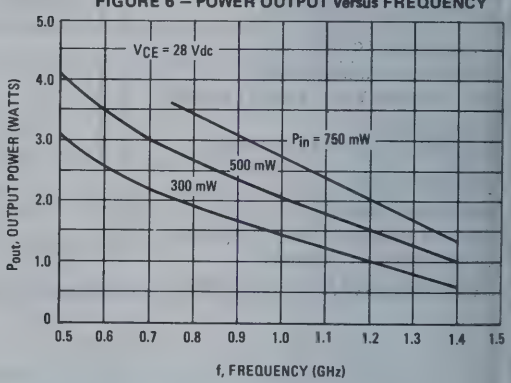


FIGURE 6 – POWER OUTPUT versus FREQUENCY



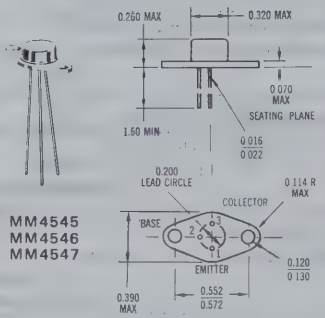
MM4545, MM4546, (SILICON)
MM4547
MM4645, MM4646,
MM4647

PNP SILICON ANNULAR TRANSISTORS

. . . designed for high-voltage amplifier and saturated switching applications at collector currents to one Ampere. Ideally suited for applications of dc-to-dc converters, relay and hammer drivers, motor controls, and servo and pulse amplifiers. High-voltage ratings permit direct-line operation.

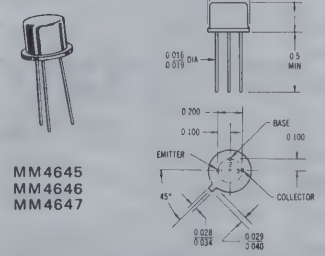
- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 200, 300 and 400 Vdc (Min)
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)} = \leq 1.5$ Vdc (Max) @ I_C = 500 mAdc
- DC Current Gain Specified — 10 mAdc to 500 mAdc

PNP SILICON GENERAL-PURPOSE TRANSISTORS



MM4545
MM4546
MM4547

Collector Connected to Case
CASE 39
TO-37



MM4645
MM4646
MM4647

Collector Connected to Case
CASE 79
TO-39

MAXIMUM RATINGS

Rating	Symbol	MM4545 MM4645	MM4546 MM4646	MM4547 MM4647	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	400	Vdc
Collector-Base Voltage	V_{CB}	200	300	400	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous	I_C	2.5			Adc
Total Device Dissipation @ $T_C = 25^oC$ MM4545,MM4546,MM4547 MM4645,MM4646,MM4647	P_D	25 5.0			Watts
Derate above 25^oC MM4545,MM4546,MM4547 MM4645,MM4646,MM4647		143 28.6			mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200			^oC

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MM4545,MM4645	BV_{CEO}*	200	–	–	Vdc
	MM4546,MM4646		300	–	–	
	MM4547,MM4647		400	–	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM4545,MM4645	BV_{CBO}	200	–	–	Vdc
	MM4546,MM4646		300	–	–	
	MM4547,MM4647		400	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 200 Vdc, $V_{BE(off)}$ = 0.5 Vdc)		I_{CEX}	–	–	10	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	–	–	–
(I_C = 100 mAdc, V_{CE} = 10 Vdc)*			25	–	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)*			20	–	–	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_J = 100 mAdc)	MM4545,MM4645	$V_{CE(sat)}$	–	0.5	1.0	Vdc
	MM4546,MM4646		–	0.6	1.2	
	MM4547,MM4647		–	0.75	1.5	
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 70 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	MM4545,MM4546,MM4645,MM4646	f_T	40	–	–	MHz
	MM4547,MM4647		30	–	–	
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	MM4545,MM4645	C_{ob}	–	–	80	pF
	MM4546,MM4547,MM4646,MM4647		–	–	60	
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc,	t_d	–	30	–	ns
Rise Time	I_{B1} = 50 mAdc)	t_r	–	50	–	ns
Storage Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc,	t_s	–	400	–	ns
Fall Time	I_{B1} = I_{B2} = 50 mAdc)	t_f	–	60	–	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ACTIVE-REGION SAFE OPERATING AREA

FIGURE 1 – MM4545, MM4546, MM4547

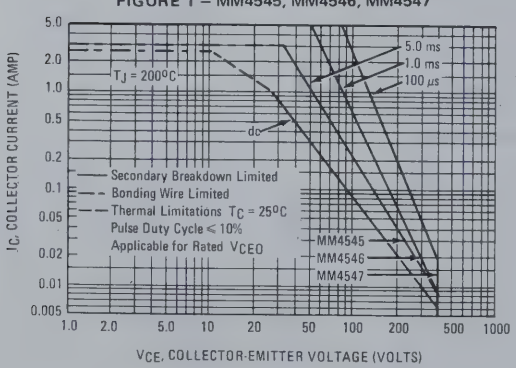
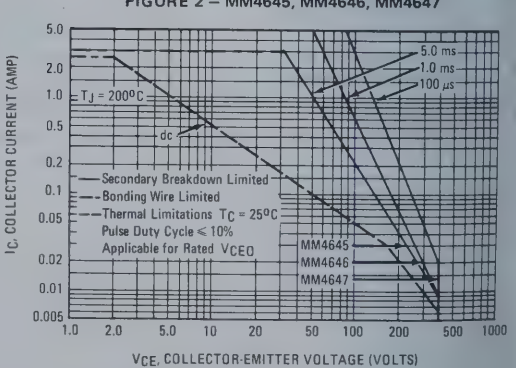


FIGURE 2 – MM4645, MM4646, MM4647



MM5000 (GERMANIUM)
MM5001
MM5002



PNP germanium high frequency transistors designed for use in low-noise, high-gain VHF/UHF amplifiers.

CASE 20
(TO-72)

Active Elements Isolated From Case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	0.3	Vdc
Collector Current	I_C	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2.0	mW mW/°C
Operating & Storage Junction Temperature	T_J, T_{stg}	-65 to +100	°C

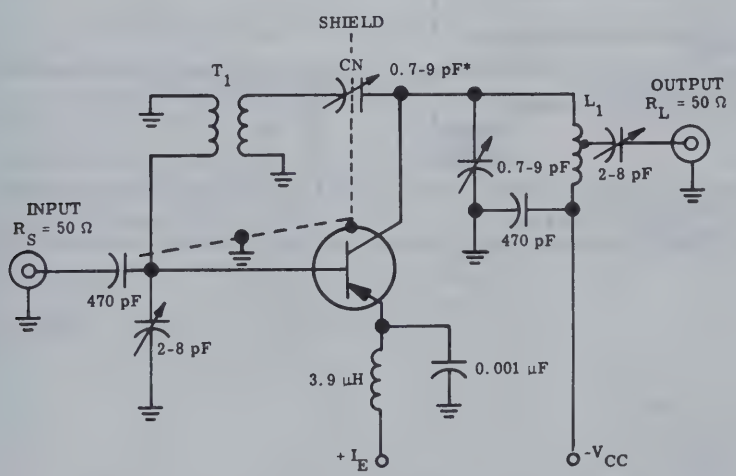


FIGURE 1 — TEST CIRCUIT FOR POWER GAIN AND NOISE FIGURE

NOTES:

L_1 1/4 in. ID, 1/2 in. long, 4 turns #20 solid copper wire, center tapped.

T_1 1/4 in. ID, close wound, 3 turns #26 solid copper wire, 1:1 ratio bi-filler wound.

* High Quality piston type capacitor.

Distance from emitter of transistor to ground side of bypass capacitor should be kept minimal.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	Units
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)	BV_{CEO}	15	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 µAdc, I_E = 0)	BV_{CBO}	30	-	-	Vdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 12 Vdc)	h_{FE}	30	-	-	-
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 3.0 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	800	-	-	MHz
Collector-Base Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	0.4	0.6	pF
Collector-Base Time Constant (I_E = 3.0 mAdc, V_{CB} = 12 Vdc, f = 31.8 MHz)	$r_b'C_c$				ps
MM5000		-	-	3.5	
MM5001		-	-	5.0	
MM5002		-	-	7.5	
Noise Figure (Figure 1) (I_C = 3.0 mAdc, V_{CE} = 12 Vdc, R_S = 50 ohms, f = 200 MHz)	NF				dB
MM5000		-	-	1.6	
MM5001		-	-	2.0	
MM5002		-	-	2.2	
Noise Figure (I_C = 3.0 mAdc, V_{CE} = 12 Vdc, R_S = 50 ohms, f = 450 MHz)	NF	-	3.5	-	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (I_C = 3.0 mAdc, V_{CE} = 12 Vdc, f = 200 MHz) (Figure 1)	G_{pe}				dB
MM5000		24	-	-	
MM5001		22	-	-	
MM5002		20	-	-	
Common-Emitter Amplifier Power Gain (I_C = 3.0 mAdc, V_{CE} = 12 Vdc, f = 450 MHz)	G_{pe}	-	16	-	dB

MM5005 (SILICON)
MM5006
MM5007

PNP SILICON ANNULAR TRANSISTORS

. . . designed for high-voltage audio driver amplifier and general purpose switching and oscillator applications.

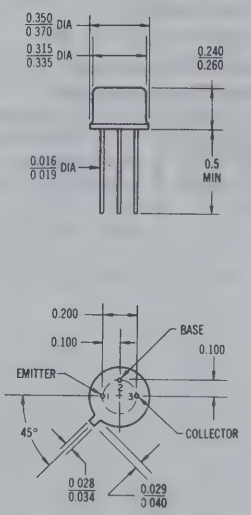
- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 100 Vdc (Min) @ I_C = 10 mAdc (MM5007)
- Low Output Capacitance —
  C_{ob} = 20 pF (Max) @ V_{CB} = 10 Vdc
- Excellent Current Gain Linearity — 1.0 to 250 mAdc
- Complements to NPN MM3005, MM3006, MM3007

PNP SILICON AUDIO TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	MM5005	MM5006	MM5007	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Collector-Base Voltage	V_{CB}	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous	I_C	2.0			Adc
Total Device Dissipation @ T_A = 25°C	P_D	1.5			Watts
Derate above 25°C		8.57			mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	8.0			Watts
Derate above 25°C		45.7			mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200			°C



CASE 79(1)
(TO-39)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MM5005	BV_{CEO}	60	–	Vdc
	MM5006		80	–	
	MM5007		100	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM5005	BV_{CBO}	80	–	Vdc
	MM5006		100	–	
	MM5007		120	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current		I_{CBO}			nAdc
(V_{CB} = 60 Vdc, I_E = 0)	MM5005		–	200	
(V_{CB} = 80 Vdc, I_E = 0)	MM5006		–	200	
(V_{CB} = 100 Vdc, I_E = 0)	MM5007		–	200	
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 2.5 Vdc)	All Types		40	–	
(I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	MM5005		50	250	
(I_C = 200 mAdc, V_{CE} = 2.5 Vdc)	MM5006		50	250	
(I_C = 250 mAdc, V_{CE} = 2.5 Vdc)	MM5007		50	250	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)		$V_{BE(on)}$	0.65	0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	20	pF

MM8000 (SILICON)
MM8001



CASE 79
(TO-39)

NPN silicon high-frequency transistor designed for high-frequency CATV amplifier applications. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

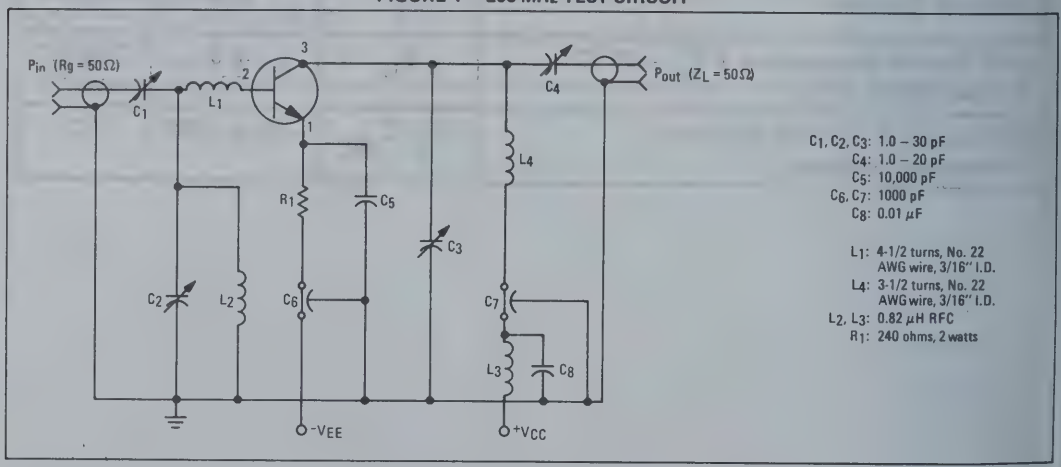
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)		$BV_{CEO(sus)}$	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	3.5	-	-	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)		I_{CEO}	-	-	20	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)		h_{FE}	30	-	-	-
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 25 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000		550	-	-	
	MM8001		700	-	-	
(I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000		700	-	-	
	MM8001		900	-	-	
(I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	MM8000		700	-	-	
	MM8001		900	-	-	
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	-	3.5	pF
Noise Figure Figure 1 Test Circuit (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		NF	-	2.7	-	dB
FUNCTIONAL TESTS						
Common-Emitter Amplifier Power Gain Figure 1 Test Circuit (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		G_{pe}	-	11.4	-	dB

FIGURE 1 – 200 MHz TEST CIRCUIT



MM8002 (SILICON)



CASE 79
(TO-39)

NPN silicon high-frequency transistor designed for high-frequency CATV amplifier applications. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

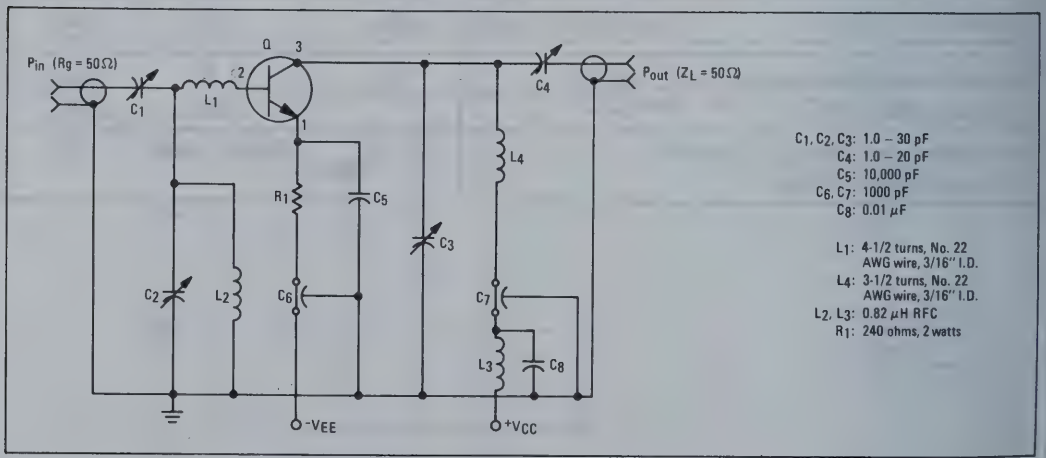
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

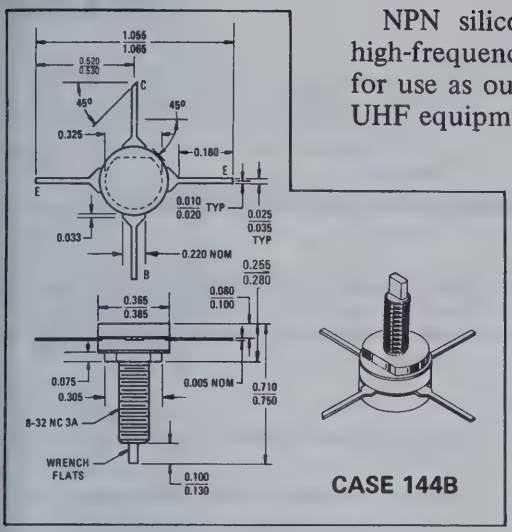
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$BV_{CEO(sus)}$	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.5	-	-	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	-	-	20	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)	h_{FE}	30	-	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product	f_T				MHz
(I_C = 25 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		1000	-	-	
(I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		1200	-	-	
(I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		1000	-	-	
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	-	3.5	pF
Noise Figure Figure 1 Test Circuit (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	NF	-	2.7	-	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain Figure 1 Test Circuit (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	G_{pe}	-	11.4	-	dB

FIGURE 1 – 200 MHz TEST CIRCUIT



MM8003 (SILICON)



CASE 144B

NPN silicon high-frequency transistor designed for high-frequency CATV amplifier applications. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

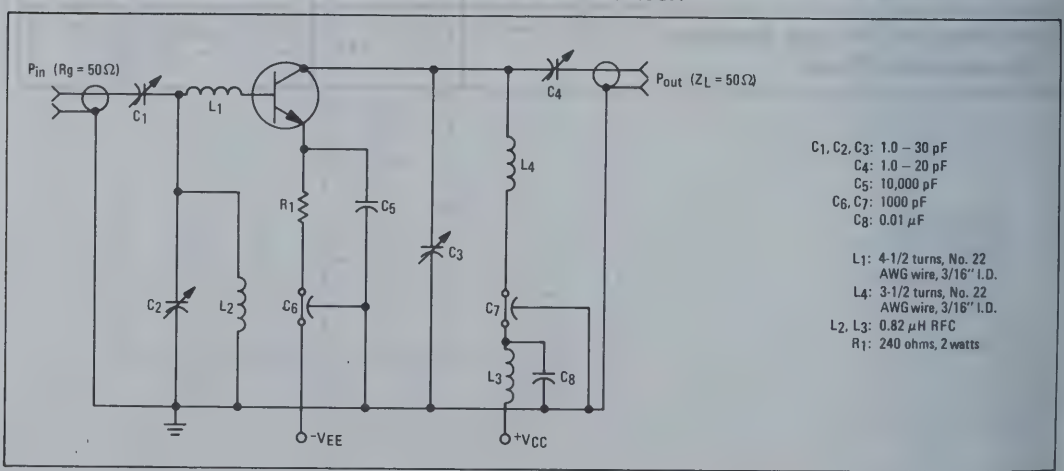
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.5	-	-	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	-	-	20	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 15 Vdc)	h_{FE}	30	-	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 25 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	1000	-	-	MHz
(I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		1200	-	-	
(I_C = 100 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)		1000	-	-	
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	-	4.0	pF
Noise Figure Figure 1 Test Circuit (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	NF	-	2.7	-	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain Figure 1 Test Circuit (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	G_{pe}	-	11.4	-	dB

FIGURE 1 — 200 MHz TEST CIRCUIT



MM8006 (SILICON)
MM8007

NPN SILICON RF SMALL-SIGNAL TRANSISTORS

. . . designed primarily for use in high-gain, low-noise, small-signal amplifiers in military and industrial equipment. Suitable for use in video wideband and general high-frequency amplifier applications of 50 to 1000 MHz.

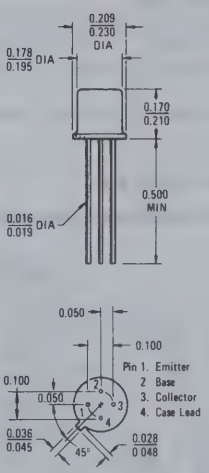
- Low Noise Figure –
  NF = 2.2 dB (Typ) @ f = 200 MHz – MM8006
- High Power Gain –
  G_{pe} = 25 dB (Typ) @ f = 200 MHz – MM8006
- High Current-Gain–Bandwidth Product –
  f_T = 1000 MHz (Min) @ I_C = 5.0 mAdc

NPN SILICON RF SMALL-SIGNAL TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	20	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



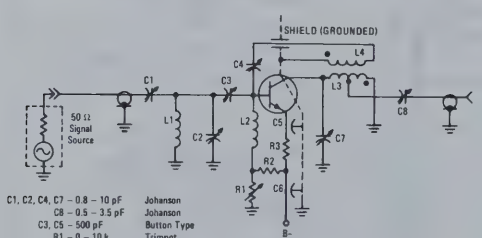
CASE 20 (10)
TO-72 PACKAGE

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	10	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)		BV_{CBO}	15	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E - 0.01 mAdc, I_C = 0)		BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)		I_{CBO}	–	1.0	10	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)		h_{FE}	25	–	–	–
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)		f_T	1000	–	3500	MHz
Collector-Base Capacitance (V_{CE} = 6.0 Vdc, I_E = 0, f = 0.1 MHz)		C_{cb}	–	1.1	1.5	pF
Collector-Base Time Constant (I_C = 10 mAdc, V_{CE} = 6.0 Vdc, f = 31.8 MHz)		$r_b'C_c$	–	5.0	–	ps
Noise Figure		NF				dB
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 60 MHz)	MM8006		–	1.5	–	
	MM8007		–	1.9	–	
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz)	MM8006		–	2.2	–	
	MM8007		–	2.7	–	
†(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	MM8006		–	–	3.8	
	MM8007		–	–	5.0	
FUNCTIONAL TEST						
†Common-Emitter Amplifier Power Gain		G_{pe}				dB
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 60 MHz)	Both Types		–	30	–	
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 200 MHz)	MM8006		–	25	–	
	MM8007		–	20	–	
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)	MM8006		14	–	–	
	MM8007		12	–	–	

†Tuned for minimum noise.

FIGURE 1 – POWER GAIN AND NOISE FIGURE TEST CIRCUIT



C1, C2, C4, C7 – 0.8 – 10 pF Johanson
C8 – 0.5 – 3.5 pF Johanson
C3, C5 – 500 pF Button Type
R1 – 0 – 10 k Trimpot
R2 – 2.7 k 1/4 watt 5%
R3 – 1.0 k 1/4 watt 5%
L1 – 1/4" Brass Rod, Solder Plated, 1-1/8" long. Placed 5/8" from the socket and in parallel with the shield, which bisects the socket. The ungrounded side is soldered directly to the ungrounded side of C2.
L2 – 0.22 μH
L3 – 1/4" Brass Rod, Solder Plated, 1-1/2" long. Placed 1/2" from the socket and in parallel with shield, which bisects the socket. The ungrounded side is soldered directly to the ungrounded side of C7. Output tap is 15/16" from ground.
L4 – 1/2 Turn #16, 5/16" above L3 and 5/8" long, (over L3).

FIGURE 2 – COLLECTOR-BASE CAPACITANCE versus VOLTAG

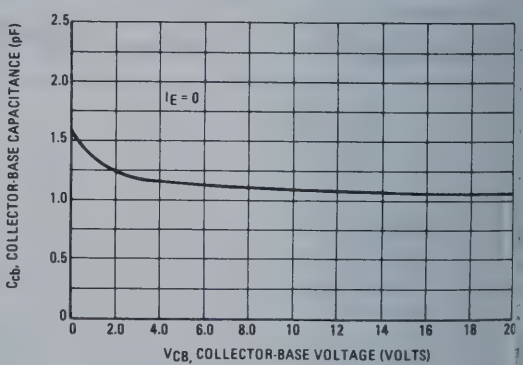


FIGURE 3 – CURRENT-GAIN–BANDWIDTH PRODUCT

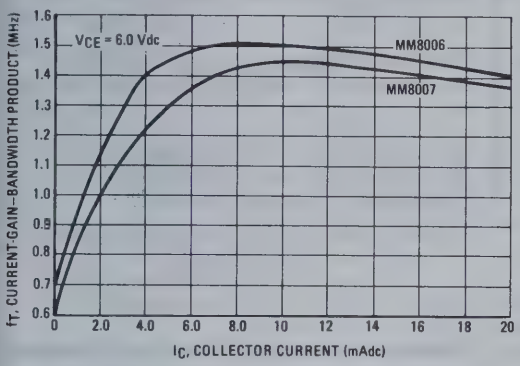


FIGURE 4 – S_{11} AND S_{22}

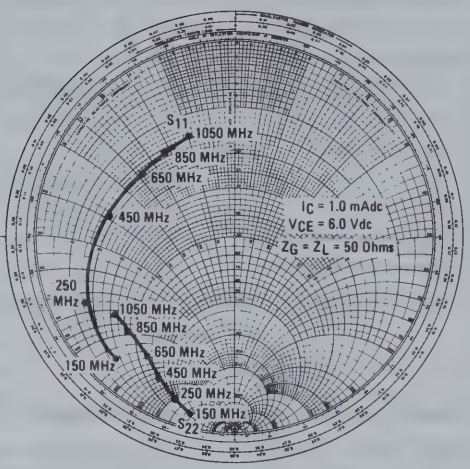


FIGURE 5 – S_{12}

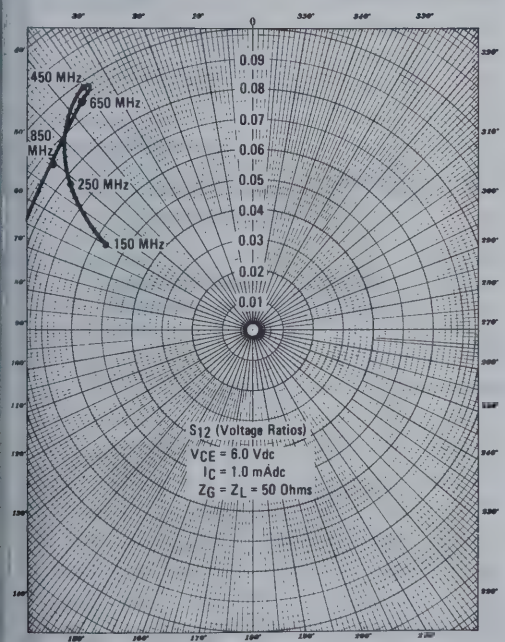


FIGURE 6 – S_{21}

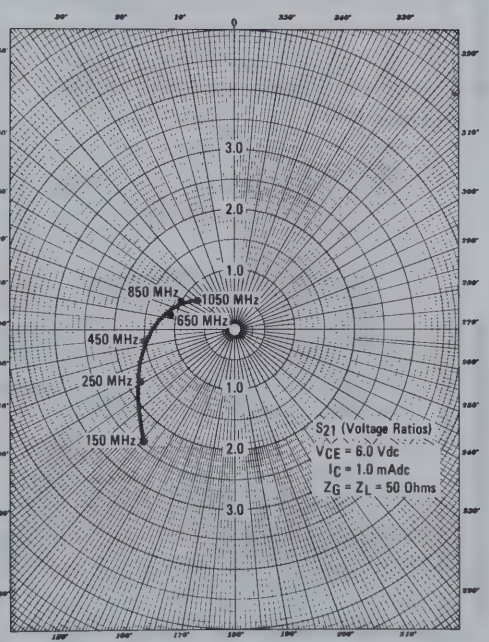


FIGURE 7 – NOISE FIGURE versus FREQUENCY

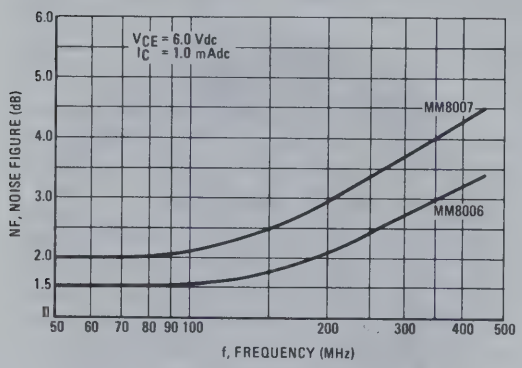


FIGURE 8 – POWER GAIN versus FREQUENCY

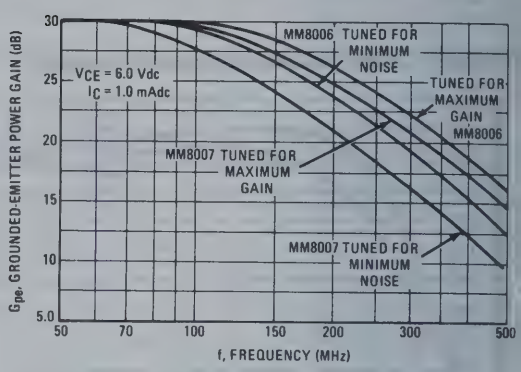


FIGURE 9 – INPUT ADMITTANCE versus FREQUENCY

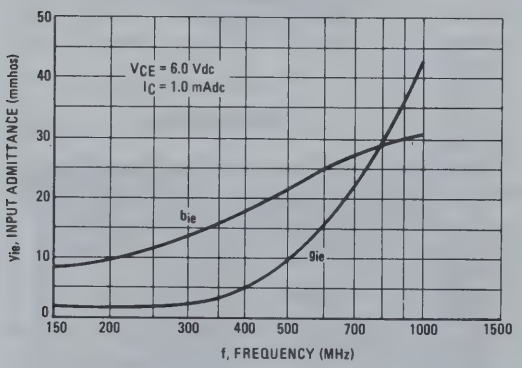


FIGURE 10 – OUTPUT ADMITTANCE versus FREQUENCY

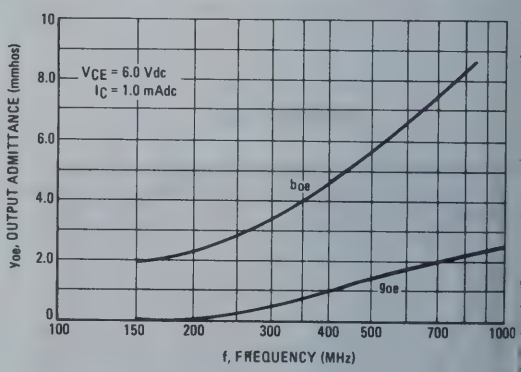


FIGURE 11 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

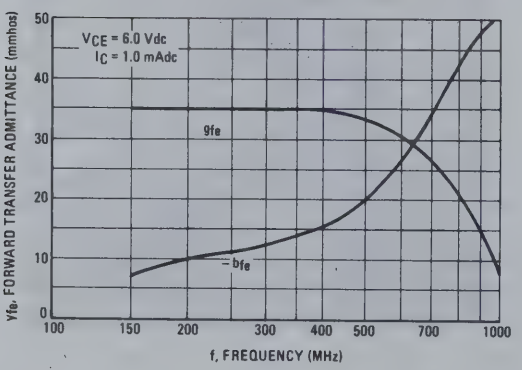
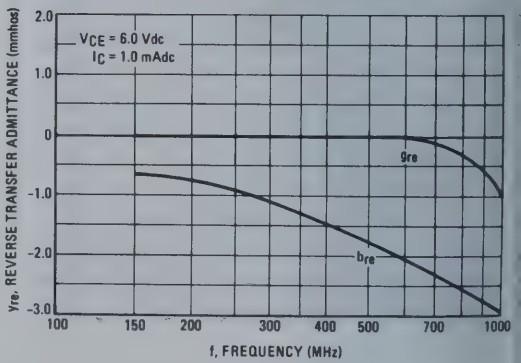


FIGURE 12 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY



MM8008 (SILICON)
MM8010
MM8011

NPN SILICON RF POWER TRANSISTORS

. . . designed primarily for oscillator, frequency multiplier, and UHF amplifier applications in military and industrial equipment.

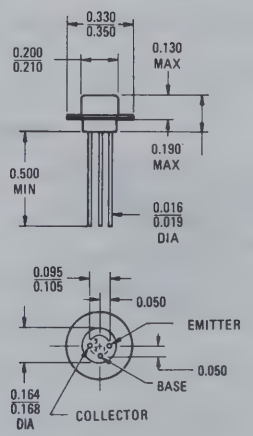
- High Power Output (Oscillator) –
  P_{out} = 300 mW (Min) @ f = 2.0 GHz (MM8008)
  200 mW (Min) @ f = 2.0 GHz (MM8010)
  100 mW (Min) @ f = 2.0 GHz (MM8011)
- High Current-Gain–Bandwidth Product –
  f_T = 1000 MHz (Typ) @ I_C = 50 mAdc
- Ideal for Radio Sonde Applications –
  P_{out} (Oscillator) = 550 mW (Typ) @ f = 1.68 GHz (MM8008)
  450 mW (Typ) @ f = 1.68 GHz (MM8010)
  300 mW (Typ) @ f = 1.68 GHz (MM8011)
- Wide Flange Case for Easy Mounting in Cavity Circuits
- Multiple Emitter Construction for Excellent High-Frequency Performance

NPN SILICON RF POWER TRANSISTORS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



CASE 23
TO-107

Collector Electrically Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	35	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	–	–	100	μAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	–	0.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	–	1100	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	1.3	3.0	pF
FUNCTIONAL TEST					
Oscillator Power Output (Figure 1) (I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 2.0 GHz) MM8008	P_{out}	0.3	–	–	Watt
MM8010		0.2	–	–	
MM8011		0.1	–	–	

FIGURE 1 – 2.0 GHz OSCILLATOR TEST CIRCUIT

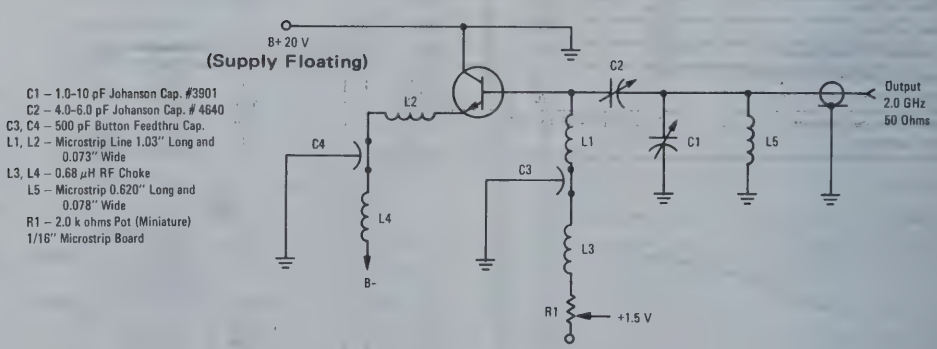


FIGURE 2 – TOP VIEW – 2.0 GHz OSCILLATOR TEST CIRCUIT

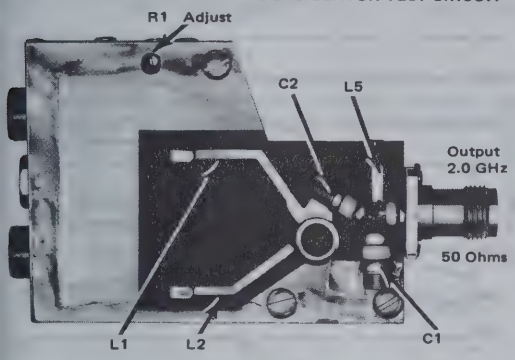


FIGURE 3 – SIDE VIEW – 2.0 GHz OSCILLATOR TEST CIRCUIT

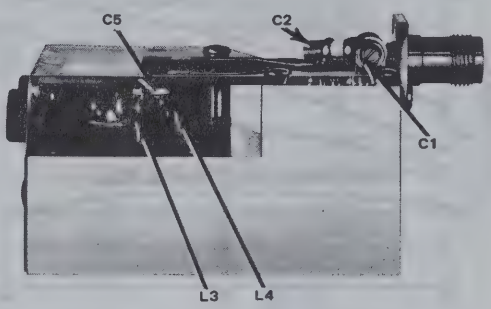


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

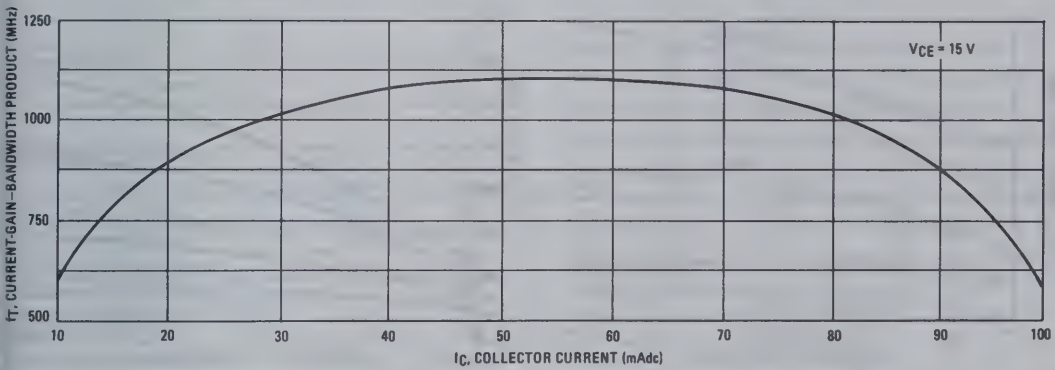
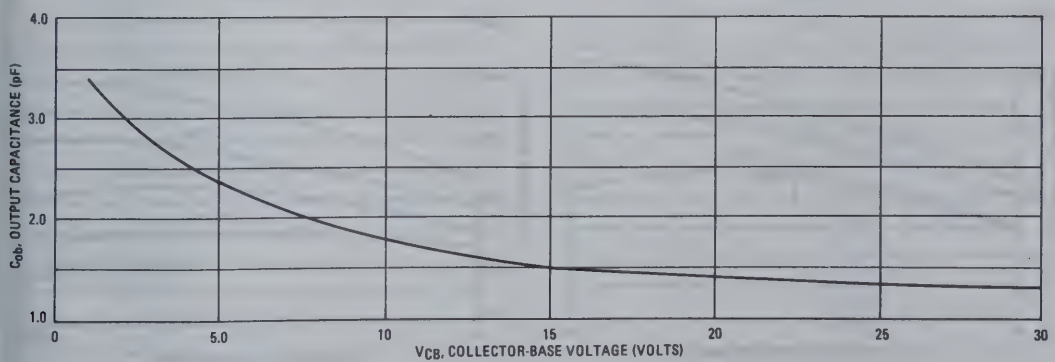


FIGURE 5 – OUTPUT CAPACITANCE versus VOLTAGE



OSCILLATOR OUTPUT POWER versus CURRENT
(SEE FIGURE 1 FOR TEST CIRCUIT)

FIGURE 6 – f = 2.0 GHz
MM8008

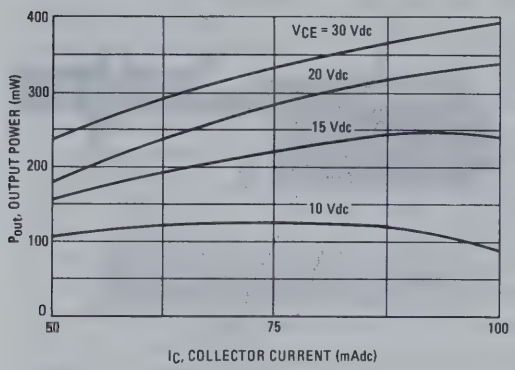
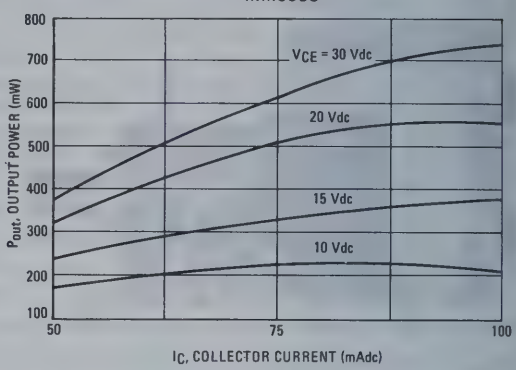
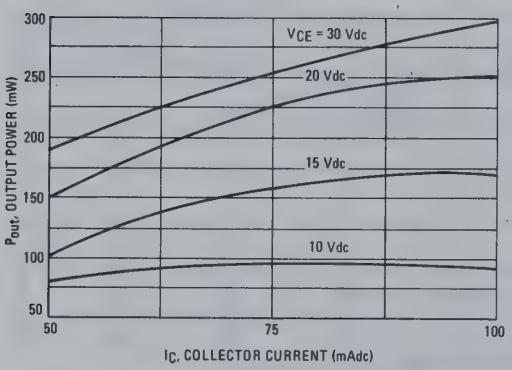


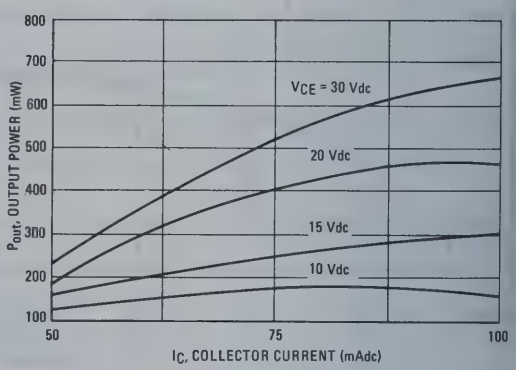
FIGURE 7 – f = 1.68 GHz
MM8008



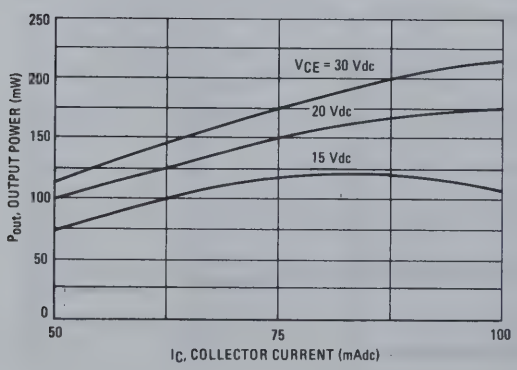
MM8010



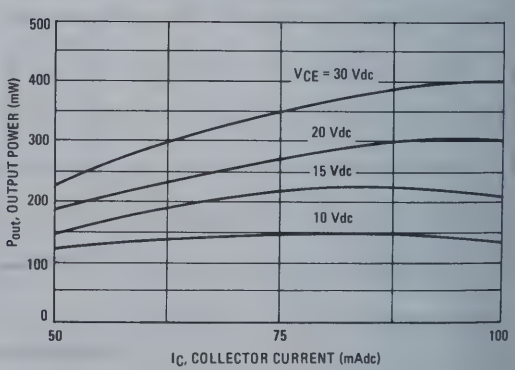
MM8010



MM8011



MM8011



MM8009 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output, driver, or pre-driver stages in UHF equipment and as a fundamental frequency oscillator at 1.68 GHz.

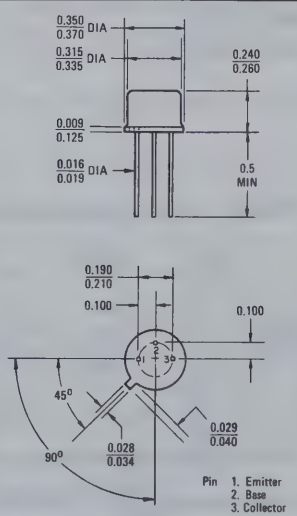
- High Output Power — P_{out} = 0.9 Watt (Min) @ f = 1.0 GHz
- High Current-Gain—Bandwidth Product — f_T = 1000 MHz (Min) @ I_C = 50 mAdc
- Ideal for Radio Sonde Applications — P_{out} (Oscillator) = 300 mW (Typ) @ f = 1.68 GHz

NPN SILICON RF POWER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	3.5 20	Watt mW/^{o}C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^{o}C



CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	55	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–	–	100	μAdc
Collector Cutoff Current (V_{CE} = 50 Vdc, V_{BE} = 0)	I_{CES}	–	–	10	μAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	1000	–	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	1.8	3.0	pF
FUNCTIONAL TEST					
Power Output (Figure 1) (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	P_{out}	0.9	–	–	Watt
Power Output (Oscillator) (Figure 2) (V_{CE} = 20 Vdc, V_{EB} = 1.5 Vdc, f = 1.68 GHz) (Minimum Efficiency = 15%)	P_{out}	–	0.3	–	Watt
Collector Efficiency (P_{in} = 316 mW, V_{CE} = 28 Vdc, f = 1.0 GHz)	η	35	–	–	%

FIGURE 1 – 1.0 GHz POWER AMPLIFIER TEST CIRCUIT

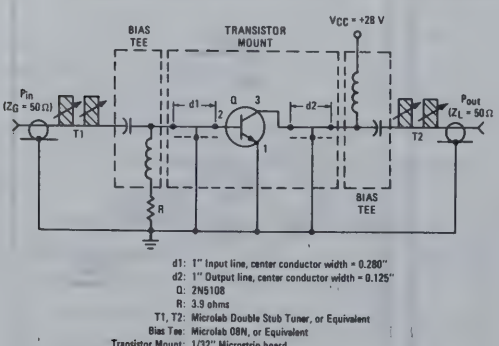


FIGURE 2 – 1.68 GHz POWER OSCILLATOR TEST CIRCUI

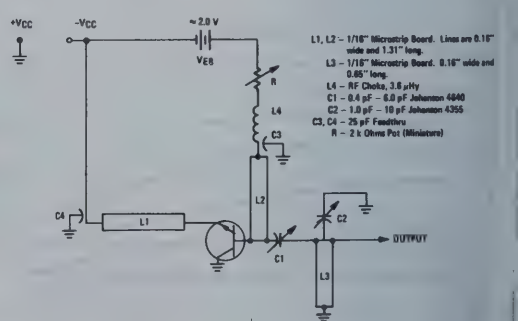


FIGURE 3 – POWER OUTPUT versus POWER INPUT

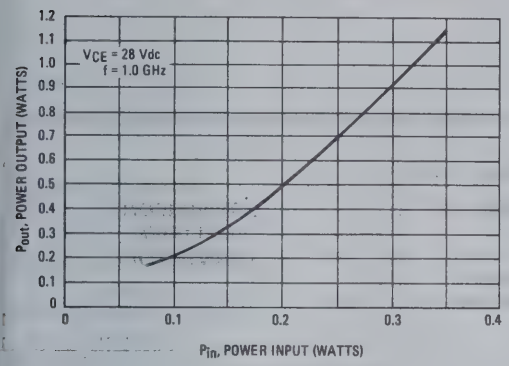


FIGURE 4 – POWER OUTPUT versus FREQUENCY

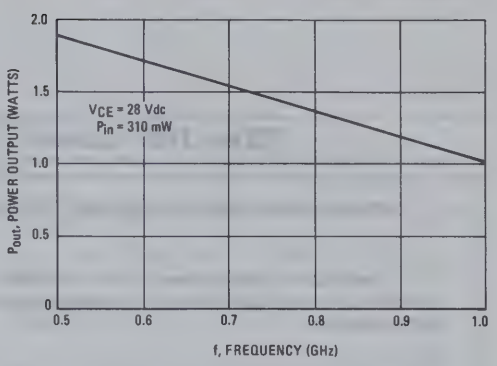


FIGURE 5 – POWER OUTPUT versus VOLTAGE

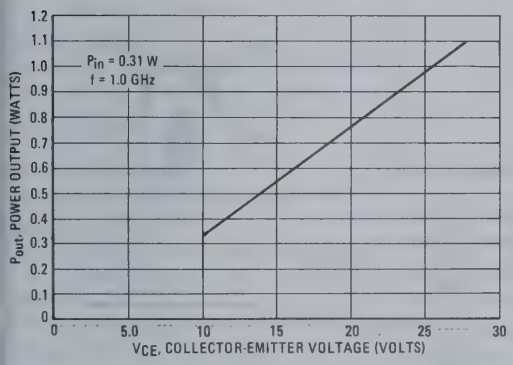


FIGURE 6 – OSCILLATOR POWER OUTPUT versus CURRENT

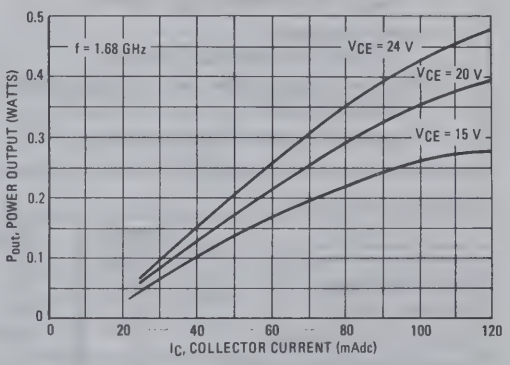


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

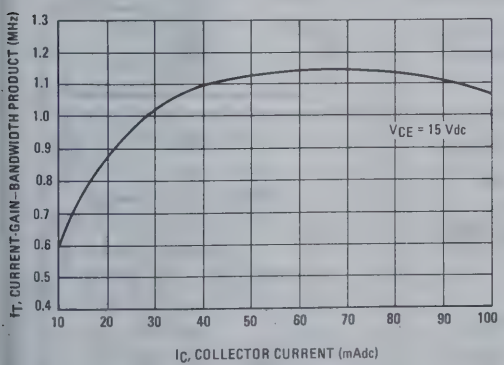
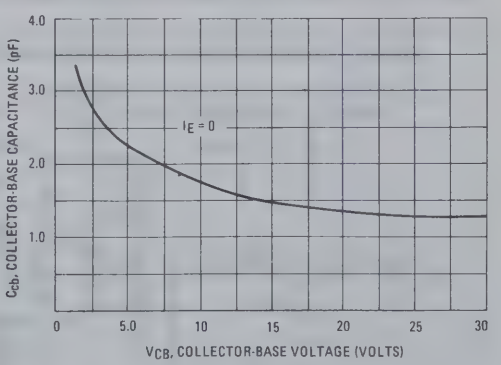


FIGURE 8 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE



MM8010
MM8011

For Specifications, See MM8008 Data.

MM8012 (SILICON)

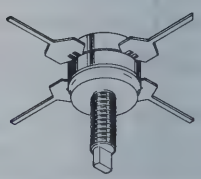
The RF Line

NPN SILICON HIGH-FREQUENCY TRANSISTOR

. . . designed for high-frequency CATV amplifier applications. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

- High Current-Gain—Bandwidth Product — f_T = 1200 MHz (Min) @ I_C = 75 mAdc
- Low Output Capacitance — C_{ob} = 4.0 pF (Max) @ V_{CB} = 30 Vdc
- Low Noise Figure — NF = 2.7 dB (Typ) @ I_C = 10 mAdc
- Stripline Package for Low Lead Inductance and Best Heat Dissipation
- Excellent Cross Modulation Performance

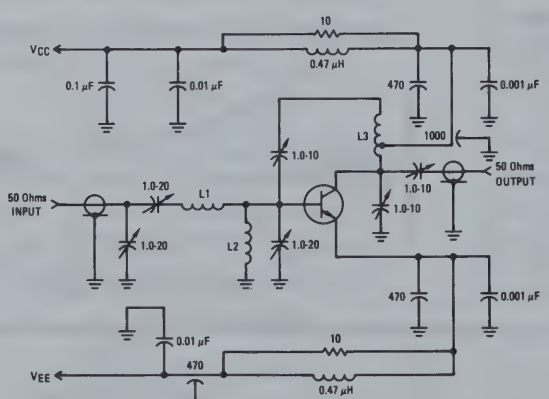
NPN SILICON AMPLIFIER TRANSISTOR



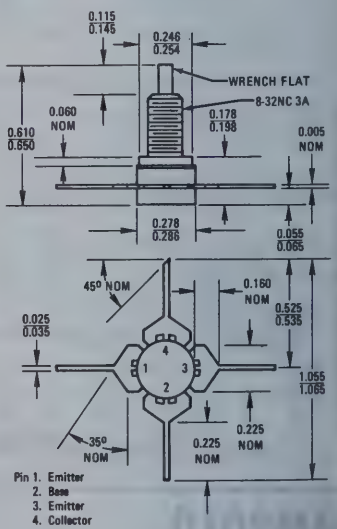
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−65 to +200	°C

FIGURE 1 — 200 MHz NOISE FIGURE AND POWER GAIN TEST CIRCUIT



L1 = 3 turns #18 AWG wire, 1/4" ID, 5/16" long
L2 = 1-1/2 turns #18 AWG wire, 1/4" ID, 3/16" long
L3 = 9-3/4 turns #18 AWG wire, 3/16" ID, 1" long, tapped 1-3/4 turn from collector.
All Capacitance in pF unless otherwise noted.



CASE 144D-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 20 Vdc)	h_{FE}	30	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 75 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	1200	1500	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.7	4.0	pF
Noise Figure (See Figure 1) (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	NF	–	2.7	–	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (See Figure 1) (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	G_{pe}	–	11.4	–	dB
Cross Modulation Distortion Ratio(1)	CM				dB
(V_{CE} = 20 Vdc, I_C = 75 mAdc, Output Level = +32 dBmV)		–	-96	–	
(V_{CE} = 20 Vdc, I_C = 75 mAdc, Output Level = +40 dBmV)		–	–	-77	

1) 12 Channel-Read on Channel 13 with no tilt and synchronous 100% square wave modulation @ 15.75 kHz.

FIGURE 2 – CURRENT-GAIN–BANDWIDTH PRODUCT

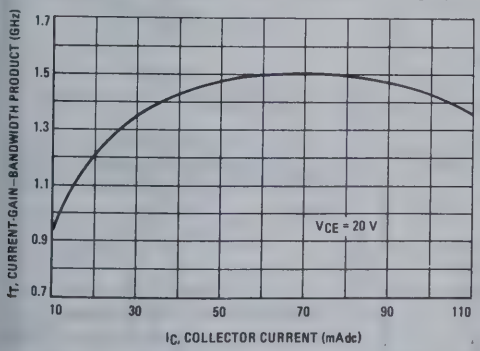
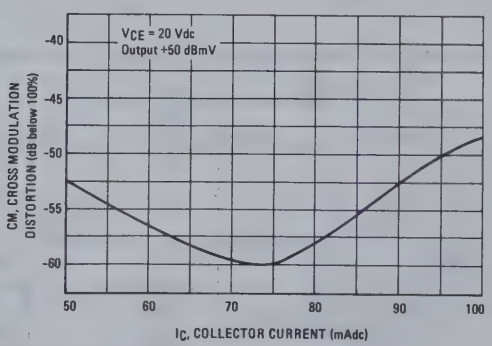


FIGURE 3 – CROSS MODULATION DISTORTION versus COLLECTOR CURRENT



MMD70 (SILICON)

SILICON EPITAXIAL SWITCHING DIODE

. . . designed for general-purpose, high-speed switching applications.

- High Breakdown Voltage —
  $V_{(BR)}$ = 50 Vdc (Min) @ $I_{(BR)}$ = 100 μAdc
- Space-Saving Micro-Miniature Package
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to MMD6050

MICRO-MINIATURE
SILICON EPITAXIAL
SWITCHING DIODE



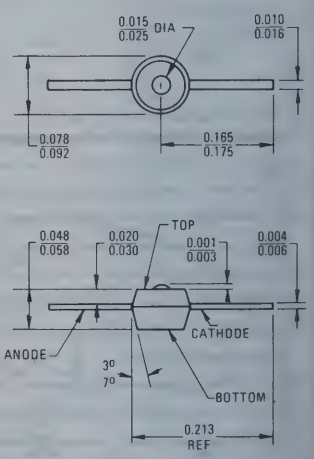
ACTUAL SIZE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	50	–	Vdc
Reverse Current (V_R = 30 Vdc)	I_R	–	100	nAdc
Forward Voltage (I_F = 100 mAdc)	V_F	0.75	1.2	Vdc
Capacitance (V_R = 0)	C	–	2.5	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 15 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	–	15	ns



Cathode identified by color dot on top of package.
CASE 166

MMD6050 (SILICON)
MMD6100
MMD6150
MMD7000

Silicon epitaxial micro-miniature switching diodes – single, series and dual diodes designed for general-purpose, high-speed switching applications.



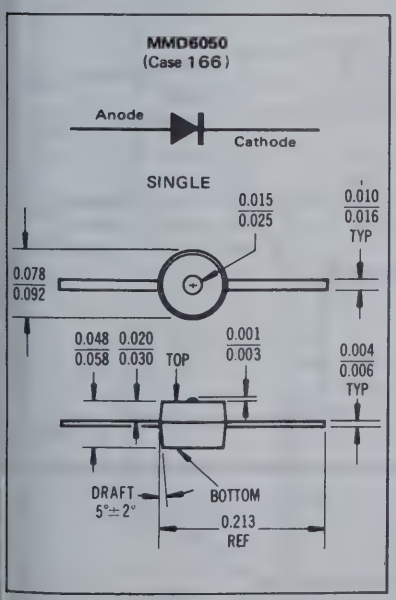
MMD6050 – Case 166

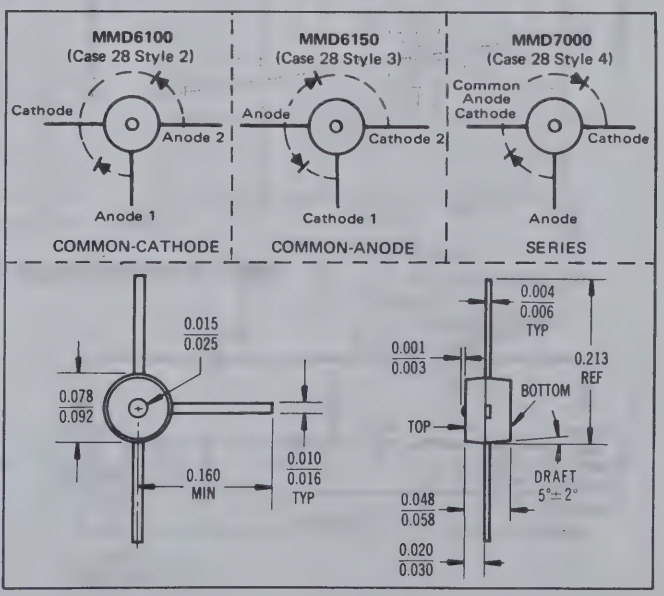


MMD6100 – Case 28 (2)
MMD6150 – Case 28 (3)
MMD7000 – Case 28 (4)

MAXIMUM RATINGS (each diode)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C





MMD6050, MMD6100, MMD6150, MMD7000 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	-	-	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	-	-	0.1	μAdc
Forward Voltage (I_F = 1.0 mAdc)	V_F	0.55	-	0.7	Vdc
(I_F = 100 mAdc)		0.85	-	1.1	
Capacitance (V_R = 0)	C	-	1.2	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc)	t_{rr}	-	1.5	5.0	ns

FIGURE 1 — FORWARD CHARACTERISTICS

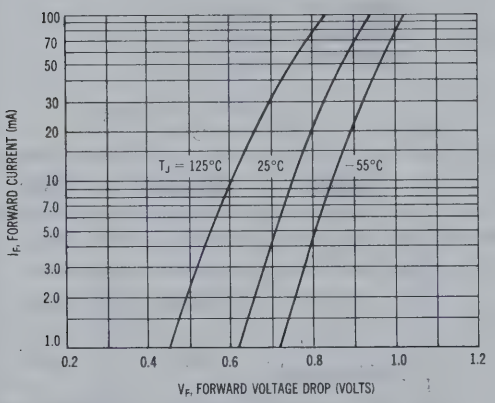


FIGURE 2 — REVERSE LEAKAGE CURRENT versus TEMPERATURE

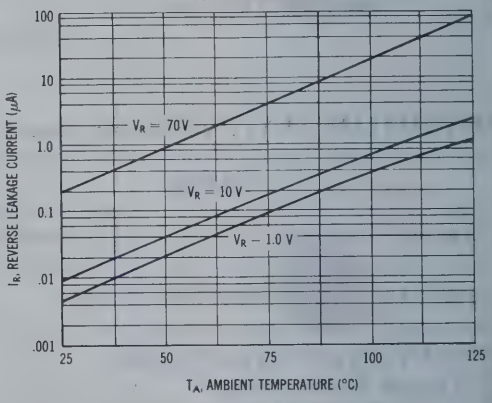


FIGURE 3 — CAPACITANCE

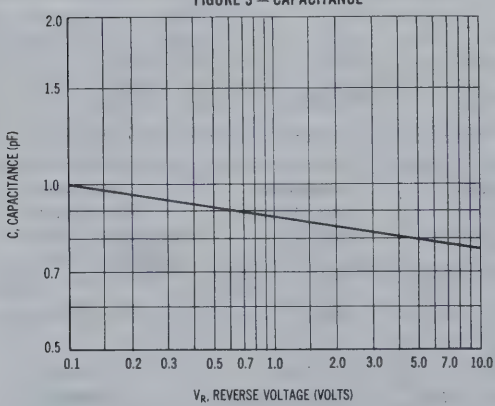


FIGURE 4 — REVERSE RECOVERY TIME

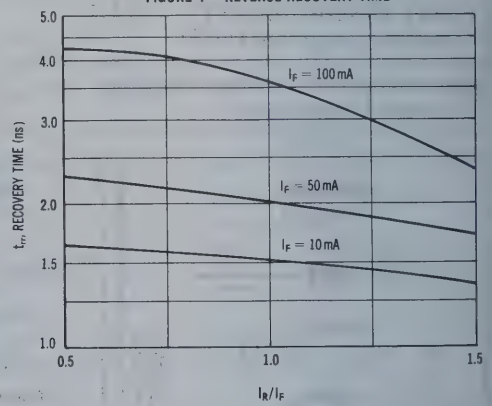
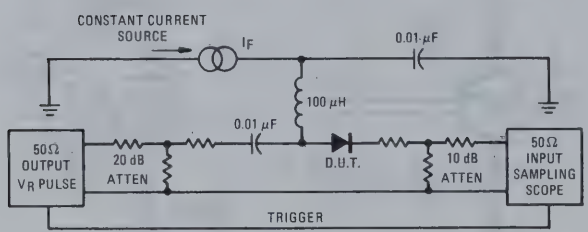
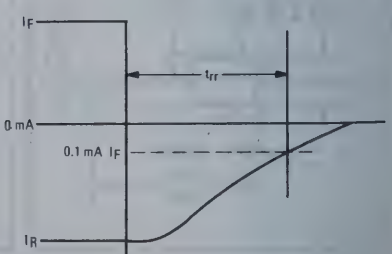


FIGURE 5 — RECOVERY TIME EQUIVALENT TEST CIRCUIT



V_R Pulse Rise Time ≤ 0.25 ns
Scope Rise Time ≤ 0.35 ns



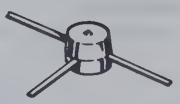
MMD7001 (SILICON)

SILICON EPITAXIAL DUAL SWITCHING DIODE

. . . designed for general purpose, high-speed switching applications.

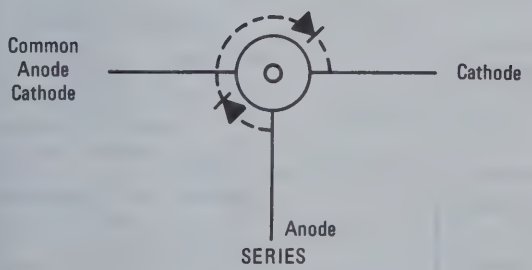
- High Breakdown Voltage –
  $V_{(BR)}$ = 45 Vdc (Min) @ $I_{(BR)}$ = 10 μAdc
- Fast Reverse Recovery Time –
  t_{rr} = 3.2 ns (Typ) @ $I_F = I_R$ = 10 mAdc
- Low Capacitance –
  C = 2.5 pF (Typ) @ V_R = 0
- Space-Saving Micro-Miniature Package

MICRO-MINIATURE SILICON EPITAXIAL DUAL SWITCHING DIODE

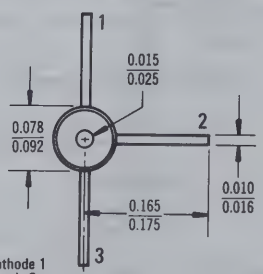


MAXIMUM RATINGS (each diode)

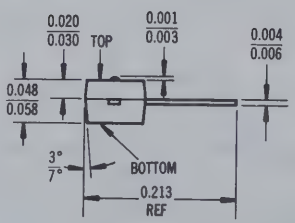
Rating	Symbol	Value	Unit
Reverse Voltage	V_R	45	Vdc
Recurrent Peak Forward Current	I_F	200	mAdc
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	600	mAdc
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C



SERIES



Pin 1. Cathode 1
2. Anode 2
3. Cathode 2, Anode 1

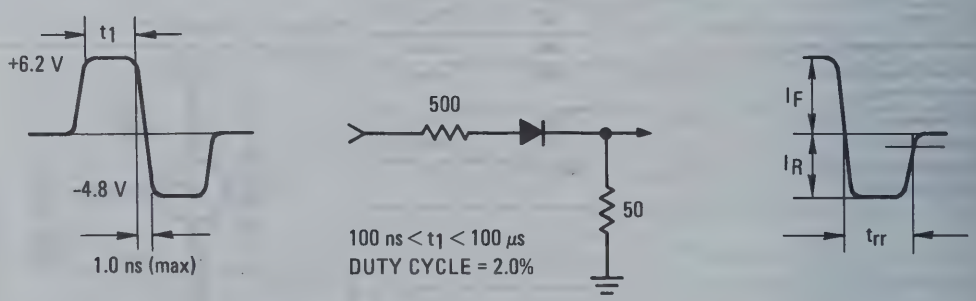


CASE 28
(Style 4)

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 10 μAdc)	$V_{(BR)}$	45	–	–	Vdc
Reverse Current (V_R = 30 Vdc)	I_R	–	–	0.1	μAdc
Forward Voltage	V_F				Vdc
(I_F = 100 mAdc)		0.75	–	0.9	
(I_F = 300 mAdc)		–	–	1.05	
(I_F = 500 mAdc)		–	–	1.15	
Capacitance (V_R = 0)	C	–	2.5	3.5	pF
Total Control Charge (I_F = 10 mAdc)	Q_S	–	–	50	pC
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	–	3.2	–	ns

FIGURE 1 – RECOVERY TIME EQUIVALENT TEST CIRCUIT

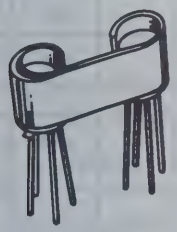


MMF1, MMF3, MMF5 (SILICON)

(Matched @ I_D = 300 μAdc)

MMF2, MMF4, MMF6

(Matched @ I_D = 750 μAdc)



TWO TO-72 CASE 20(1)
STYLE IN CLIP

Matched silicon N-channel junction field-effect transistors consisting of two individual MFE2003 device types which have been carefully matched for critical applications, such as differential amplifier service. Each matched pair is packaged in a metal clip for pair identity and each device is marked with the basic MFE2003 type number and a date code for further identification in the event of removal from the clip.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	20	mAdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (each MFE2003) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	-	-	Vdc
Gate-Source Voltage (I_D = 0.3 mAdc, V_{DS} = 15 Vdc)	V_{GS}	0.5	-	5.0	Vdc
Gate-Source Cutoff Voltage (I_D = 0.5 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	0.2	-	8.0	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0)	I_{GSS}	-	-	50	pAdc
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 150°C)		-	-	50	nAdc
Gate Reverse Current (V_{DG} = 15 Vdc, I_D = 750 μAdc)	I_G	-	-	25	pAdc
(V_{DG} = 15 Vdc, I_D = 750 μAdc, T_A = 100°C)		-	-	25	nAdc

ELECTRICAL CHARACTERISTICS (continued) (each MFE2003) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	0.5	-	10	mAdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)	V_{GSF}	-	-	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance (V_{DG} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert y_{fs}\rvert$	1500	-	6500	μmhos
(V_{DG} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(y_{fs})$	1500	-	-	
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(y_{is})$	-	500	-	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\lvert y_{os}\rvert$	-	-	50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	-	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	-	2.0	pF
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Mohm, f = 100 Hz, BW = 1.0 Hz)	NF	-	-	2.5	dB
MATCHING CHARACTERISTICS (MMF1 thru MMF6, See Note)					
Zero-Gate Voltage Drain Current Ratio (I_{DSS_1} is the lower of the two values)	$\frac{I_{DSS_1}}{I_{DSS_2}}$				-
(V_{DSS} = 15 Vdc, V_{GS} = 0) MMF1, MMF2		0.95	-	1.0	
MMF3, MMF4, MMF5, MMF6		0.90	-	1.0	
Forward Transfer Admittance Ratio ($\lvert y_{fs}\rvert_1$ is the lower of the two values)	$\frac{\lvert y_{fs}\rvert_1}{\lvert y_{fs}\rvert_2}$				-
(V_{DG} = 15 Vdc, I_D = 300 μAdc) MMF1		0.98	-	1.0	
MMF3, MMF5		0.95	-	1.0	
(V_{DG} = 15 Vdc, I_D = 750 μAdc) MMF2		0.98	-	1.0	
MMF4, MMF6		0.95	-	1.0	
Differential Output Admittance	$\lvert \lvert y_{os}\rvert_1 - \lvert y_{os}\rvert_2 \rvert$				μmho
(V_{DG} = 15 Vdc, I_D = 300 μAdc, f = 1.0 kHz) MMF1, MMF3, MMF5		-	-	1.0	
(V_{DG} = 15 Vdc, I_D = 750 μAdc, f = 1.0 kHz) MMF2, MMF4, MMF6		-	-	1.0	
Differential Gate-Source Voltage	$\lvert V_{GS_1} - V_{GS_2}\rvert$				mVdc
(V_{DG} = 15 Vdc, I_D = 300 μAdc) MMF1, MMF3, MMF5		-	-	5.0	
(V_{DG} = 15 Vdc, I_D = 750 μAdc) MMF2, MMF4, MMF6		-	-	5.0	
Differential Gate Reverse Current	$\lvert I_{G_1} - I_{G_2}\rvert$				nAdc
(V_{DG} = 15 Vdc, I_D = 300 μAdc, T_A = 100°C)		-	1.0	10	
(V_{DG} = 15 Vdc, I_D = 750 μAdc, T_A = 100°C)		-	1.0	10	
Differential Gate-Source Voltage Change with Temperature	See TABLE I				

TABLE I - Differential Gate-Source Voltage Change with Temperature

Conditions:

V_{DG} = 15 Vdc

MMF1, MMF3, MMF5 — I_D = 300 μAdc

MMF2, MMF4, MMF6 — I_D = 750 μAdc

Device Type	0°C to +25°C	+25°C to +100°C
MMF1, MMF2	0.250 mVdc	0.750 mVdc
MMF3, MMF4	0.625 mVdc	1.875 mVdc
MMF5, MMF6	1.250 mVdc	3.750 mVdc

NOTE: Matching Characteristics apply only to pairs of devices originally packaged as a matched pair.

MMT70 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for low-level, low-noise amplifier applications.

- Space Saving Micro-Miniature Package
- One-Piece, Injection Molded Unibloc Package for High Reliability

MICRO-MINIATURE NPN SILICON AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

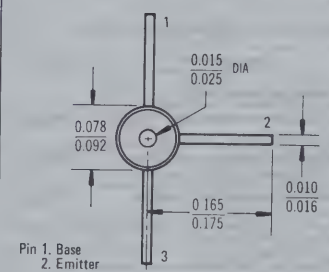
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	$^oC/mW$

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0		–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	150	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	–	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	–	8.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz)	NF	–	1.0	–	dB



CASE 28 (1)

MMT71 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for low-level, low-noise amplifier applications.

- Low Noise Figure — NF = 1.5 dB (Typ) @ f = 1.0 kHz
- Low Output Capacitance — C_{ob} = 2.0 pF (Typ) @ V_{CB} = 5.0 Vdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to 2N5086

MICRO-MINIATURE

PNP SILICON AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

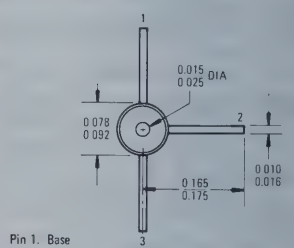
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous Peak	I_C	50 100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

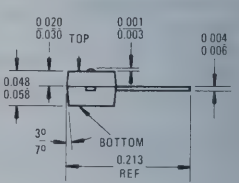
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	25	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	150	—	—	—
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	—	2.0	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	—	—	10	pF
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 kohms, f = 1.0 kHz)	NF	—	1.5	—	dB



Pin 1. Base
2. Emitter
3. Collector



CASE 28 (1)

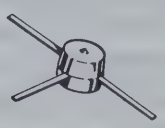
MMT72 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-speed, low-current switching applications where high-density packaging is required.

- Ideal for Thick Film Digital Circuit Applications
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-MINIATURE
NPN SILICON
SWITCHING
TRANSISTOR

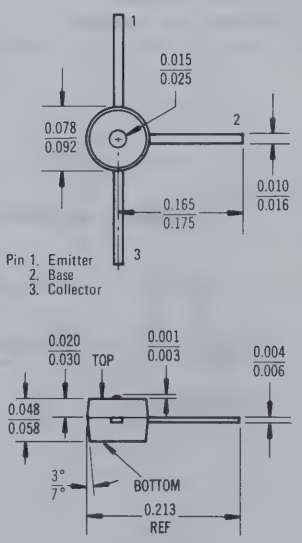


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Emitter Voltage	V_{CES}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current-Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW mW/^{o}C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^{o}C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	^{o}C/mW



CASE 28(1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	10	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	12	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	30	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	6.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	–	20	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	–	30	ns

FIGURE 1 – t_{on} CIRCUIT

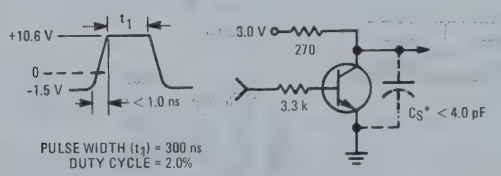
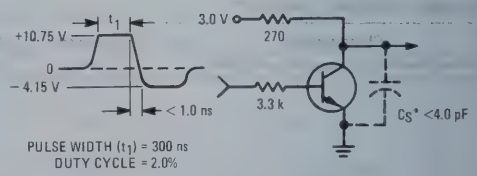


FIGURE 2 – t_{off} CIRCUIT



*Total shunt capacitance of test jig and connectors.

MMT73 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for high-speed, low-current switching applications where high-density packaging is required.

- Ideal for Thick Film Digital Circuit Applications
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to 2N3546

MICRO-MINIATURE

PNP SILICON SWITCHING TRANSISTOR

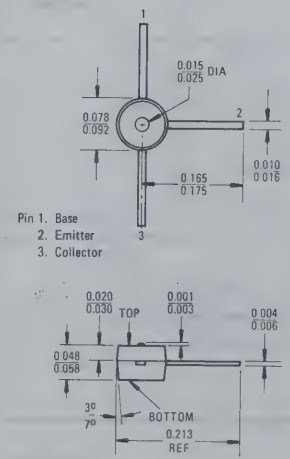


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	8.0	Vdc
Collector-Emitter Voltage	V_{CES}	8.0	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	$^oC/mW$

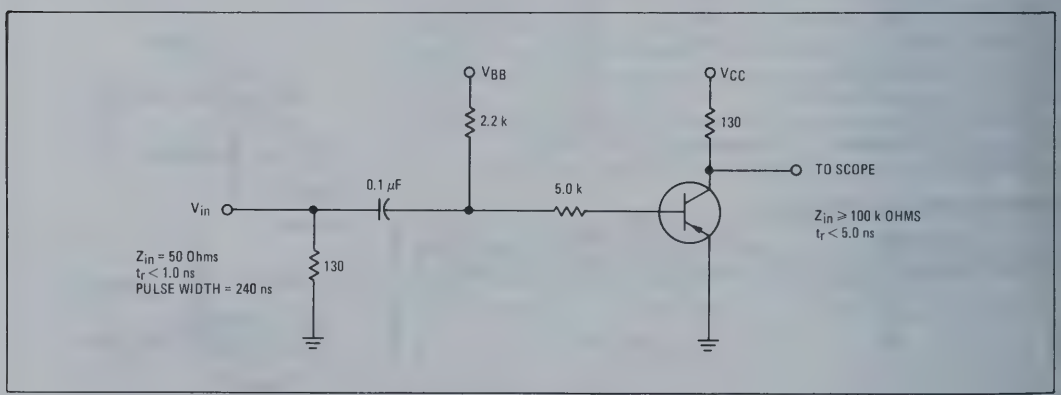


CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	8.0	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	8.0	–	Vdc
Emitter-Base Breakdown Voltage (I_C = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 3.0 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	 30 20	 – –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	5.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	–	30	ns
Turn-Off Time (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_{off}	–	30	ns

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



	V_{in} Vdc	V_{BB} Vdc	V_{CC} Vdc	I_C mA	I_{B1} mA	I_{B2} mA
t_{on}	-5.8	Gnd	-1.5	10	1.0	1.0
t_{off}	+10	-8.0	-1.5	10	1.0	1.0

MMT74 (SILICON)

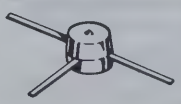
NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-gain, low-noise amplifier, oscillator and mixer applications.

- High Current-Gain–Bandwidth Product –
  f_T = 1000 MHz (Typ) @ I_C = 4.0 mAdc
- Low Collector – Base Capacitance
  C_{cb} = 1.0 pF (Typ) @ V_{CB} = 10 Vdc
- One-Piece, Injection Molded Unibloc Package for High Reliability

MICRO-MINIATURE

NPN SILICON RF AMPLIFIER TRANSISTOR

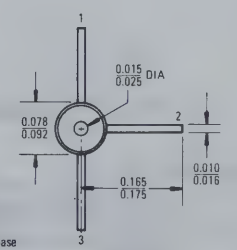


MAXIMUM RATINGS

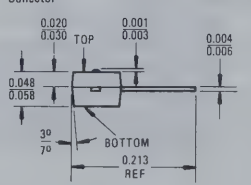
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	40	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW mW/^{o}C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^{o}C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	^{o}C/mW



Pin 1. Base
2. Emitter
3. Collector



CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	12	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	700	1000	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	1.0	3.0	pF
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 450 MHz)	NF	–	4.0	–	dB
FUNCTIONAL TEST					
Common Emitter Amplifier Power Gain (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	G_{pe}	–	14	–	dB

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN

Capacitance values in pF

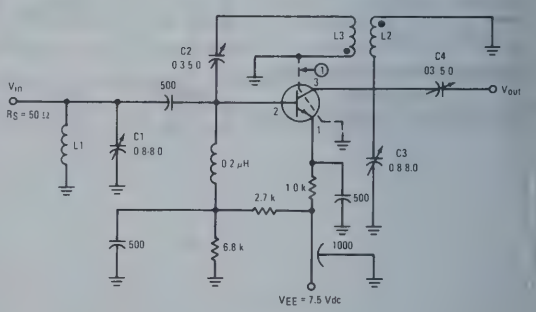
L1, L2 – Silver plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.

L3 – 1/2" turn #16 AWG wire, located 1/4" from and parallel to L2.

① – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.
(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.
(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.
(D) Interchange connections to signal generator and RF voltmeter.
(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.
(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.



MMT75-PNP (SILICON)
MMT76-NPN

COMPLEMENTARY SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose switching and amplifier applications and for complementary circuitry where high-density packaging is required.

- Current Gain Specified in Two Ranges for Design Flexibility
- Low Output Capacitance –
  C_{ob} = 5.0 pF (Max) @ V_{CB} = 5.0 Vdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to NPN-2N3903, and PNP-2N3905

MICRO-MINIATURE COMPLEMENTARY SILICON SWITCHING AND AMPLIFIER TRANSISTORS

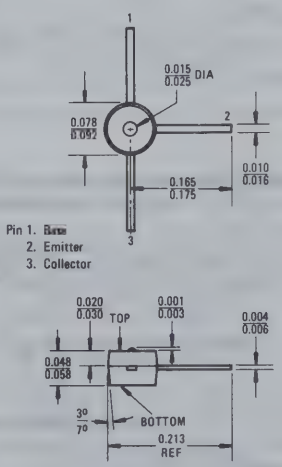


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW



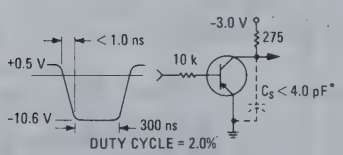
CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	–	–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	Both		50	–	400	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	MMT75		20	–	–	
	MMT76		30	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	–	5.0	pF
Noise Figure		NF				dB
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms,	MMT75		–	1.0	–	
BW = 10 Hz to 15.7 kHz)	MMT76		–	3.0	–	
SWITCHING CHARACTERISTICS						
Delay Time	MMT75	t_d	–	25	–	ns
(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc,	MMT76		–	24	–	
Rise Time I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	MMT75	t_r	–	18	–	ns
	MMT76		–	13	–	
Storage Time	MMT75	t_s	–	140	–	ns
(V_{CC} = 3.0 Vdc, I_C = 10 mAdc,	MMT76		–	125	–	
Fall Time I_{B1} = I_{B2} = 1.0 mAdc)	MMT75	t_f	–	15	–	ns
	MMT76		–	11	–	

DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

FIGURE 1 – MMT75 –PNP



STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT

FIGURE 2 – MMT75–PNP

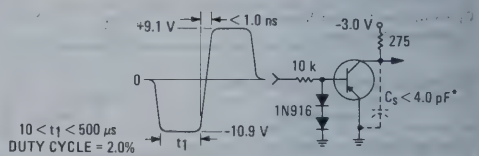


FIGURE 3 – MMT76 –NPN

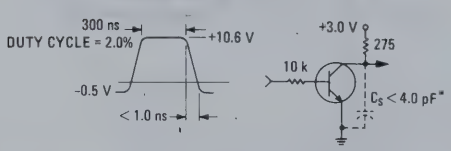
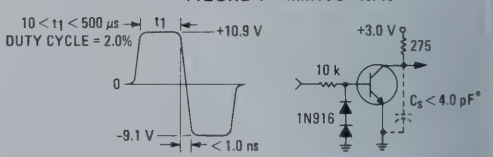


FIGURE 4 – MMT76 –NPN



*Total shunt capacitance of test jig and connectors

MMT918 (SILICON)



NPN silicon annular micro-miniature transistor designed for VHF and UHF amplifier, mixer and oscillator applications.

CASE 28 (1)

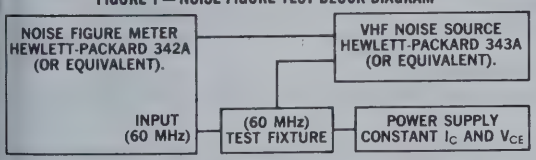
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

FIGURE 1 — NOISE FIGURE TEST BLOCK DIAGRAM



The test fixture shall consist of a 60 MHz tuned amplifier and suitable biasing circuits. It should be constructed utilizing good very-high-frequency design techniques.

The effective source susceptance should be tuned for each device being tested to obtain minimum noise figure. Note that because the HP 343A has a 50-ohm output resistance, a suitable impedance transformer must be used to obtain an effective source conductance of 2.5 mmho at the transistor with minimum losses.

FIGURE 2 — NEUTRALIZED 200 MHz POWER AMPLIFIER GAIN TEST CIRCUIT

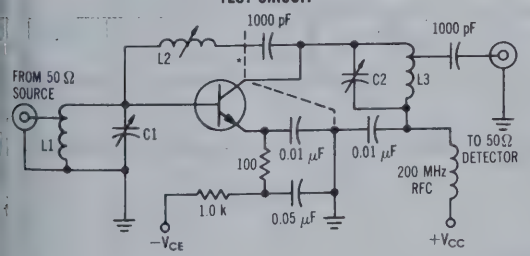
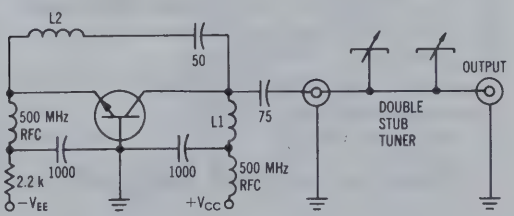


FIGURE 3 — 500 MHz OSCILLATOR TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	15	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	-	10	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}*	20	-	-	-
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$*	-	-	0.4	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$*	-	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (V_{CE} = 10 Vdc, I_C = 4.0 mAdc, f = 100 MHz)	f_T	600	-	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f ≥ 0.1 MHz and ≤ 1.0 MHz)	C_{ob}	-	-	1.7	pF
(V_{CB} = 0, I_E = 0, f ≥ 0.1 MHz and ≤ 1.0 MHz)		-	-	3.0	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f ≥ 0.1 MHz and ≤ 1.0 MHz)	C_{ib}	-	-	2.0	pF
Noise Figure (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 ohms, f = 60 MHz)	NF	-	-	6.0	dB
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (Figure 2) (V_{CC} = 12 Vdc, I_C = 6.0 mAdc, f = 200 MHz)	G_{pe}	-	23	-	dB
Power Output (Figure 3) (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	P_{out}	-	60	-	mW
Collector Efficiency (Figure 3) (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	η	-	50	-	%

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMT930 (SILICON)
MMT2484



CASE 28 (1)

NPN silicon annular micro-miniature transistor designed for low-level, low-noise amplifier applications.

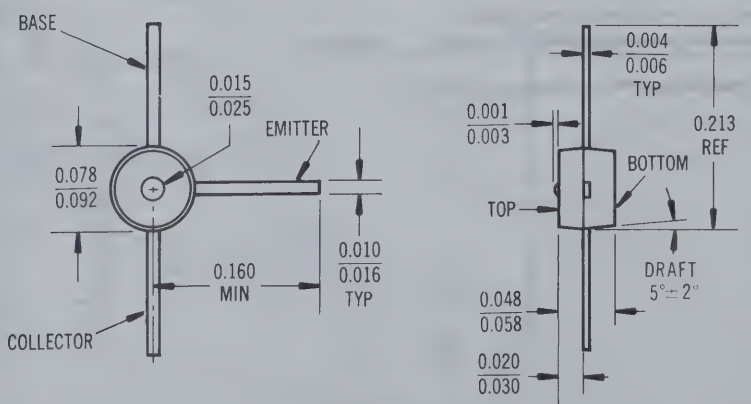
MAXIMUM RATINGS

Rating	Symbol	MMT930	MMT2484	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	225 2.05		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

OUTLINE DIMENSIONS



CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	MMT930 MMT2484	$BV_{CEO(sus)}$*	45 60	- -	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	-	0.01	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MMT930 MMT2484		100 175	- -	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	MMT930 MMT2484		125 200	- -	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMT930 MMT2484		150 250	- -	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)*	Both Types		-	800	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	-	0.35	Vdc
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.5	0.7	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)		f_T	60	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0)		C_{ob}	-	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0)		C_{ib}	-	6.0	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 10 kHz, Power Bandwidth = 15.7 kHz)	MMT2484	NF	-	3.0	dB

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMT2222 (SILICON)

NPN silicon annular micro-miniature transistor designed for high-speed switching circuits and DC to VHF amplifier applications.



CASE 28 (1)

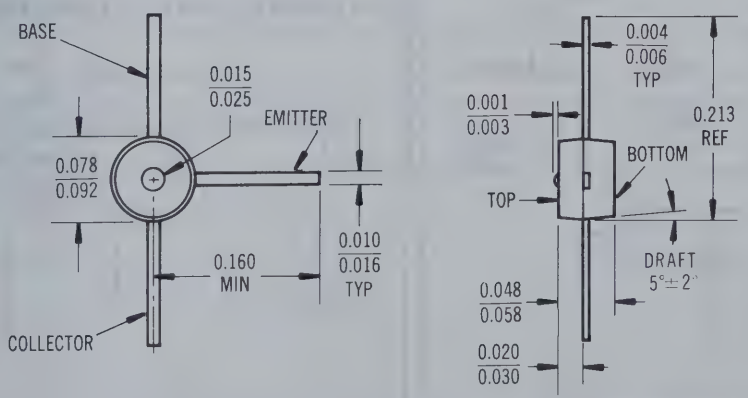
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/W

OUTLINE DIMENSIONS



CASE 28 (1)

MMT2222 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	-	-	0.05	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	50	-	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	-	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*		100	-	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)*		30	-	-	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$*	-	0.2	0.4	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)		-	0.9	1.6	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$*	-	0.85	1.3	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)		-	1.4	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	-	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	-	3.5	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 MHz)	C_{ib}	-	-	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1)	t_{on}	-	16	-	ns
Turn-Off Time (Figure 2)	t_{off}	-	160	-	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SATURATED TURN-ON SWITCHING TIME TEST CIRCUIT

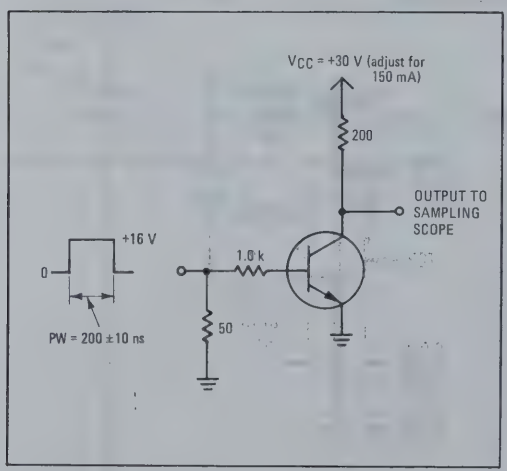
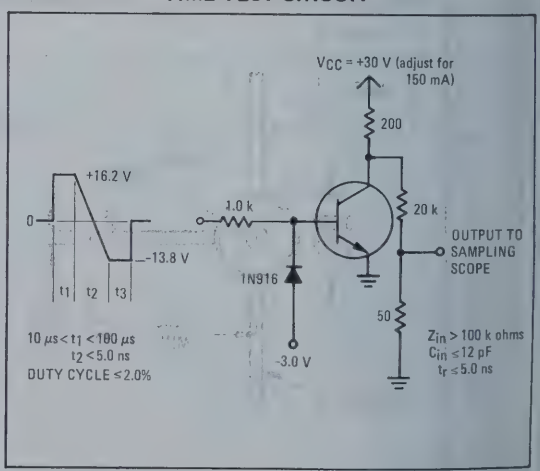


FIGURE 2 – SATURATED TURN-OFF SWITCHING TIME TEST CIRCUIT



Rise time (t_r) of applied pulse shall be 2.0 ns max; duty cycle ≤ 2.0%.

MMT2369 (SILICON)



CASE 28 (1)

NPN silicon micro-miniature annular transistor designed for high-speed, low current switching applications where high-density packaging is required.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

MMT2369 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}*	40 20	120 -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.70	0.85	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	500	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	4.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	-	12	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	t_{off}	-	18	ns
Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	$t_{s(rs)}$	-	13	ns

* Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — t_{on} CIRCUIT

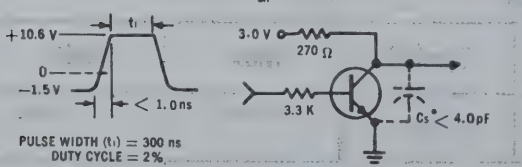
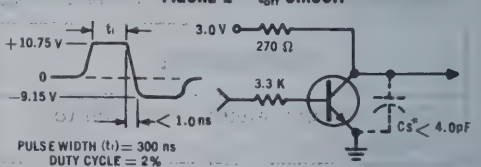


FIGURE 2 — t_{off} CIRCUIT



* Total shunt capacitance of test jig and connectors.

MMT2484

For Specifications, See MMT930 Data.

MMT2857 (SILICON)

NPN silicon annular micro-miniature transistor designed for high-gain, low-noise amplifier, oscillator and mixer applications.



CASE 28 (1)

MAXIMUM RATINGS

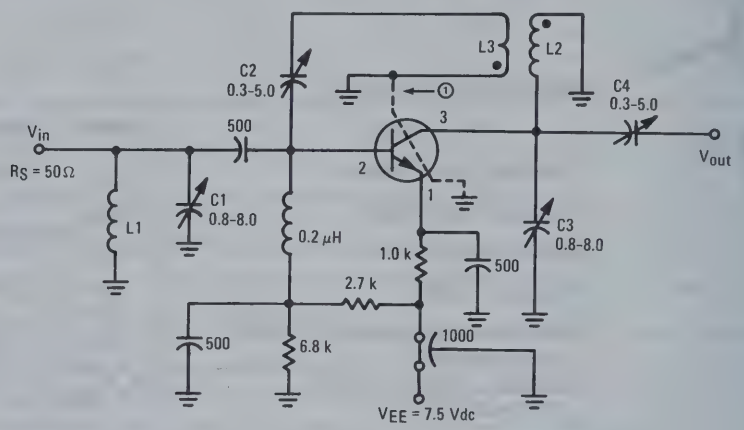
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	40	mAdc
Total Device Dissipation @T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C and case grounded unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	15	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	30	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	-	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	-	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz	f_T	1,000	1,300	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz) (Emitter and Case Guarded)	C_{cb}	-	0.5	1.0	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.9 MHz)	$r_b'C_c$	-	8.0	-	ps
Noise Figure* (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 450 MHz)	NF*	-	3.8	-	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	G_{pe}	-	18	-	dB

*Measured in circuit of Figure 1 with no connections for input circuit losses or post amplifier contribution.

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



Capacitance values in pF

L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.

L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.

① – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

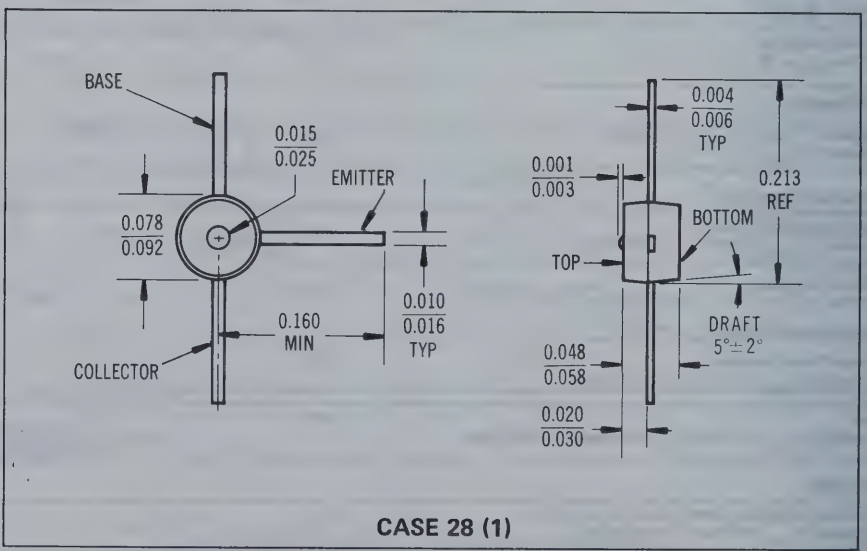
(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.

(D) Interchange connections to signal generator and RF voltmeter.

(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

OUTLINE DIMENSIONS



CASE 28 (1)

MMT2907 (SILICON)



CASE 28 (1)

PNP silicon annular micro-miniature transistor designed for general-purpose switching and amplifier applications, where high-density packaging is required.

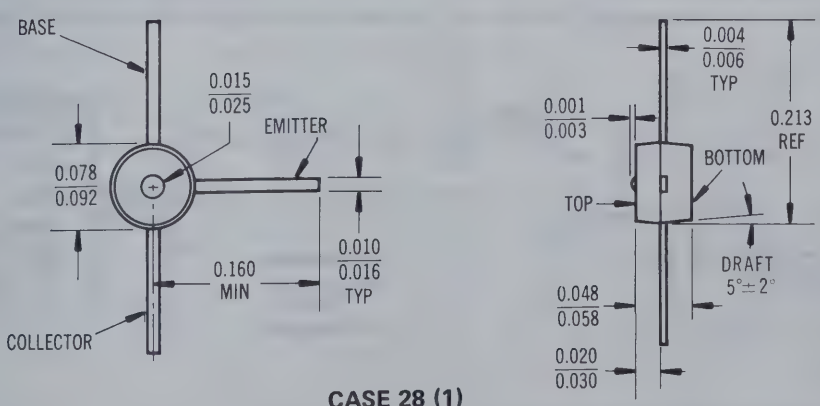
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current - Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

OUTLINE DIMENSIONS



CASE 28 (1)

MMT2907 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	40	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	-	-	50	nAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				-
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	-	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	-	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*		100	-	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)*		30	-	-	
Collector-Emitter Saturation Voltage*	$V_{CE(sat)}$*				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		-	0.2	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)		-	-	1.6	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)*		-	0.85	1.3	
(I_C = 300 mAdc, I_B = 30 mAdc)		-	-	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	260	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 MHz)	C_{ob}	-	4.8	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 MHz)	C_{ib}	-	-	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1)	t_{on}	-	20	-	ns
Turn-Off Time (Figure 2)	t_{off}	-	150	-	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1–SATURATED TURN–ON SWITCHING TIME TEST CIRCUIT

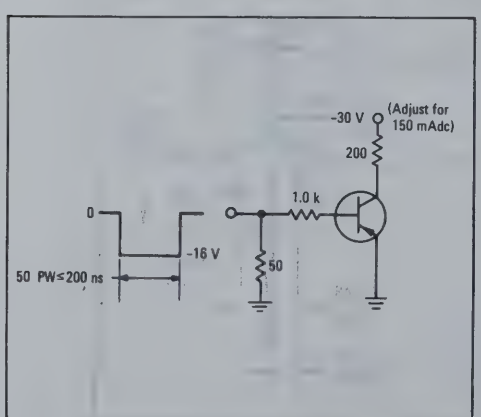
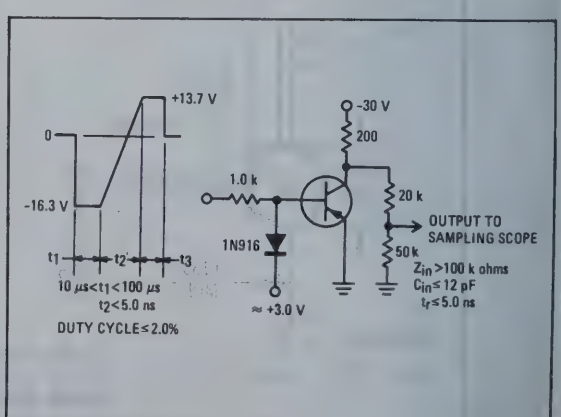


FIGURE 2–SATURATED TURN-OFF SWITCHING TIME TEST CIRCUIT



MMT3014 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-speed, saturated switching applications where high-density packaging is required.

- High-Speed Switching Times –
  $t_{on} + t_{off}$ = 41 ns (Max) @ I_C = 30 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.22 Vdc (Max) @ I_C = 30 mAdc
- Space Saving Micro-Miniature Package
- Ideal for Thick Film Digital Circuit Applications
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-MINIATURE

NPN SILICON SWITCHING TRANSISTOR

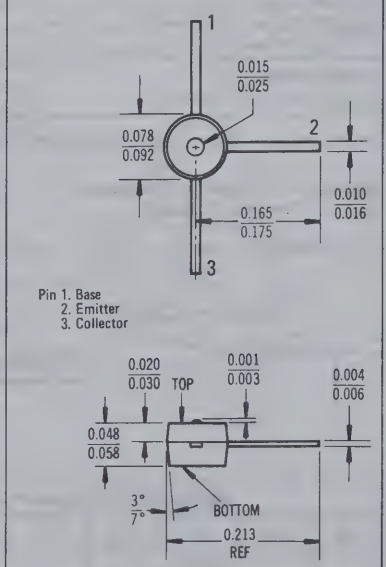


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW



Pin 1. Base
2. Emitter
3. Collector

CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}*	50 25	200 –	–
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	–	0.22	Vdc
Base-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{BE(sat)}$	0.70	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	–	MHz
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	8.0	pF
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	5.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	–	16	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 3.0 mAdc)	t_{off}	–	25	ns
Charge Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	τ_s	–	18	ns

*Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT

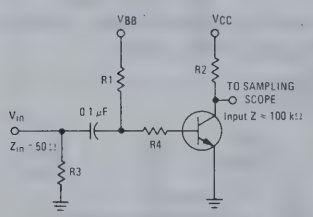
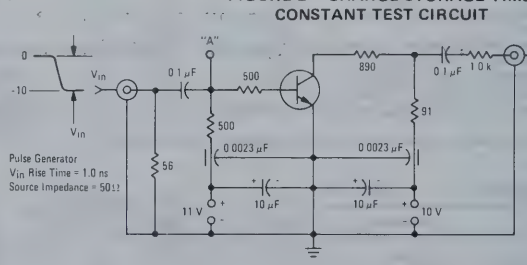


FIGURE 2 – CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



Vin Rise Time less than 1.0 ns, PW = 300 ns, Duty Cycle = 2.0%

SWITCHING TEST CIRCUIT VALUES								INPUT PULSE		
Test	V_{in}	V_{BB}	V_{CC}	R1	R2	R3	R4	t_r	t_f	Pulse Width
	VOLTS			OHMS				ns		
t_{on}	7.0	GND	2.0	100	62	100	2.0 k	<1.0	–	>200
t_{off}	-13	7.0	2.0							

MMT3546 (SILICON)

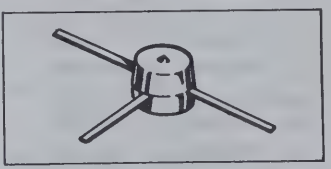
PNP SILICON ANNULAR TRANSISTOR

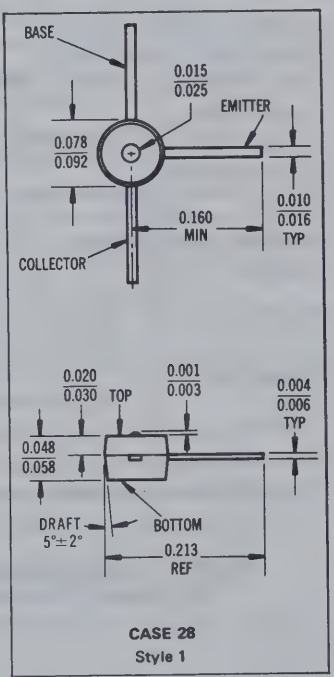
. . . designed for high-speed, low-level switching applications, where high-density packaging is required.

- Space Saving Micro-Miniature Package
- Ideal for Thick Film Digital Circuit Applications
- Total Switching Time = 60 ns @ I_C = 50 mAdc
- One-Piece, Injection-Molded Unibloc† Package for High Reliability

MICRO-MINIATURE

PNP SILICON SWITCHING TRANSISTOR





CASE 28
Style 1

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current - Continuous	I_C	250	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

MMT3546 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	12	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}*	30	-	-
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		15	-	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$*	-	0.15	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		-	0.5	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$*	0.7	0.9	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)		-	1.6	
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	700	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	-	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time	(V_{CC} = 3.0 Vdc, V_{BE} = 2.0 Vdc,	t_d	-	10	ns
Rise Time	I_C = 50 mAdc, I_{B1} = 5.0 mAdc)	t_r	-	15	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 50 mAdc,	t_s	-	20	ns
Fall Time	I_{B1} = I_{B2} = 5.0 mAdc)	t_f	-	15	ns

*Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

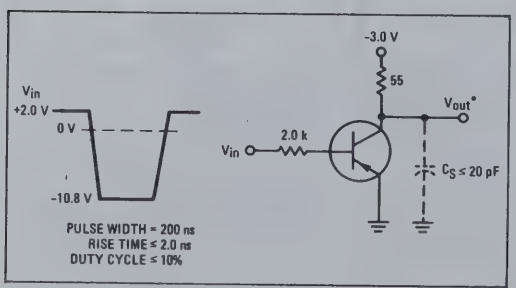
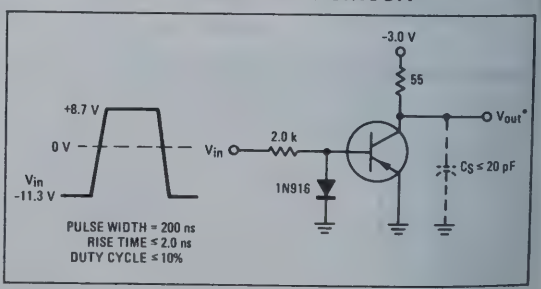


FIGURE 2 – STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*OSCILLOSCOPE RISE TIME ≤ 1.0 ns

MMT3798 (SILICON)
MMT3799

PNP silicon annular micro-miniature transistors designed for low-level, low-noise amplifier applications.



CASE 28 (1)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous Peak	I_C	50 100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	60		-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	-	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS						
DC Current Gain*		h_{FE}*				-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	MMT3798		75	-	-	
	MMT3799		150	-	-	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	MMT3798		150	-	450	
	MMT3799		300	-	900	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	MMT3798		150	-	-	
	MMT3799		300	-	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MMT3798		125	-	-	
	MMT3799		250	-	-	
Collector-Emitter Saturation Voltage* (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{CE(sat)}$*	-	-	0.25	Vdc
Base-Emitter Saturation Voltage* (I_C = 1.0 mAdc, I_B = 100 μAdc)		$V_{BE(sat)}$*	-	-	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	MMT3798	f_T	40	120	-	MHz
	MMT3799		40	150	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	2.0	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	-	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798	h_{ie}	-	8.0	-	k ohms
	MMT3799		-	16	-	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798	h_{re}	-	2.0	-	X 10^{-4}
	MMT3799		-	4.0	-	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798	h_{fe}	-	275	-	-
	MMT3799		-	475	-	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3798	h_{oe}	-	18	-	μmhos
	MMT3799		-	30	-	
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 100 Hz)	MMT3798	NF	-	4.0	-	dB
	MMT3799		-	2.5	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz)	MMT3798		-	1.5	-	
	MMT3799		-	0.8	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 10 kHz)	MMT3798		-	1.0	-	
	MMT3799		-	0.8	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, BW = 10 Hz to 15.7 kHz)	MMT3798		-	2.5	3.5	
	MMT3799		-	1.5	2.5	

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMT3823 (SILICON)

MICRO-T
SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTOR

Depletion Mode (Type A) Field-Effect Transistor designed for RF amplifier and mixer applications where high density packaging is required.

- Low Cross-Modulation and Intermodulation Distortion
- Drain and Source Interchangeable
- Low 100-MHz Noise Figure – 2.0 dB (Typ)
- Low Transfer and Input Capacitances
  C_{rss} = 1.0 pF (Typ); C_{iss} = 4.0 pF (Typ)
- Space Saving Micro-Miniature Package – Ideal for Thick Film Circuit Applications

MICRO-MINIATURE
JUNCTION
FIELD-EFFECT
TRANSISTOR

SYMMETRICAL
SILICON
N-CHANNEL

Type A

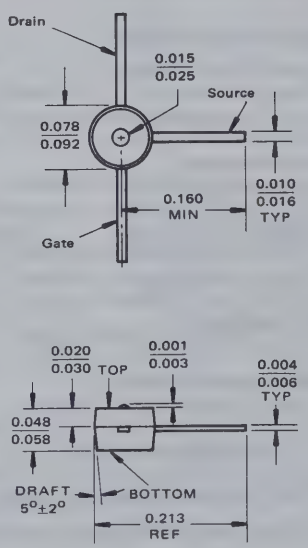


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	-30	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW



CASE 28
Style 5

Drain and Source may be Interchanged

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-30	–	–	Vdc
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0)	I_{GSS}	–	–	-1.0	nAdc
Gate-Source Cutoff Voltage (I_D = 1.0 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	–	–	-8.0	Vdc
Gate-Source Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)	V_{GS}	-1.0	–	-8.0	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	5.0	–	20	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)*	$\|y_{fs}\|$*	3000	–	8000	μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		–	4000	–	
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(y_{is})$	–	500	–	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)*	$\|y_{os}\|$*	–	25	–	μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(y_{os})$	–	125	–	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	4.0	–	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	1.0	–	pF
Common-Source Spot Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1000 ohms, f = 100 MHz)	NF	–	2.0	–	dB

*Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

MMT3903 (SILICON)
MMT3904



CASE 28(1)

NPN silicon micro-miniature annular transistors designed for general purpose switching and amplifier applications and for complementary circuitry with type MMT3905 and MMT3906, where high-density packaging is required.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector-Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

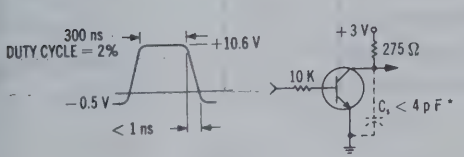
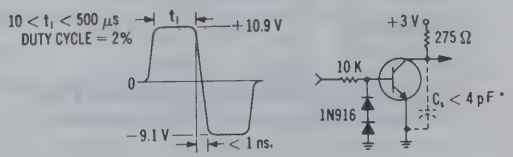


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}*	40	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)		I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 100 μAdc, V_{CE} = 1.0 Vdc)	MMT3903	h_{FE}*	20	-	-	
	MMT3904		40	-	-	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MMT3903		35	-	-	
	MMT3904		70	-	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MMT3903		50	-	150	
	MMT3904		100	-	300	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$*	-	-	0.2	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$*	-	-	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMT3903	f_T	250	-	-	MHz
	MMT3904		300	-	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	-	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	-	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	-	3.0	-	k ohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	-	2.0	-	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3903	h_{fe}	-	100	-	-
	MMT3904		-	200	-	
Output Admittance (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	-	10	-	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms Noise Bandwidth — f = 10 Hz to 15.7 kHz)		NF	-	3.0	-	dB

SWITCHING CHARACTERISTICS

Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc,	t_d	-	24	-	ns
Rise Time	I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_r	-	13	-	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc,	t_s	-	125	-	ns
Fall Time	I_{B1} = I_{B2} = 1.0 mAdc)	t_f	-	11	-	ns

* Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.
For characteristic curves, see 2N3903/2N3904 Data.

MMT3905 (SILICON)
MMT3906



CASE 28 (1)

PNP silicon micro-miniature annular transistors designed for general purpose switching and amplifier applications and for complementary circuitry with types MMT3903 and MMT3904 where high-density packaging is required.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current - Continuous	I_C	200	mAdc
Total Device Dissipation T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

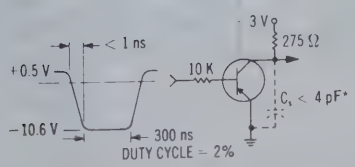
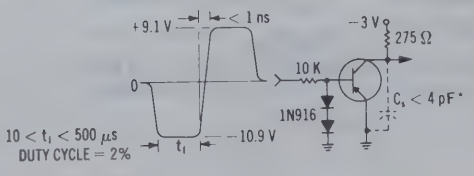


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}*	40	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current ($V_{BE(off)}$ = 4.0 Vdc, I_C = 0		I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS						
DC Current Gain*		h_{FE}*				-
(I_C = 100 μAdc, V_{CE} = 1.0 Vdc)	MMT3905		30	-	-	
	MMT3906		60	-	-	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	MMT3905		40	-	-	
	MMT3906		80	-	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MMT3905		50	-	150	
	MMT3906		100	-	300	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$*	-	-	0.25	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$*	-	-	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	MMT3905	f_T	200	-	-	MHz
	MMT3906		250	-	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	-	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	-	4.0	-	k ohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	-	2.0	-	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MMT3905	h_{fe}	-	100	-	-
	MMT3906		-	200	-	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	-	15	-	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, Noise Bandwidth — f = 10 Hz to 15.7 kHz)		NF	-	1.0	-	dB

SWITCHING CHARACTERISTICS

Delay Time	(V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc,	t_d	-	25	-	ns
Rise Time	I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_r	-	18	-	ns
Storage Time	(V_{CC} = 3.0 Vdc, I_C = 10 mAdc,	t_s	-	140	-	ns
Fall Time	I_{B1} = I_{B2} = 1.0 mAdc)	t_f	-	15		ns

* Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.
For characteristic curves, see 2N3905/2N3906 Data.

MMT3960A (SILICON)

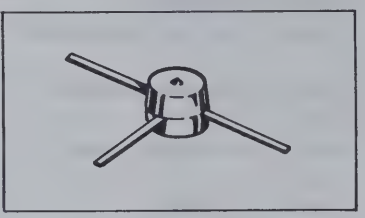
NPN SILICON ANNULAR TRANSISTOR

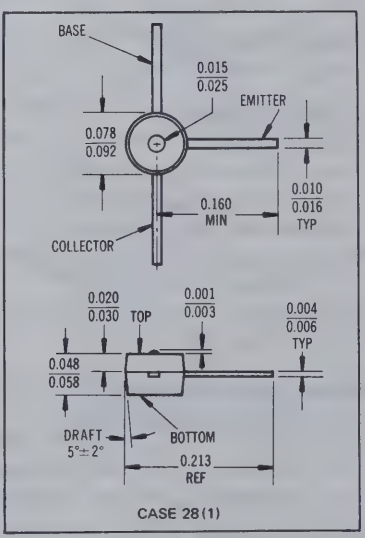
. . . designed for high-speed current-mode logic switching applications.

- High Current-Gain—Bandwidth Product — f_T = 2250 MHz (Typ) @ I_C = 10 mAdc
- Low Input and Output Capacitance — C_{ob} = 1.3 pF (Typ) @ V_{CB} = 4.0 Vdc; C_{ib} = 1.2 pF (Typ) @ V_{BE} = 0.5 Vdc
- Excellent Current-Mode Performance — t_r = 0.75 ns (Typ)
- Low Collector-Base Time Constant — $r_b'C_C$ = 15 ps (Typ) @ I_C = 30 mAdc
- One-Piece, Injection-Molded Unibloc Package for High Reliability

MICRO-MINIATURE

NPN SILICON HIGH-SPEED SWITCHING TRANSISTOR





CASE 28(1)

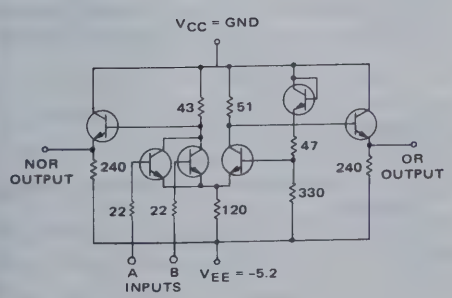
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	8.0	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	225 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

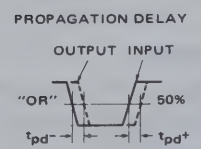
THERMAL CHARACTERISTICS

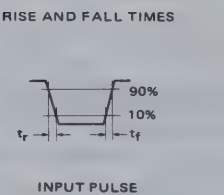
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	°C/mW

FIGURE 1 — TWO INPUT OR/NOR ECL GATE



All Transistors are MMT3960A Types





ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	8.0	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current (V_{EB} = 1.5 Vdc, I_C = 0)	I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS					
DC Current Gain*	h_{FE}*				-
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		30	-	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		30	-	200	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)		30	-	-	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$*	-	-	0.2	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$*	0.75	-	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product	f_T				MHz
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)		-	2000	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		-	2250	-	
(I_C = 30 mAdc, V_{CE} = 2.0 Vdc, f = 100 MHz)		1600	2500	-	
Output Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	1.3	2.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	1.2	3.0	pF
Collector-Base Time Constant (I_E = 30 mAdc, V_{CB} = 2.0 Vdc, f = 100 MHz)	$r_b'C_c$	-	15	-	ps
SWITCHING CHARACTERISTICS					
Turn-On Delay Time (Figure 1)	$t_{on(delay)}$	-	1.0	-	ns
Rise Time (Figure 1)	t_r	-	0.75	-	ns
Turn-Off Delay Time (Figure 1)	$t_{off(delay)}$	-	1.1	-	ns
Fall Time (Figure 1)	t_f	-	0.85	-	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

MMT8015 (SILICON)

NPN SILICON RF SMALL–SIGNAL TRANSISTOR

. . . designed for low-noise, high-gain, small-signal microwave amplifiers. Ideal for microstrip circuits where high density packaging is required.

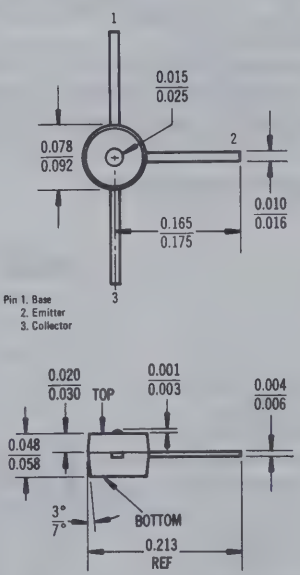
- Unneutralized Power Gain –
  G_{PE} = 12 dB (Typ) @ f = 1.0 GHz
- Low Noise Figure –
  NF = 3.5 dB (Typ) @ f = 1.0 GHz
- Characterized with Scattering Parameters

NPN SILICON MICRO–T RF SMALL–SIGNAL TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	15	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +135	°C



CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	10	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	BV_{CBO}	15	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)	I_{CBO}	–	1.0	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)	h_{FE}	25	–	300	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.35	–	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	1.0	–	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 6.0 mAdc, V_{CE} = 6.0 Vdc, f = 250 MHz)	f_T	1000	2000	–	MHz
Collector-Base Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	0.50	1.0	pF
Collector-Base Time Constant (I_C = 6.0 mAdc, V_{CE} = 6.0 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	4.0	–	ps
Noise Figure (1) (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 1.0 GHz)	NF	–	3.2	4.0	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (1) (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc, f = 1.0 GHz)	G_{pe}	6.0	7.5	–	dB
Common-Emitter Amplifier Power Gain (2) (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc, f = 1.0 GHz)	G_{pe}	10	13	–	dB

(1) Biased For Minimum Noise
(2) Biased For Optimum Gain

FIGURE 1 – POWER GAIN AND NOISE FIGURE TEST CIRCUIT

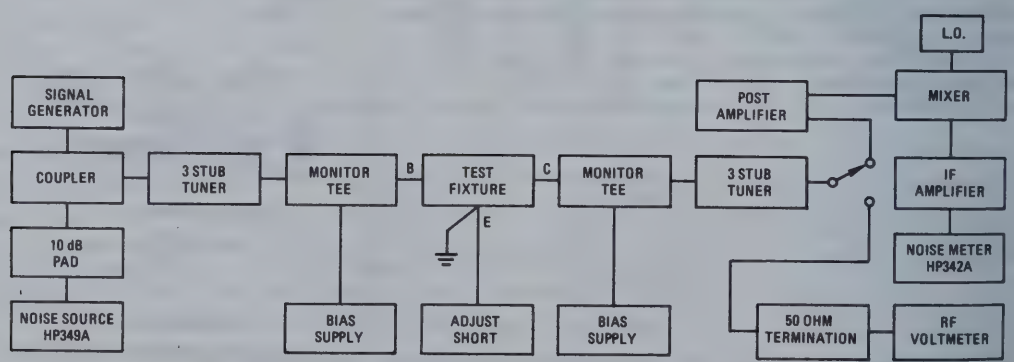


FIGURE 2 – COLLECTOR–BASE CAPACITANCE versus VOLTAGE

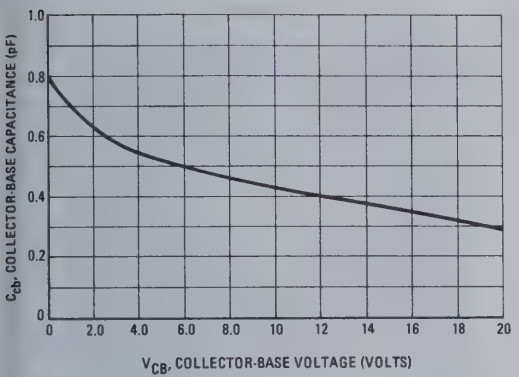


FIGURE 3 – CURRENT–GAIN – BANDWIDTH PRODUCT

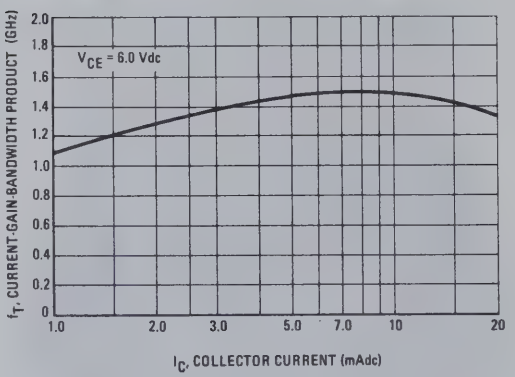


FIGURE 4 – NOISE FIGURE versus FREQUENCY

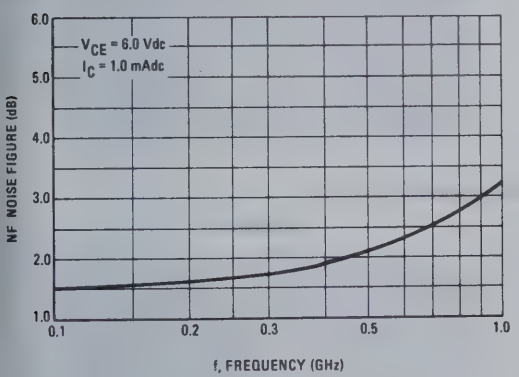


FIGURE 5 – UNNEUTRALIZED POWER GAIN versus FREQUENCY

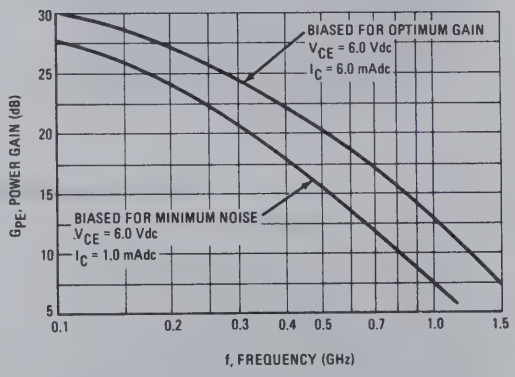
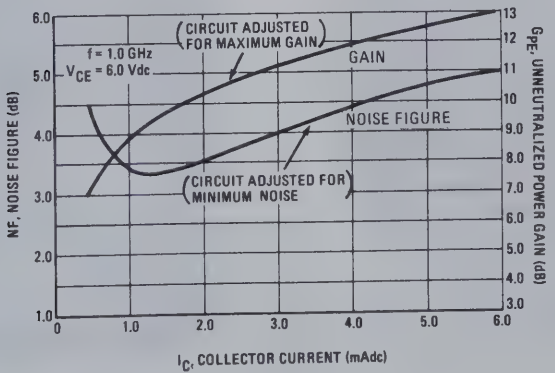


FIGURE 6 – NOISE FIGURE AND GAIN versus CURRENT
(See Test Circuit Figure 1)



S_{11}, S_{22}, INPUT AND OUTPUT REFLECTION COEFFICIENTS

V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc

FIGURE 7

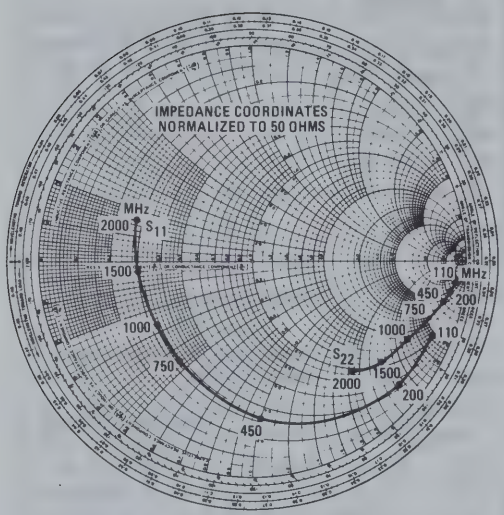
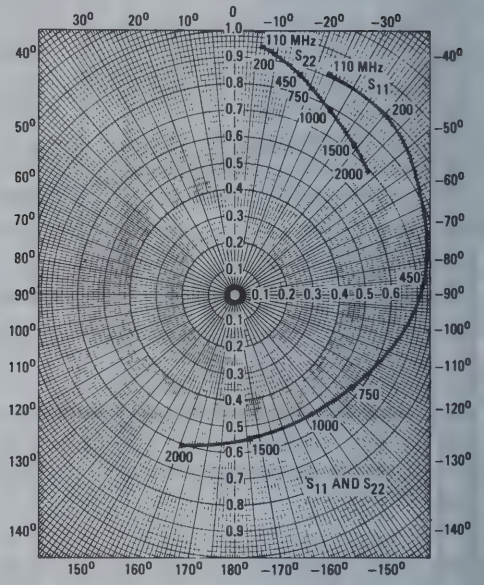


FIGURE 8



V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc

FIGURE 9

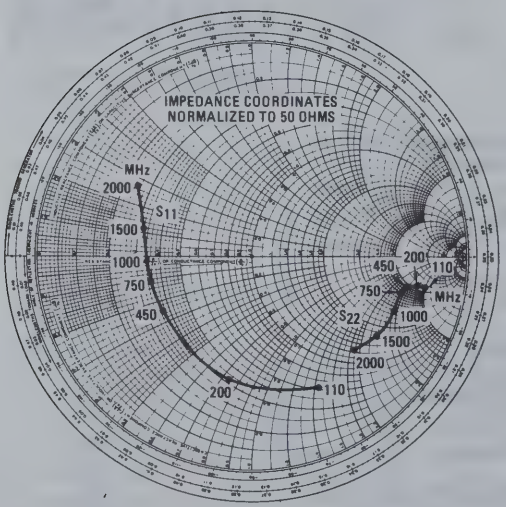
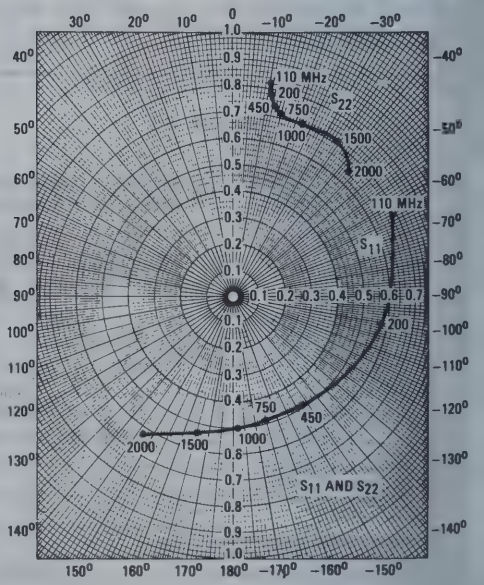


FIGURE 10



S_{12}, REVERSE TRANSMISSION COEFFICIENT

S_{21}, FORWARD TRANSMISSION COEFFICIENT

V_{CC} = 6.0 Vdc, I_C = 1.0 mAdc, Z_G = Z_L = 50 Ohms

FIGURE 11

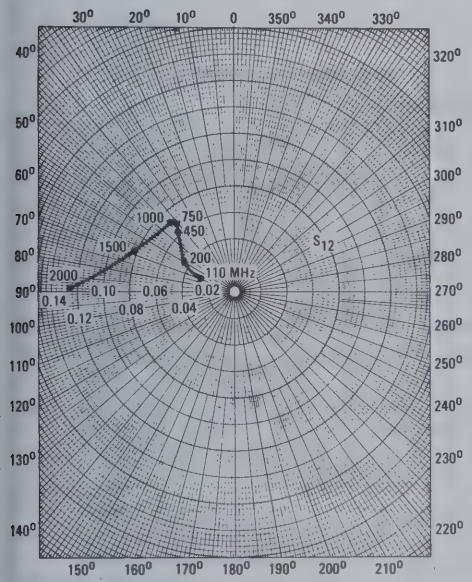
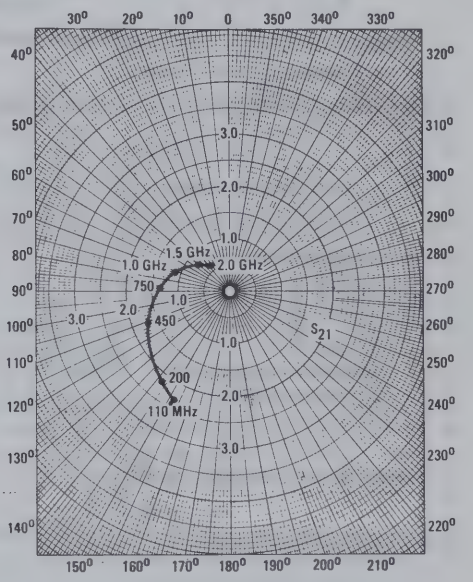


FIGURE 12



V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc, Z_G = Z_L = 50 Ohms

FIGURE 13

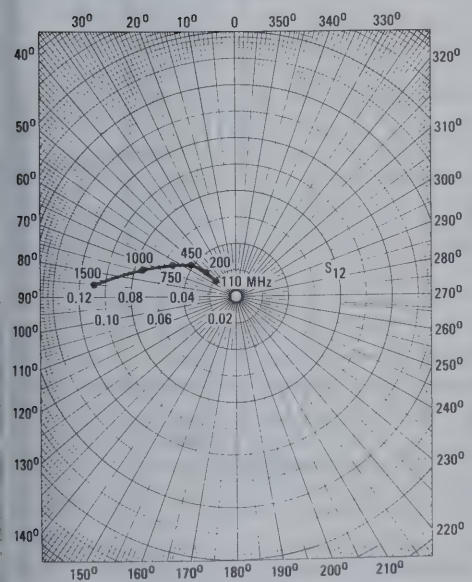
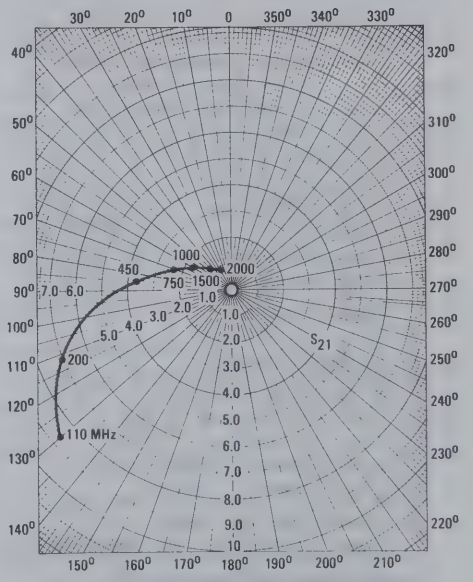
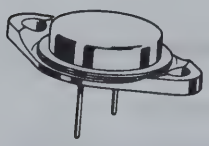


FIGURE 14



MP110 (GERMANIUM)



PNP germanium power transistor designed for high-gain power amplification in the audio range.

CASE 11
(TO-3)

Collector connected to case

MAXIMUM RATINGS ($T_C = 25°C$ unless otherwise noted)

Rating	Symbol	MP110	Unit
Collector-Emitter Voltage	V_{CEX}	65	Vdc
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Emitter Voltage	V_{CES}	50	Vdc
Collector Current-Continuous Peak	I_C	7 15	Adc
Base Current	I_B	2	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	106 1.25	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 25 mAdc, $V_{BE(off)}$ = 2 Vdc	BV_{CEX}	65	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 0.6 Adc, R_{BE} = 68 ohms)	BV_{CER}	40	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 0.2 Adc, V_{BE} = 0)	BV_{CES}	50	—	—	Vdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_J = 75°C)	I_{CBO}	— — —	— — —	0.2 2.0 15	mAdc
Emitter Cutoff Current (V_{BE} = 20 Vdc, I_C = 0)	I_{EBO}	—	—	8.0	mAdc
Floating Potential (V_{CB} = 40 Vdc, I_E = 0)	V_{FL}	—	—	0.8	Vdc
ON CHARACTERISTICS					
DC Current Gain (See Note) (I_C = 50 mAdc, V_{CE} = 2 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	60 74	— —	— 250	—
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 0.2 Adc)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter "On" Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	—	—	0.5	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	f_T	—	320	—	kHz

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE

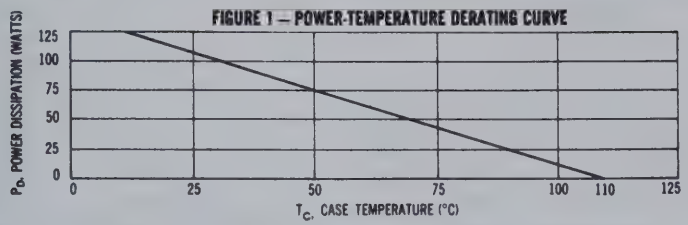


FIGURE 2 — DC CURRENT GAIN

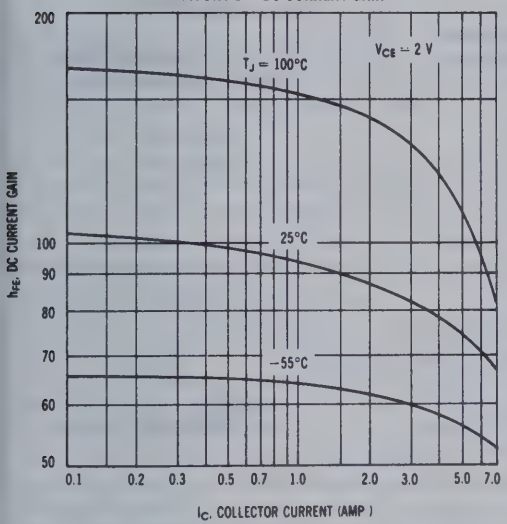


FIGURE 3 — TRANSCONDUCTANCE

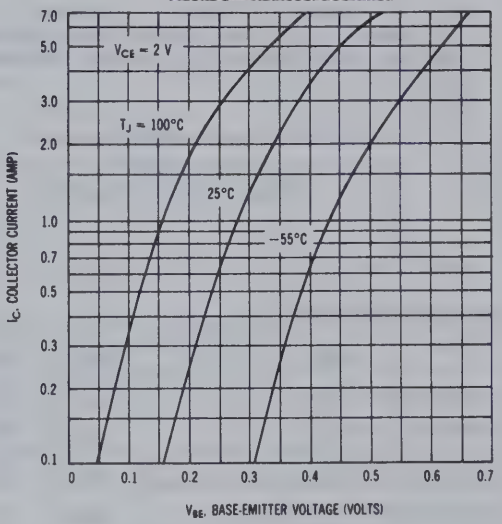


FIGURE 4 — ACTIVE REGION SAFE OPERATING AREA

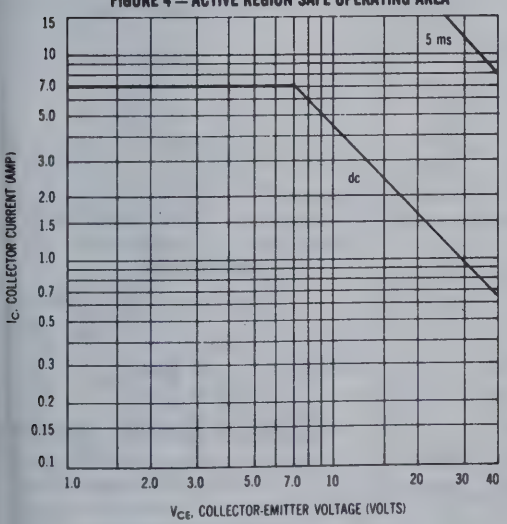
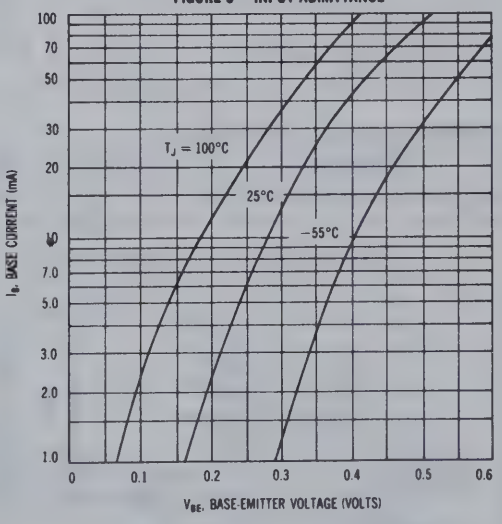


FIGURE 5 — INPUT ADMITTANCE



NOTE: Transistors are color coded to identify gain ranges as shown. No guarantee is made of gain distribution. $I_C = 1$ Adc, $V_{CE} = 2$ Vdc

COLOR CODE	h_{FE}	
	Min.	Max.
red	74	111
orange	100	133
yellow	119	164
green	145	200
blue	179	250

MP110B (GERMANIUM)

PNP GERMANIUM POWER SWITCHING TRANSISTOR

. . . designed for high-current switching applications requiring low saturation voltages, fast switching times and good safe operating area.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltage –
  $V_{CE(sat)}$ = 0.5 Vdc @ I_C = 5.0 Adc

25 AMPERE

PNP ADE GERMANIUM POWER TRANSISTOR

90 VOLTS
106 WATTS



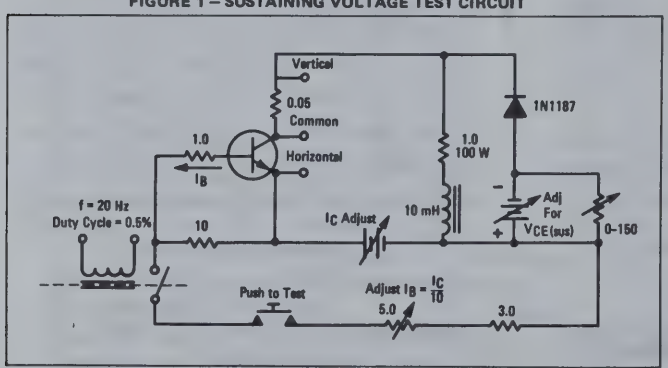
MAXIMUM RATINGS

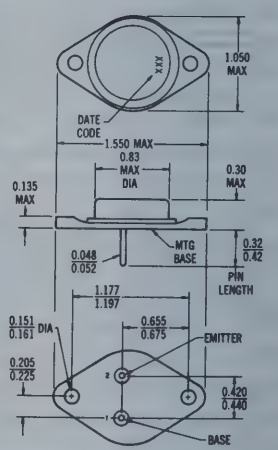
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	90	Vdc
Emitter-Base Voltage	V_{EB}	2.0	Vdc
Collector Current - Continuous	I_C	25	Adc
Base Current - Continuous	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	106 1.25	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT





Collector Connected to Case

CASE 11A
(TO-3)

Except Pin Diameter

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 Adc) (See Figure 1)	$V_{CE(sus)}$	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 mAdc, I_C = 0)	BV_{EBO}	2.0	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 50 Vdc, R_{EB} = 100 Ohms)	I_{CER}	-	10	mAdc
Collector Cutoff Current (V_{CE} = 90 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	I_{CEX}	-	20	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	I_{CBO}	-	200	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)* Red Green Blue (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	65 100 150 55	120 200 300 -	-
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 100 mAdc)	$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	- -	0.45 0.60	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc)	f_T	500	-	kHz

*For desired h_{FE} range, specify color code.

MP500 thru MP502 (GERMANIUM)
MP504 thru MP506

CASE 7



PNP germanium power transistors for high-gain, high-power amplifier and switching applications in high reliability industrial equipment.

MAXIMUM RATINGS

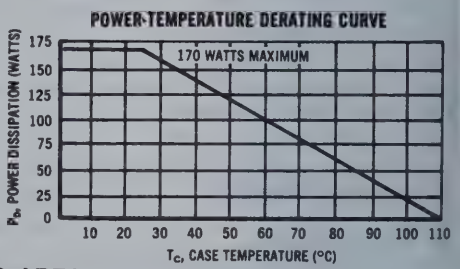
Rating	Symbol	MP500 MP504	MP501 MP505	MP502 MP506	Unit
Collector-Base Voltage	V_{CB}	45	60	75	Volts
Collector-Emitter Voltage	V_{CES}	45	60	75	Volts
Collector-Emitter Voltage	V_{CEO}	30	45	60	Volts
Emitter-Base Voltage	V_{EB}	25	30	40	Volts
Collector Current	I_C	60	60	60	Amp
Power Dissipation at $T_C = 25^oC$	P_D	170	170	170	Watts
Junction Temperature Range	T_J	← -65 to+ 110 →			°C

POWER DERATING

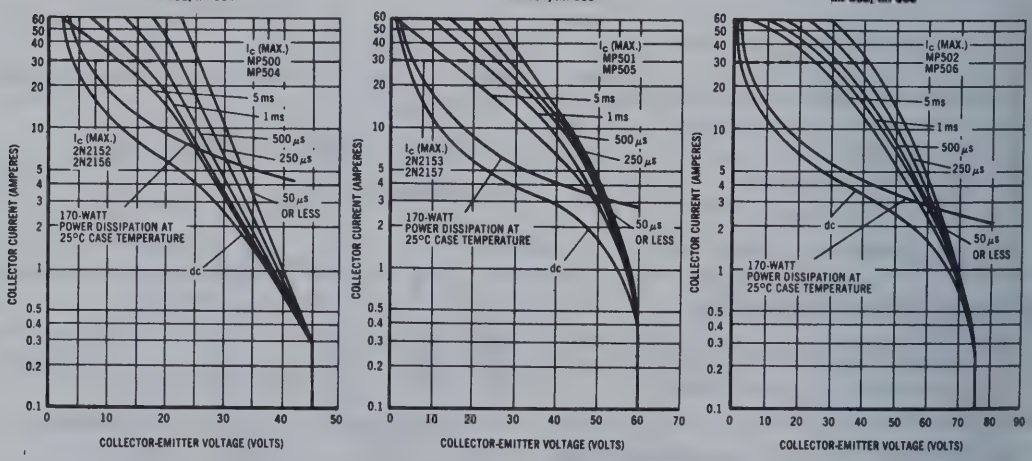
The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110^\circ - T_C}{0.5}$$



SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

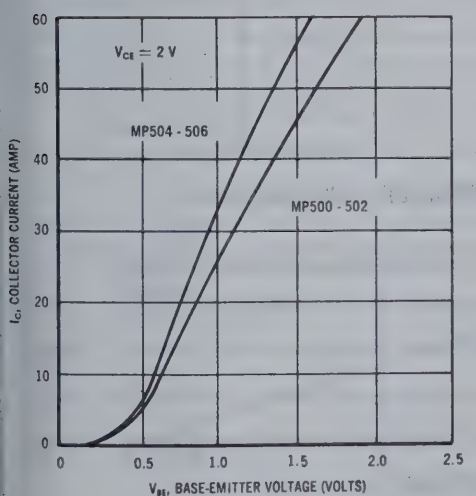
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO1}				mAdc
(V_{CB} = -45 V, I_E = 0)	MP500 MP504		—	0.9	4.0	
(V_{CB} = -60 V, I_E = 0)	MP501 MP505		—	0.9	4.0	
(V_{CB} = -75 V, I_E = 0)	MP502 MP506		—	0.9	4.0	
Collector-Base Cutoff Current		I_{CBO}				mAdc
(V_{CB} = V_{CBmax}, I_E = 0, T_C = +71°C)			—	4.0	15	
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = -2 V, I_E = 0)			—	80	200	
Emitter-Base Cutoff Current		I_{EBO}				mAdc
(V_{EB} = -25 V, I_C = 0)	MP500 MP504		—	0.2	4.0	
(V_{EB} = -30 V, I_C = 0)	MP501 MP505		—	0.2	4.0	
(V_{EB} = -40 V, I_C = 0)	MP502 MP506		—	0.2	4.0	
Emitter-Base Cutoff Current		I_{EBO}				mAdc
(V_{EB} = $V_{EB\,max}$, I_C = 0, T_C = +71°C)			—	2.7	15	
Collector-Emitter Breakdown Voltage*		BV_{CES}*				Vdc
(I_C = 300 mA, V_{EB} = 0)	MP500 MP504		-45	—	—	
	MP501 MP505		-60	—	—	
	MP502 MP506		-75	—	—	
Collector-Emitter Breakdown Voltage*		BV_{CEO}*				Vdc
(I_C = 1.0 A, I_B = 0)	MP500 MP504		-30	—	—	
	MP501 MP505		-45	—	—	
	MP502 MP506		-60	—	—	
Floating Potential		V_{EBF}				Vdc
(V_{CB} = 45 V, I_E = 0)	MP500 MP504		—	—	1.0	
(V_{CB} = 60 V, I_E = 0)	MP501 MP505		—	—	1.0	
(V_{CB} = 75 V, I_E = 0)	MP502 MP506		—	—	1.0	
DC Current Transfer Ratio		h_{FE1}				—
(I_C = 15 A, V_{CE} = 2 V)	MP500 through MP502		30	47	60	
	MP504 through MP506		50	63	100	
(I_C = 50 A, V_{CE} = 2 V)	All Types	h_{FE}	12	20	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 15 A, I_B = 1 A)			—	0.11	0.2	
(I_C = 50 A, I_B = 5 A)			—	0.2	0.45	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 15 A, I_B = 1 A)			—	0.7	1.5	
(I_C = 50 A, I_B = 5 A)			—	2.0	2.5	
Common Emitter Cutoff Frequency		$f_{\alpha e}$				kHz
(I_C = 15 A, V_{CE} = 2 V)			2	3.6	—	

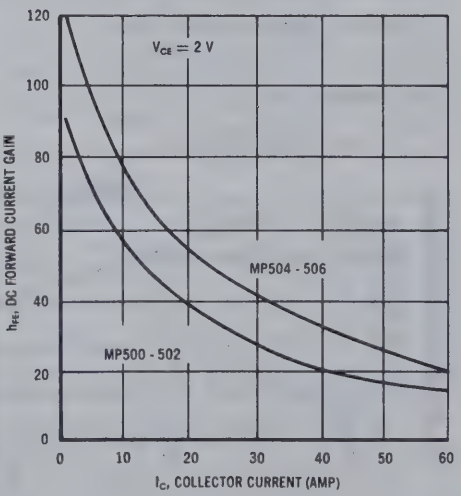
*To avoid excessive heating of collector junction, perform this test with a sweep method.

INPUT AND TRANSFER CHARACTERISTICS

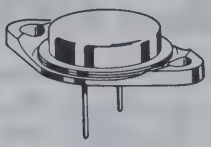
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



DC CURRENT GAIN versus COLLECTOR CURRENT



MP525 (GERMANIUM)



CASE 3
(TO-3 modified)

Germanium PNP power transistor designed for audio amplifier applications requiring gains of 30 — 150 at I_C = 3 amp.

MAXIMUM RATINGS

Rating	Symbol	MP525	Unit
Collector-Emitter Voltage	V_{CEX}	60	Vdc
Collector Current (Continuous)	I_C	7	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 106 1.25	 Watts W/°C
Junction Temperature Range	T_J	-65 to +110	°C
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 300 mA, R_{BE} = 10 ohms)	BV_{CER}	35	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 0)	I_{CES}	-	15	mA
Collector-Emitter Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc)	I_{CEX}	-	15	mA
Collector-Base Cutoff Current (V_{CB} = 2 Vdc, I_E = 0)	I_{CBO}	-	200	μA
DC Current Gain (I_C = 3 Adc, V_{CE} = 2 Vdc)	h_{FE}	30	150	-

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE

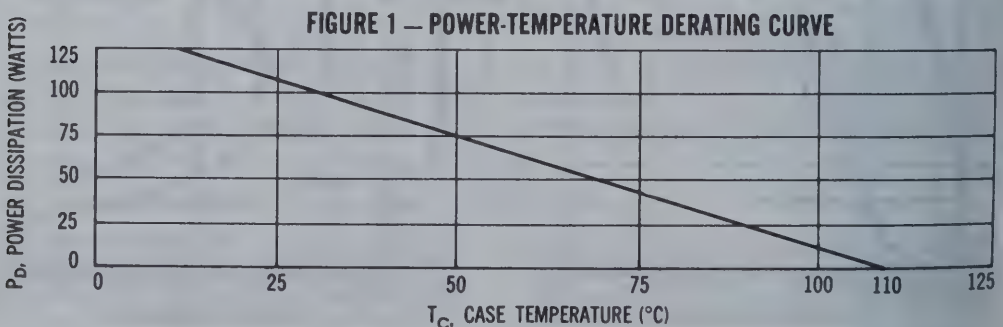


FIGURE 2 — DC CURRENT GAIN

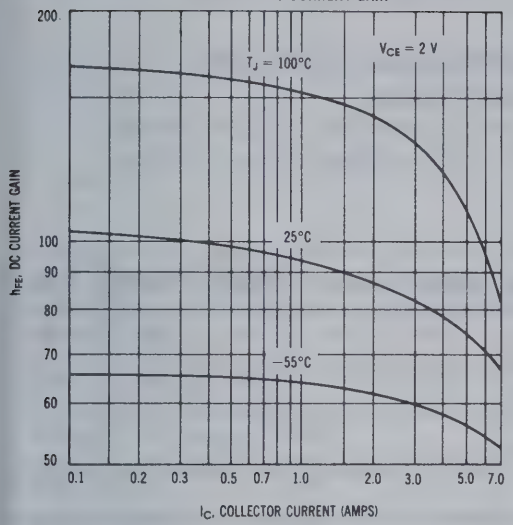


FIGURE 3 — TRANSCONDUCTANCE

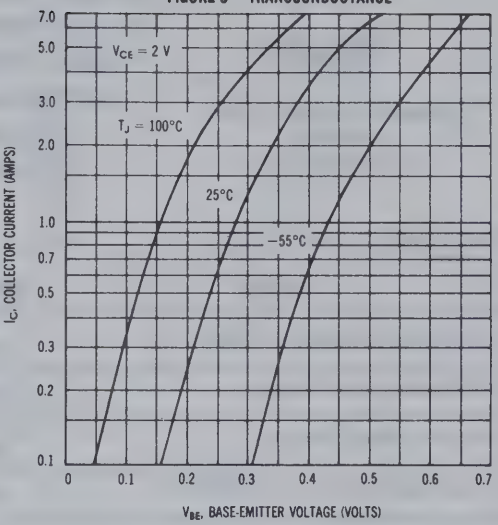


FIGURE 4 — ACTIVE REGION SAFE OPERATING AREA

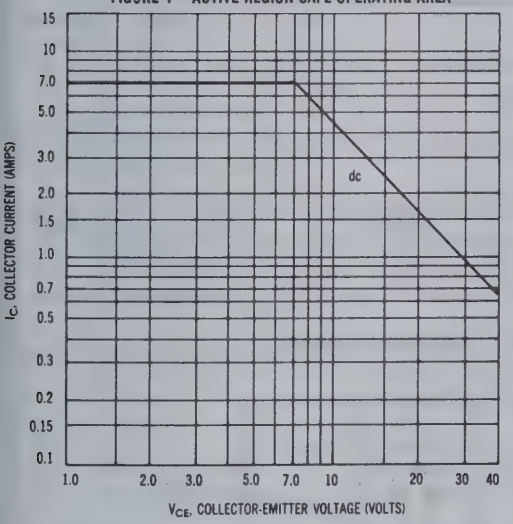
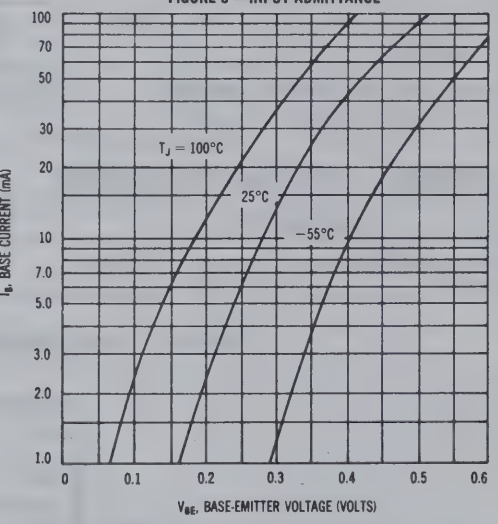


FIGURE 5 — INPUT ADMITTANCE



NOTE: Transistors are numerically coded to identify gain ranges as shown. No guarantee is made of gain distribution.
$I_C = 3$ Adc, $V_{CE} = 2$ Vdc

Bracket	h_{FE}	
	Min.	Max.
MP525-1	30	45
-2	40	60
-3	50	75
-4	60	90
-5	80	120
-6	100	150

MP600 (GERMANIUM)
thru
MP603



Collector Connected to Case
CASE 11A
(TO-3 modified)

PNP Germanium power transistors designed for high-current switching applications requiring low saturation voltages, short switching times and good sustaining voltage capability.

- Alloy Diffused Epitaxial Construction
- Low Saturation Voltages –
  $V_{CE(sat)}$ = 0.75 Vdc (Max) @ I_C = 25 Adc
  $V_{BE(sat)}$ = 1.2 Vdc (Max) @ I_C = 25 Adc

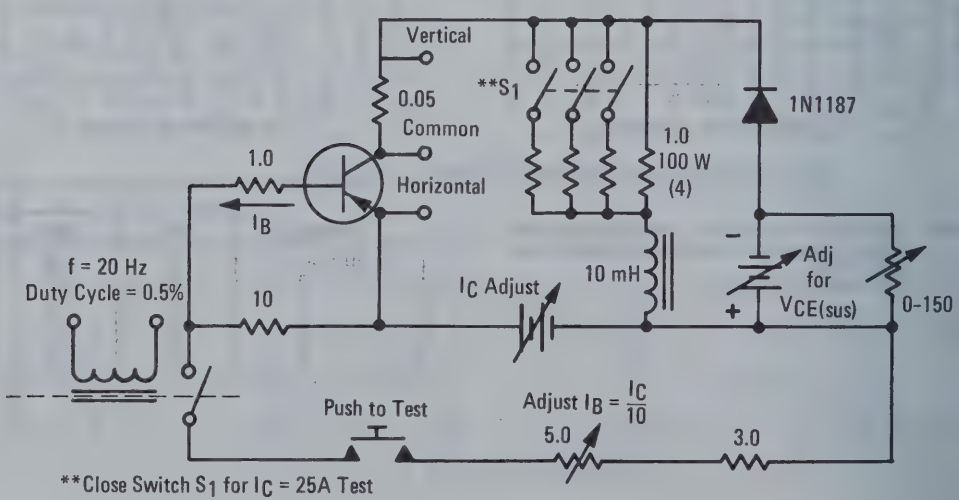
MAXIMUM RATINGS

Rating	Symbol	MP600	MP601	MP602	MP603	Unit
Collector-Emitter Voltage	V_{CEO}	50	60	70	80	Vdc
Collector-Base Voltage	V_{CB}	75	75	90	90	Vdc
Emitter-Base Voltage	V_{EB}	1.5				Vdc
Collector Current - Continuous	I_C	25				Adc
Base Current - Continuous	I_B	5.0				Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	85 1.0				Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS:					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	MP600	BV_{CEO}	50	-	Vdc
	MP601		60	-	
	MP602		70	-	
	MP603		80	-	
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 5.0 Adc)	MP600	$V_{CE(sus)}$	50	-	Vdc
	MP601		60	-	
	MP602		70	-	
	MP603		80	-	
(I_C = 25 Adc)	MP600		30	-	
	MP601		40	-	
	MP602		40	-	
	MP603		50	-	
Emitter-Base Breakdown Voltage (I_E = 100 mAdc, I_C = 0)		BV_{EBO}	1.5	-	Vdc
Floating Potential (V_{CB} = 60 Vdc, I_E = 0)		V_{EBF}	-	0.4	Vdc
Collector Cutoff Current (V_{CE} = 75 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP600, MP601	I_{CEX}	-	10	mAdc
(V_{CE} = 90 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP602, MP603		-	10	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	200	μAdc
Emitter Cutoff Current (V_{EB} = 0.5 Vdc, I_C = 0)		I_{EBO}	-	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	50	-	-
Collector-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 1.25 Adc)		$V_{CE(sat)}$	-	0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 1.25 Adc)		$V_{BE(sat)}$	-	1.2	Vdc
Emitter-Base On Voltage (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		$V_{EB(on)}$	-	0.6	Vdc
Pulse Energy Test* (See Figure 2) (I_C = 3.3 Adc, V_{CE} = 30 Vdc)		PET*	1.0	-	Joule
SWITCHING CHARACTERISTICS					
Rise Time	(V_{CC} = 22 Vdc, I_C = 15 Adc, I_{B1} = I_{B2} = 1.5 Adc) See Figure 3	t_r	-	10	μs
Storage Time		t_s	-	6.0	μs
Fall Time		t_f	-	13	μs

*Pulse Test: Pulse Width = 10 ms, Duty Cycle = 2.5%.

FIGURE 2 – PULSE ENERGY TEST CIRCUIT

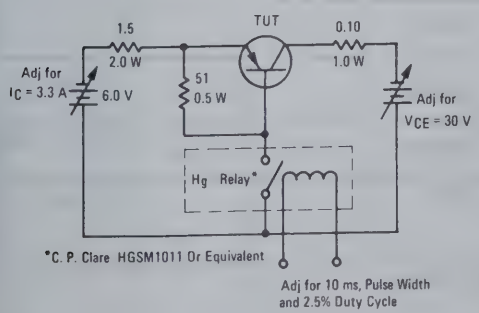
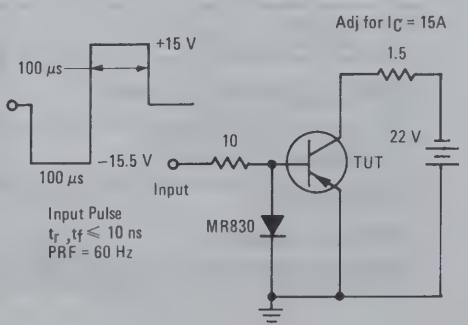
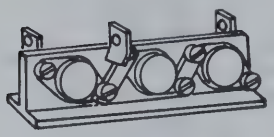


FIGURE 3 – SWITCHING TIME TEST CIRCUIT



MP800 (GERMANIUM)
MP801



CASE 118

PNP germanium power transistor designed for ultra-high current applications requiring high gain and extremely low saturation voltage. Collector electrically isolated from heat sink.

MAXIMUM RATINGS

Rating	Symbol	MP800	MP801	Unit
Collector-Emitter Voltage	V_{CEO}	60	45	Vdc
Collector-Emitter Voltage	V_{CES}	75	60	Vdc
Emitter-Base Voltage	V_{EB}	20		Vdc
Collector Current*	I_C*	150		Amp
Total Device Dissipation @ T_C = 25°C	P_D	250		Watts
Operating Junction Temperature Range	T_J	-65 to +110		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.33	°C/W

ELECTRICAL CHARACTERISTICS

** For Epoxy Encapsulated unit, add "A" to device type, i.e. MP800A

(T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 Adc, I_B = 0)	MP800	BV_{CEO}	60	-	Vdc
	MP801		45	-	
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	MP800	I_{CBO}	-	12	mAdc
(V_{CB} = 60 Vdc, I_E = 0)	MP801		-	12	
ON CHARACTERISTICS					
DC Current Gain (I_C = 150 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	15	-	-
Collector-Emitter Saturation Voltage (I_C = 150 Adc, I_B = 15 Adc)		$V_{CE(sat)}$	-	0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 150 Adc, I_B = 15 Adc)		$V_{BE(sat)}$	-	1.0	Vdc
Safe Operating Area	(Figure 1)	SOA			Volts
100% Test - Clamped V_{CE}	MP800		-	45	
	MP801		-	40	

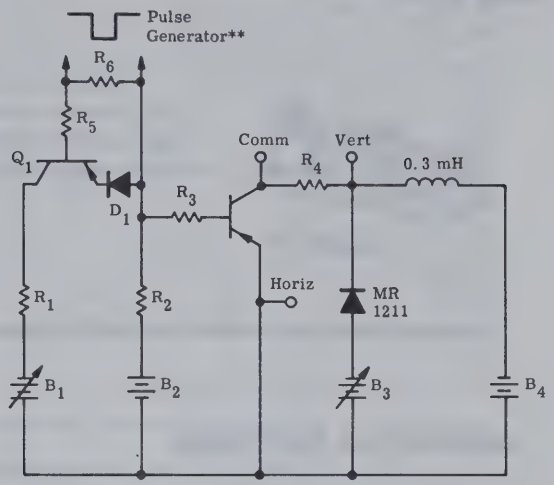
* For currents above 150 Amp, contact your local representative.

FIGURE 1 — SAFE OPERATING AREA TEST CURRENT

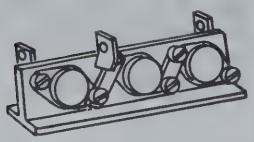
R_1 = 1.0Ω, 200 W
R_2 = 10Ω, 2.0 W
R_3 = 0.1Ω, 1%, 20 W
R_4 = 0.001Ω
R_5 = 10Ω, 2.0 W
R_6 = 50Ω, 1.0 W
Q_1 = 2N2832
D_1 = 1N1183

B_1 = Adj for $I_{B(on)}$ = 15 A
B_2 = 6.0 V
B_3 = Adj for clamped V_{CE}
B_4 = 20 V

** Adj P. W. to obtain I_C = 150 A



MP900 (GERMANIUM)
MP901
MP902



CASE 118

Collector is electrically isolated from heat sink chassis

PNP germanium power transistors designed for high-power inverters up to 2.0 kW, high-current switching, motor speed control, and high-current power supplies applications.

MAXIMUM RATINGS

Rating	Symbol	MP900	MP901	MP902	Unit
Collector-Emitter Voltage	V_{CEO}	60	90	120	Vdc
Collector-Base Voltage	V_{CB}	80	110	140	Vdc
Emitter-Base Voltage	V_{EB}	2.0			Vdc
Collector Current	I_C	150			Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	250 2.94			Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +110			°C

THERMAL CHARACTERISTICS

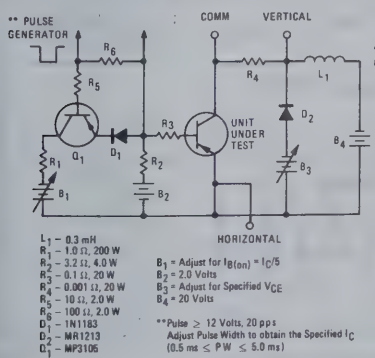
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.33	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector Cutoff Current		I_{CEO}				mAdc
(V_{CE} = 60 Vdc, I_B = 0)	MP900		-	-	300	
(V_{CE} = 90 Vdc, I_B = 0)	MP901		-	-	300	
(V_{CE} = 120 Vdc, I_B = 0)	MP902		-	-	300	
Collector Cutoff Current		I_{CEX}				mAdc
(V_{CE} = 80 Vdc, V_{BE} = 0.2 Vdc, T_C = 70°C)	MP900		-	-	50	
(V_{CE} = 110 Vdc, V_{BE} = 0.2 Vdc, T_C = 70°C)	MP901		-	-	50	
(V_{CE} = 140 Vdc, V_{BE} = 0.2 Vdc, T_C = 70°C)	MP902		-	-	50	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 2.0 Vdc, I_E = 0)	All Types		-	-	0.6	
(V_{CB} = 80 Vdc, I_E = 0)	MP900		-	-	10	
(V_{CB} = 110 Vdc, I_E = 0)	MP901		-	-	10	
(V_{CB} = 140 Vdc, I_E = 0)	MP902		-	-	10	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 70 Adc, V_{CE} = 2.0 Vdc)			20	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 150 Adc, I_B = 30 Adc)			-	-	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 150 Adc, I_B = 30 Adc)			-	-	1.3	
Safe Operating Area* (Figure 1)		SOA*				Vdc
(I_C = 50 Adc)	MP900		80	-	-	
	MP901		85	-	-	
	MP902		100	-	-	
(I_C = 150 Adc)	MP900		35	-	-	
	MP901		45	-	-	
	MP902		55	-	-	
SWITCHING CHARACTERISTICS						
Rise Time	(I_C = 75 Adc, I_{B1} = I_{B2} = 7.5 Adc, (Figure 2)	t_r	-	25	-	μs
Storage Time		t_s	-	5	-	μs
Fall Time		t_f	-	15	-	μs

*100% Test-Clamped V_{CE}

FIGURE 1 – SAFE OPERATING AREA TEST CIRCUIT

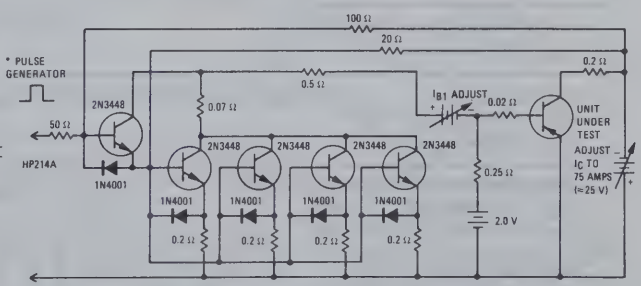


L_1 – 0.3 mH
R_1 – 1.0 Ω, 200 W
R_2 – 3.2 Ω, 4.0 W
R_3 – 0.1 Ω, 20 W
R_4 – 0.001 Ω, 20 W
R_5 – 10 Ω, 2.0 W
R_6 – 100 Ω, 2.0 W
D_1 – 1N1183
D_2 – MR1213
D_3 – MP3105

B_1 = Adjust for $I_{B(on)} = I_C/5$
B_2 = 2.0 Volts
B_3 = Adjust for Specified V_{CE}
B_4 = 20 Volts

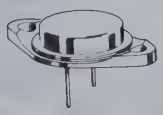
**Pulse ≥ 12 Volts, 20 pps
Adjust Pulse Width to obtain the Specified I_C
(0.5 ms ≤ PW ≤ 5.0 ms)

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



*INPUT PULSE REPETITION RATE = 20 Hz, PULSE WIDTH = 100 μs.

MP1612, A, B (GERMANIUM)



CASE 11A
(TO-3 modified)

High-current, germanium PNP power transistor developed specially for high-speed, high-frequency, applications such as television horizontal deflection circuits.

MAXIMUM RATINGS

Rating	Symbol	MP1612	MP1612A	MP1612B	Unit
Collector-Base Voltage	V_{CB}	100	140	160	Volts
Emitter-Base Voltage	V_{EB}	2.5	2.5	2.5	Volts
Collector Current (Continuous)	I_C	20	20	20	Amp
Base Current (Continuous)	I_B	5	5	5	Amp
Power Dissipation	P_D	85	85	85	Watts
Operating Junction Temperature Range	T_J	-65 to +110			°C

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mA
(V_{CB} = 80 V, I_E = 0)	MP1612		—	10	
(V_{CB} = 120 V, I_E = 0)	MP1612A		—	10	
(V_{CB} = 140 V, I_E = 0)	MP1612B		—	10	
Collector-Emitter Current		I_{CES}			mA
(V_{CE} = 100 V, V_{BE} = 0)	MP1612		—	20	
(V_{CE} = 140 V, V_{BE} = 0)	MP1612A		—	20	
(V_{CE} = 160 V, V_{BE} = 0)	MP1612B		—	20	
Collector-Emitter Cutoff Current		I_{CEX}			mA
(V_{CE} = 50 V, V_{BE} = 0.2 V, T_C = +85°C)	MP1612		—	40	
(V_{CE} = 75 V, V_{BE} = 0.2 V, T_C = +85°C)	MP1612A		—	40	
(V_{CE} = 100 V, V_{BE} = 0.2 V, T_C = +85°C)	MP1612B		—	40	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 50 mAdc, I_C = 0)			2.5	—	
DC Current Gain		h_{FE}			—
(I_C = 5.0 A, V_{CB} = 2 V)			40	—	
(I_C = 10 A, V_{CB} = 2 V)			25	100	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)			—	0.30	
(I_C = 20 Adc, I_B = 2.0 Adc)			—	0.5	
Fall Time (Figure 5)		t_f			μs
(I_C = 5 Adc, I_{B1} = 0.5 Adc, I_{B2} = 1.0 Adc)			—	1.25	
(I_C = 10 Adc, I_{B1} = 0.5 Adc, I_{B2} = 1.0 Adc)			—	1.5	

SAFE OPERATING AREAS

FIGURE 1 — MP1612

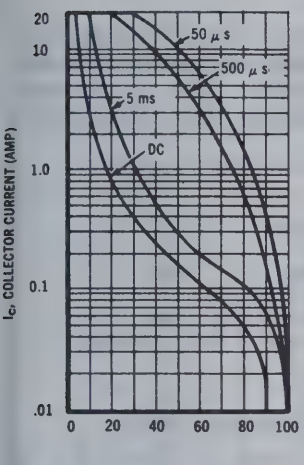


FIGURE 2 — MP1612A

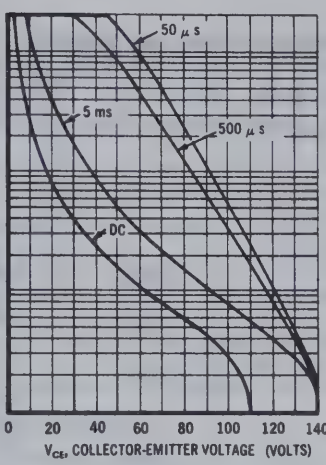
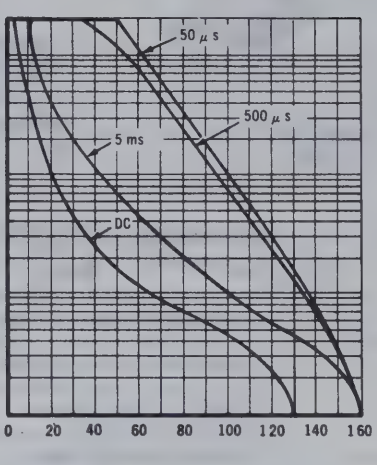
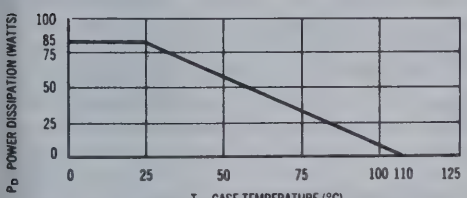


FIGURE 3 — MP1612B



The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. As secondary breakdown is independent of temperature and duty cycle, these curves can be used as long as the average power derating curve (Figure 4) is also taken into consideration to insure operation below the maximum junction temperature.

FIGURE 4 — POWER – TEMPERATURE DERATING CURVE



THESE TRANSISTORS ARE ALSO SUBJECT TO SAFE AREA CURVES AS INDICATED BY FIGURES 1, 2, 3.

FIGURE 5 — FALL TIME TEST CIRCUIT

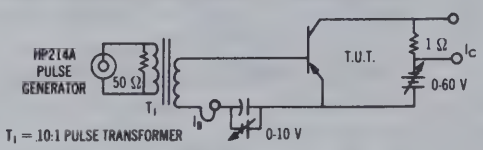
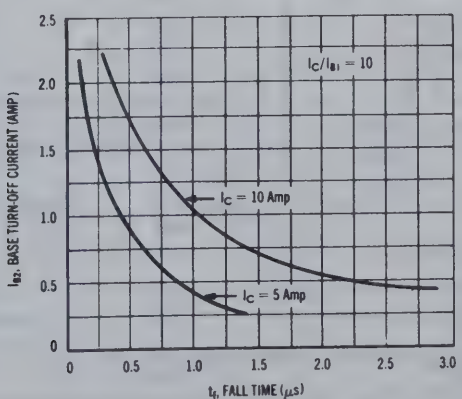


FIGURE 6 — BASE TURN-OFF CURRENT versus FALL TIME



MP1613 (GERMANIUM)



CASE 11
(TO-3)

Medium-current germanium PNP power transistor, designed for use in 12 Volt vertical deflection circuits in television receivers; features: high breakdown voltage, low leakage current, and low saturation voltage.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	75	Vdc
Collector-Emitter Voltage	V_{CES}	90	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	50	Vdc
Collector Current — Continuous — Peak	I_C	7.0 15	Adc Adc
Base Current — Continuous	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	85 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

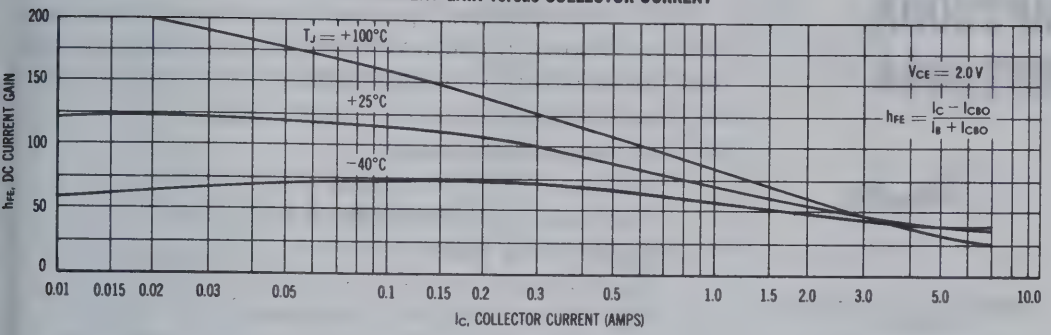
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

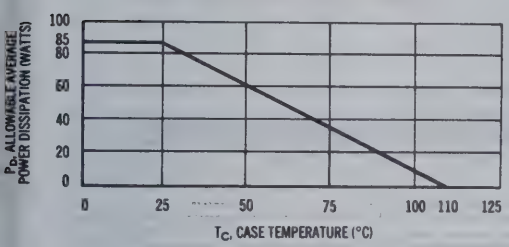
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc, I_B = 0)	BV_{CEO}*	75	-	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc, V_{BE} = 0)	BV_{CES}*	90	-	-	Vdc
Collector Cutoff Current (V_{CE} = 37.5 Vdc, I_B = 0)	I_{CEO}	-	-	30	mAdc
Collector Cutoff Current (V_{CE} = 90 Vdc, V_{BE} = 1.0 Vdc, T_C = +100°C)	I_{CEX}	-	-	10	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0) (V_{CB} = V_{CB} max, I_E = 0)	I_{CBO}	- -	- -	0.06 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 12 Vdc, I_C = 0)	I_{EBO}	-	-	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	- 40	120 70	200 -	-
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc)	$V_{CE(sat)}$	-	-	0.25	Vdc

* Sweep Test: 1/2 sine wave, 60 Hz.

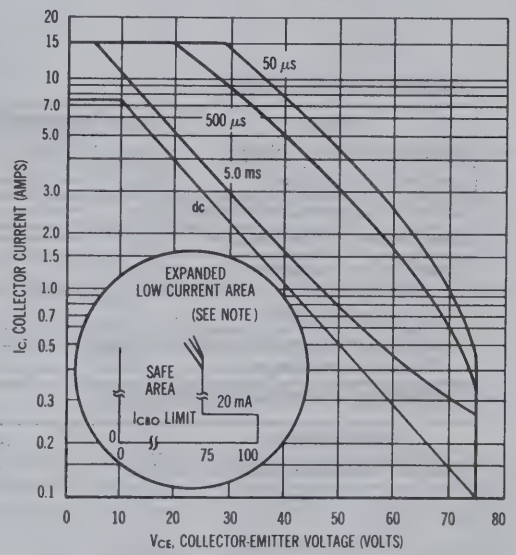
DC CURRENT GAIN versus COLLECTOR CURRENT



POWER-TEMPERATURE DERATING CURVE

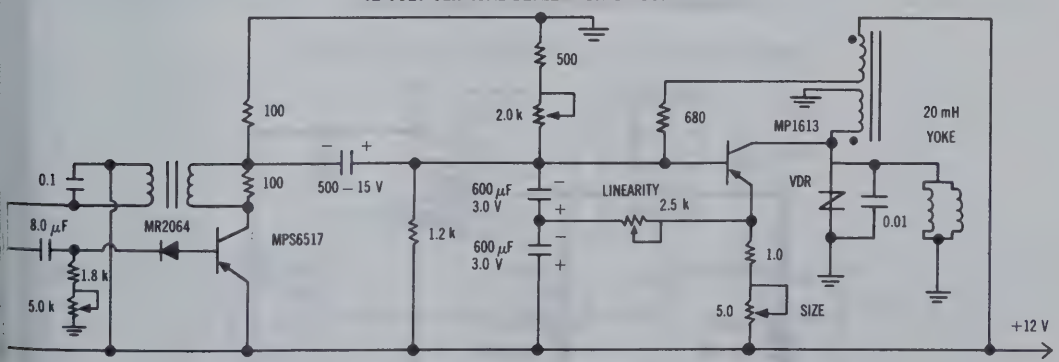


SAFE OPERATING AREAS



NOTE: — The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

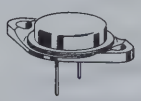
12 VOLT VERTICAL DEFLECTION CIRCUIT



MP2000A (GERMANIUM)
MP2100A
MP2200A
MP2300A
MP2400A

PNP Alloy-Diffused Epitaxial Germanium power transistors designed for high-voltage switching, core drivers, and power converter applications.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages –
  $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 25 Adc
  $V_{BE(sat)}$ = 1.0 Vdc (Max) @ I_C = 25 Adc
- Fast Switching Times –
  t_{on} = 9.0 μs (Typ) @ I_C = 10 Adc
  t_{off} = 17 μs (Typ) @ I_C = 10 Adc



Collector Connected To Case
CASE 11A
(TO-3 modified)

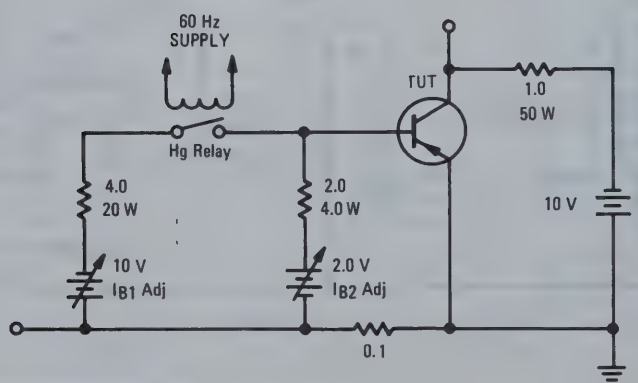
MAXIMUM RATINGS

Rating	Symbol	MP2000A	MP2100A	MP2200A	MP2300A	MP2400A	Unit
Collector-Emitter Voltage	V_{CEO}	30	60	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	2.0					Vdc
Collector Current-Continuous	I_C	25					Adc
Base Current – Continuous	I_B	5.0					Adc
Total Device Dissipation @ T_C = 25°C	P_D	106					Watts
Derate above 25°C		1.25					W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +110					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

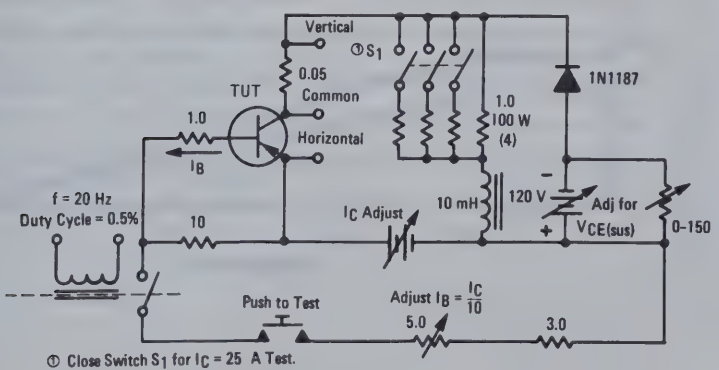
FIGURE 1 – SWITCHING TEST CIRCUIT



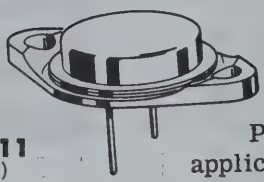
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_E = 0)	MP2000A	BV_{CEO}	30	–	–	Vdc
	MP2100A		60	–	–	
	MP2200A		80	–	–	
	MP2300A		100	–	–	
	MP2400A		120	–	–	
Collector-Emitter Sustaining Voltage (Figure 2) (I_C = 8.0 Adc)	MP2000A	$V_{CE(sus)}$	30	–	–	Vdc
	MP2100A		60	–	–	
	MP2200A		80	–	–	
	MP2300A		100	–	–	
	MP2400A		120	–	–	
(I_C = 25 Adc)	MP2000A		30	–	–	
	MP2100A, MP2200A, MP2300A		60	–	–	
	MP2400A		80	–	–	
Emitter-Base Breakdown Voltage (I_E = 0.5 Adc, I_C = 0)		BV_{EBO}	2.0	–	–	Vdc
Collector Cutoff Current		I_{CEX}				mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2000A		–	–	10	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	MP2000A		–	–	25	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2100A		–	–	10	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	MP2100A		–	–	25	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2200A		–	–	10	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	MP2200A		–	–	25	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2300A		–	–	10	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	MP2300A		–	–	25	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	MP2400A		–	–	10	
(V_{CE} = 140 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	MP2400A		–	–	25	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	–	–	200	μAdc
ON CHARACTERISTIC						
DC Current Gain (I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	25	–	–	–
Collector-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{CE(sat)}$	–	–	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{BE(sat)}$	–	–	1.0	Vdc
Base-Emitter On Voltage (I_C = 8.0 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	–	–	0.8	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		f_T	–	210	–	kHz
Turn-On Time (Figure 1) (I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)		t_{on}	–	9.0	–	μs
Turn-Off Time (Figure 1) (I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)		t_{off}	–	17	–	μs

FIGURE 2 – SUSTAINING VOLTAGE TEST CIRCUIT



MP2060 thru MP2063 (GERMANIUM)

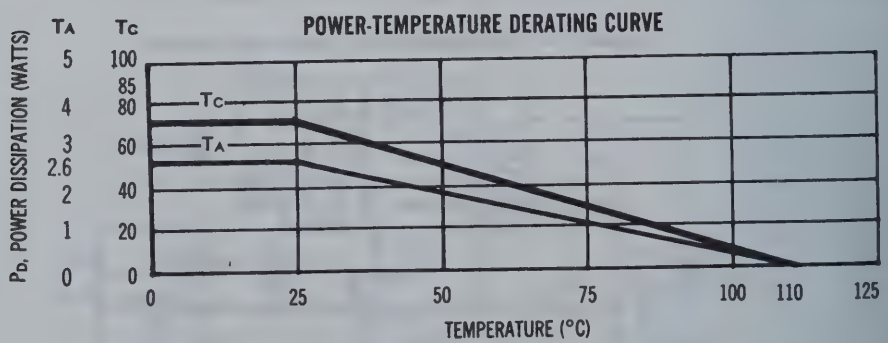


CASE 11
(TO-3)

PNP germanium power transistors for audio amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	MP2060	MP2061	MP2062	MP2063	Unit
Collector-Emitter Voltage	V_{CES}	30	45	60	75	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	25	35	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	75	90	Vdc
Emitter-Base Voltage	V_{EB}	← 20 →				Vdc
Collector Current (Continuous)	I_C	← 7 →				Adc
Peak Collector Current (PW ≦ 5 ms)	I_C	← 15 →				Adc
Base Current (Continuous)	I_B	← 2 →				Adc
Storage Temperature	T_{stg}	← -65 to +110 →				°C
Operating Case Temperature	T_C	← - 65 to +110 →				°C
Total Device Dissipation @T_C = 25°C Derate above 25°C	P_D	← 85 → ← 1 →				Watts W/°C
Thermal Resistance Junction to Case	θJC	1.0				°C/W
Thermal Resistance Case to Ambient	θCA	32.7				°C/W



MP2060 thru MP2063 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
DC Forward Current Gain (Note 1) (I_C = 3 Adc, V_{CE} = 2 Vdc)		h_{FE}	30	—	150	—
Current Gain-Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 12 Vdc)		f_T	—	600	—	kc
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{BE(sat)}$	—	—	0.70	Vdc
DC Transconductance (I_C = 3.0 Adc, V_{CE} = 2 Vdc)		g_{FE}	3.0	—	—	mhos
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc)	MP2060	BV_{CES}*	30	—	—	Vdc
	MP2061		45	—	—	
	MP2062		60	—	—	
	MP2063		75	—	—	
Collector-Emitter Sustaining Voltage* (I_C = 500 mAdc)	MP2060	$BV_{CEO(sus)}$*	25	—	—	Vdc
	MP2061		35	—	—	
	MP2062		40	—	—	
	MP2063		60	—	—	
Collector-Base Breakdown Voltage (I_C = 20 mAdc)	MP2060	BV_{CBO}	40	—	—	Vdc
	MP2061		60	—	—	
	MP2062		75	—	—	
	MP2063		90	—	—	
Collector-Base Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 2 Vdc)			—	—	0.060	
(V_{CB} = 25 Vdc)	MP2060		—	—	1.0	
(V_{CB} = 35 Vdc)	MP2061		—	—	1.0	
(V_{CB} = 40 Vdc)	MP2062		—	—	1.0	
(V_{CB} = 60 Vdc)	MP2063		—	—	1.0	
Collector-Emitter Cutoff Current		I_{CEX}				mAdc
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2060		—	—	10	
(V_{CE} = 45 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2061		—	—	10	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2062		—	—	10	
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2063		—	—	10	
Emitter-Base Cutoff Current (V_{BE} = 20 Vdc)		I_{EBO}	—	—	1.0	mAdc
Input Impedance (I_C = -500 mAdc, V_{CE} = -12 Vdc, i_b = 1 mAdc, f = 1 kHz)		h_{ie}	—	25	—	ohms
Distortion (I_C = -500 mAdc, V_{CE} = -12 Vdc, R_S = 30 ohms, R_L = 25 ohms, R_E (unbypassed) = 0.33 ohm, P_{out} = 2 watts)		η	—	3	—	%

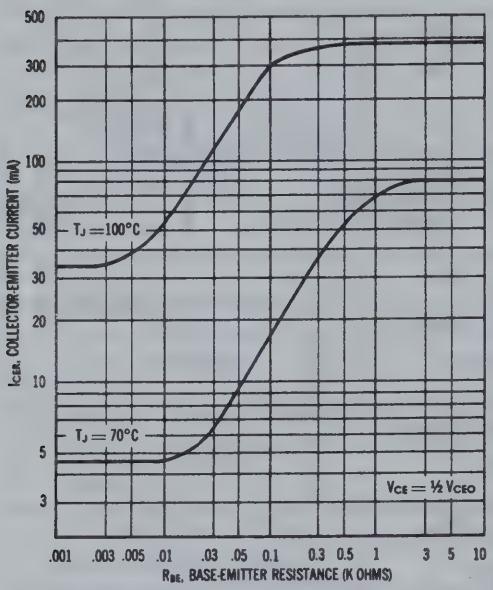
*Sweep Test: 1/2 sine wave, 60 Hz

NOTE: upon customer's request the transistors will be numerically coded to identify matched pairs. The dc current transfer ratios are sorted into approximately 1:1.5 ranges. Any two devices within a bracket constitute a matched pair. No guarantee is made of gain distribution.

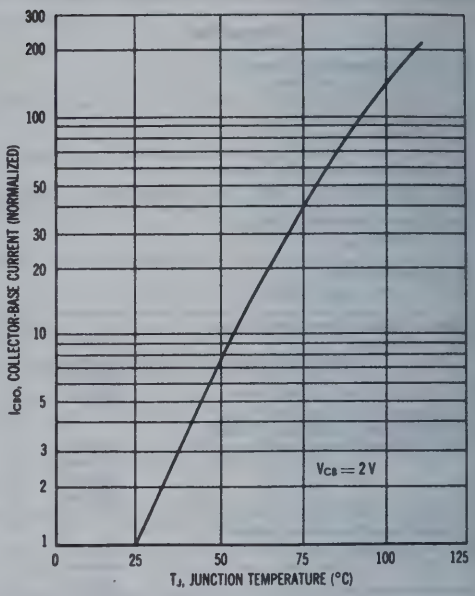
I_C = 3 Adc, V_{CE} = 2 Vdc

Bracket	h_{FE} Min	h_{FE} Max
-1	30	45
-2	40	60
-3	50	75
-4	60	90
-5	80	120
-6	100	150

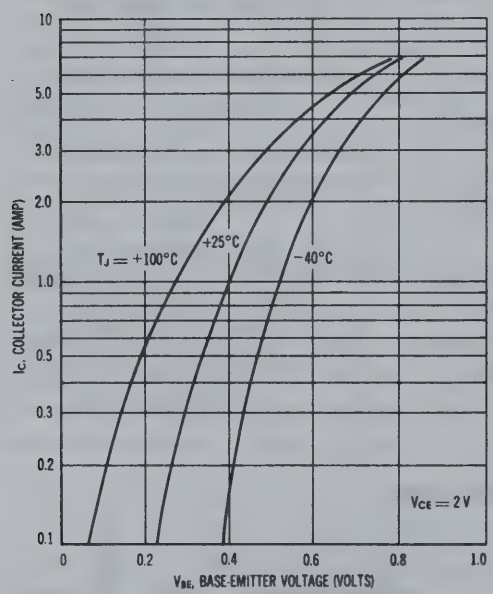
COLLECTOR-EMITTER CURRENT versus BASE-EMITTER RESISTANCE



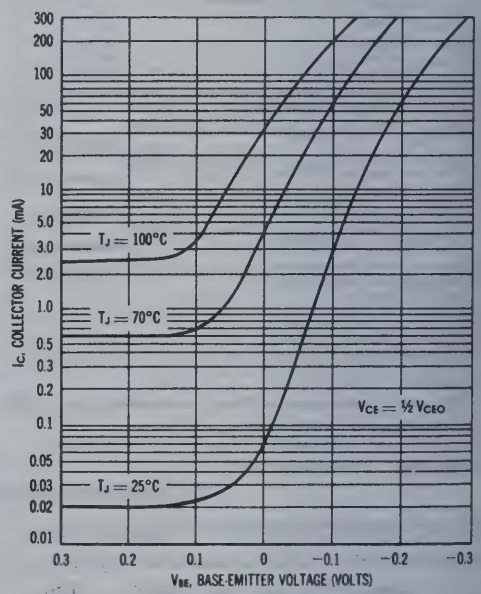
NORMALIZED COLLECTOR-BASE CURRENT



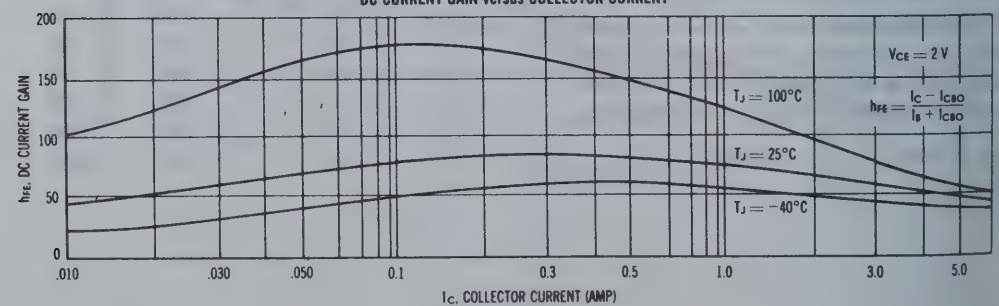
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



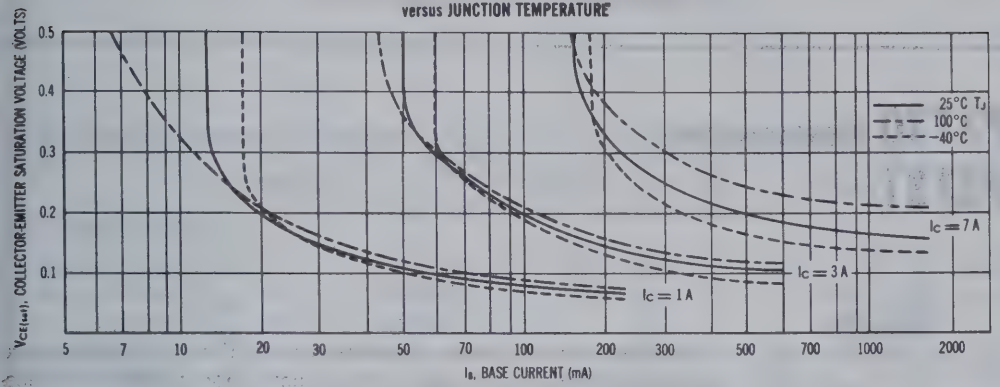
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



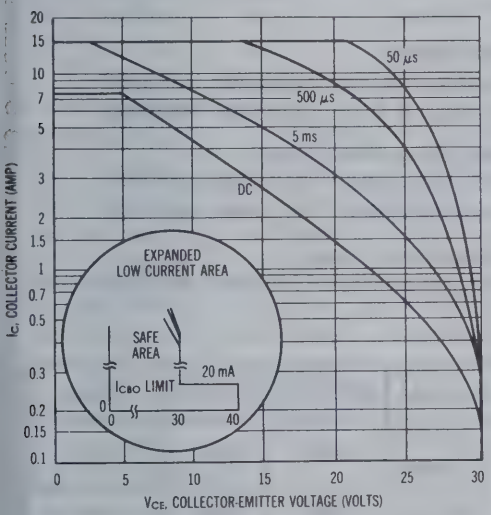
DC CURRENT GAIN versus COLLECTOR CURRENT



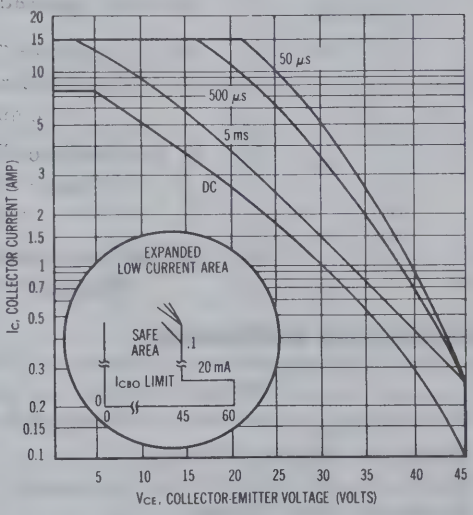
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS
versus JUNCTION TEMPERATURE



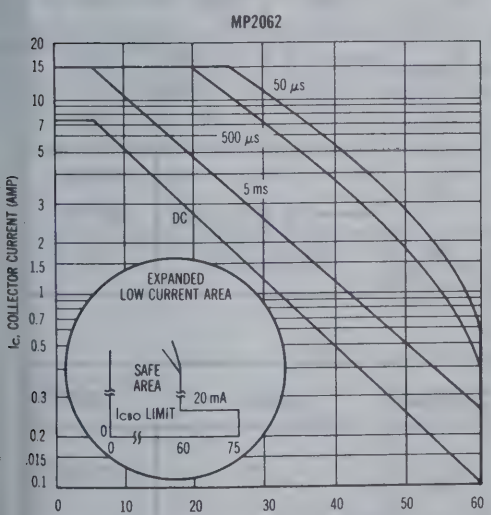
MP2060



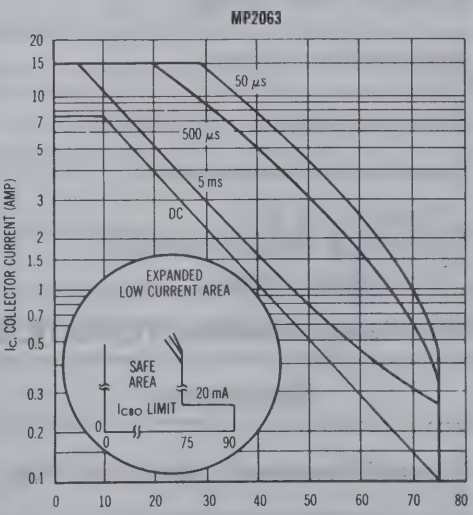
MP2061



MP2062



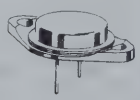
MP2063



MP2100A, MP2200A, MP2300A, MP2400A

For Specifications, See MP2000A Data.

MP3730 (GERMANIUM)
MP3731



Collector Connected to Case
CASE 11
(TO-3)

PNP Germanium power transistors with the MP3730 designed primarily for medium-power, vertical deflection amplifier applications in television receivers and the MP3731 designed for horizontal deflection applications.

- Low Collector Cutoff Current —
  I_{CES} = 5.0 mAdc (Max) @ V_{CE} = 200 Vdc MP3730
  = 10 mAdc (Max) @ V_{CE} = 320 Vdc MP3731
- Low Collector Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 50 mAdc MP3730
  = 0.5 Vdc (Max) @ I_C = 6.0 Adc MP3731
- Low Base-Emitter Saturation Voltage —
  $V_{BE(sat)}$ = 0.8 Vdc (Max) @ I_C = 6.0 Adc MP3731

MAXIMUM RATINGS

Rating	Symbol	MP3730	MP3731	Unit
Collector-Emitter Voltage	V_{CES}	200	320	Vdc
Collector-Base Voltage	V_{CB}	200	320	Vdc
Emitter-Base Voltage	V_{EB}	← 2.0 →		Vdc
Collector Current — Continuous	I_C	5.0	10	Adc
Total Device Dissipation @ T_C = 25°C	P_D	← 56 →		Watts
Derate above 25°C		← 0.67 →		W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110		°C

THERMAL CHARACTERISTICS

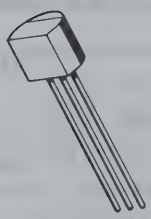
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.5	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current		I_{CES}			mAdc
(V_{CE} = 200 Vdc, V_{BE} = 0)	MP3730		-	5.0	
(V_{CE} = 320 Vdc, V_{BE} = 0)	MP3731		-	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 10 Vdc, I_E = 0)			-	0.4	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 0.5 Vdc, I_C = 0)	MP3730		-	50	
(V_{BE} = 2.0 Vdc, I_C = 0)	MP3731		-	50	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 50 mAdc, V_{CE} = 4.0 Vdc)	MP3730		10	200	
(I_C = 2.25 Adc, V_{CE} = 4.0 Vdc)	MP3730		15	-	
(I_C = 6.0 Adc, V_{CE} = 3.0 Vdc)	MP3731		15	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	MP3730		-	0.5	
(I_C = 2.25 Adc, I_B = 150 mAdc)	MP3730		-	0.75	
(I_C = 6.0 Adc, I_B = 400 mAdc)	MP3731		-	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 6.0 Adc, I_B = 400 mAdc)	MP3731		-	0.8	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 50 mAdc, V_{CE} = 4.0 Vdc)	MP3730		-	0.6	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product		f_T			MHz
(I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)			1.0	-	

MPF102 (SILICON)

Silicon N-channel junction field-effect transistor designed for VHF amplifier and mixer applications.



CASE 29 (5)
(TO-92)

Drain and Source may be interchanged

MAXIMUM RATINGS (T_A = 25°C)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating Junction Temperature	T_J	125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	BV_{GSS}	25	—	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 100°C)	I_{GSS}	— —	2.0 2.0	nAdc μAdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 2.0 nAdc)	$V_{GS(off)}$	—	8	Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 0.2 mAdc)	V_{GS}	0.5	7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc)	I_{DSS}*	2	20	mAdc
DYNAMIC CHARACTERISTICS				
Forward Transfer Admittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)	$\lvert y_{fs} \rvert$*	2000	7500	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	—	7	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)	C_{rss}	—	3	pF
Forward Transfer Admittance, (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$\lvert y_{fs} \rvert$	1600	—	μmhos
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{is})$	—	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{os})$	—	200	μmhos

*Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%

MPF108 (SILICON)

SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTOR

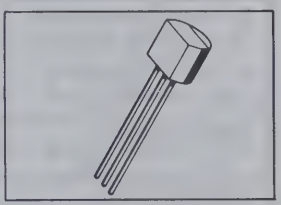
Depletion mode (Type A) transistor designed for VHF amplifier and mixer applications.

- Devices are Classified and Identified in 2:1 I_{DSS} Ranges
- Low Cross-Modulation and Intermodulation Distortion
- Guaranteed 100 MHz Parameters
- Drain and Source Interchangeable
- Low Transfer and Input Capacitance —
  C_{rss} = 1.2 pF (Typ) @ V_{DS} = 15 Vdc
  C_{iss} = 5.0 pF (Typ) @ V_{DS} = 15 Vdc
- Low Leakage Current
- Unibloc Plastic Encapsulated Package

JUNCTION FIELD-EFFECT TRANSISTOR

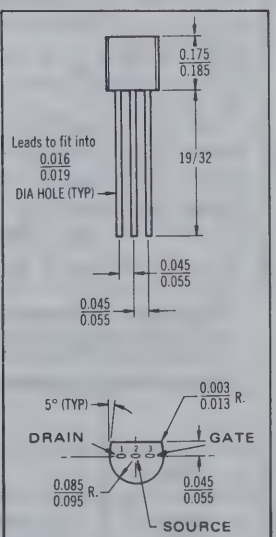
SYMMETRICAL SILICON N-CHANNEL

Type A



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +135	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



CASE 29(5)
TO-92

Drain and Source may be Interchanged.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-25	-	Vdc
Gate-Source Cutoff Voltage* (V_{DS} = 15 Vdc, I_D = 10 μAdc)	$V_{GS(off)}$*	0.5	8.0	Vdc
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)	I_{GSS}	-	1.0	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 100°C)		-	-1.0	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	1.5	24	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{fs}*	2000	7500	μmhos
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$\|y_{fs}\|$	1600	-	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	-	75	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{os})$	-	200	μmhos
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	$Re(y_{is})$	-	800	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	6.5	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	2.5	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)	NF	-	2.5	dB
(V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 k ohm, f = 100 MHz)		-	3.0	

*To characterize these devices to narrower limits, regarding I_{DSS}, $V_{GS(off)}$ and y_{fs}, the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

Color	I_{DSS}	$V_{GS(off)}$	y_{fs}
Orange	1.5 mAdc Min, 3.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μmhos
Yellow	2.5 mAdc Min, 5.0 mAdc Max	0.5 Vdc Min, 5.0 Vdc Max	2000 to 6500 μmhos
Green	4.0 mAdc Min, 8.0 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μmhos
Blue	7.0 mAdc Min, 14 mAdc Max	1.0 Vdc Min, 7.0 Vdc Max	2500 to 7000 μmhos
Violet	12 mAdc Min, 24 mAdc Max	2.0 Vdc Min, 8.0 Vdc Max	3000 to 7500 μmhos

MPF109 (SILICON)

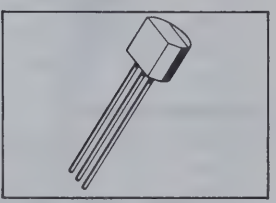
SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTOR

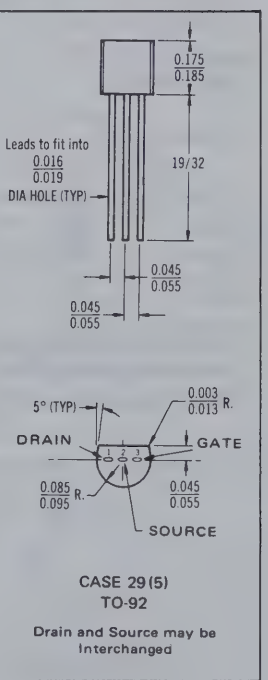
Depletion mode (Type A) transistor designed for general-purpose audio and switching applications.

- Devices are Classified and Identified in 2:1 Zero-Gate Voltage Drain Current Ranges (2:1 I_{DSS} Ranges)
- Drain and Source Interchangeable
- High AC Input Impedance
- High DC Input Resistance
- Low Transfer and Input Capacitance
- Low Cross-Modulation and Intermodulation Distortion
- Unibloc Plastic Encapsulated Package

JUNCTION FIELD-EFFECT TRANSISTOR

SYMMETRICAL SILICON N-CHANNEL





CASE 29(5)
TO-92

Drain and Source may be Interchanged

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +135	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-25	-	Vdc
Gate-Source Cutoff Voltage* (V_{DS} = 15 Vdc, I_D = 10 μAdc)	$V_{GS(off)}$*	0.2	8.0	Vdc
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)	I_{GSS}	-	-1.0	nAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	0.5	24	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{fs}*	800	6000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{os}	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	3.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 1.0 kHz)	NF	-	2.5	dB

*To characterize these devices to narrower limits, regarding I_{DSS}, $V_{GS(off)}$ and y_{fs}, the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

MPF111 (SILICON)

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

Depletion Mode (Type A) device designed for general-purpose amplifier and switching applications.

- Low Transfer Capacitance – C_{rss} = 1.5 pF (Typ) @ V_{DS} = 10 Vdc
- Low Input Capacitance – C_{iss} = 4.5 pF (Typ) @ V_{DS} = 10 Vdc
- Unibloc Plastic Encapsulated Package
- Drain and Source Interchangeable

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

(Type A)



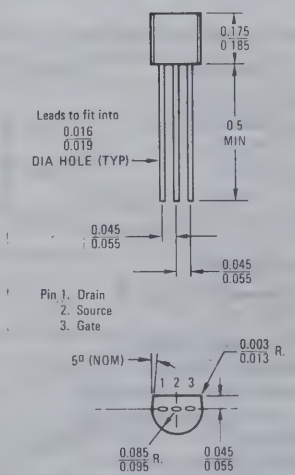
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	20	Vdc
Drain-Gate Voltage	V_{DG}	20	Vdc
Gate-Source Voltage	V_{GS}	-20	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	200 2.0	mW $mW/^oC$
Operating Junction Temperature	T_J	125	^oC
Storage Temperature Range	T_{stg}	-65 to +135	^oC

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)	BV_{GSS}	-20	-35	-	Vdc
Gate Reverse Current (V_{GS} = -10 Vdc, V_{DS} = 0)	I_{GSS}	-	0.1	100	nAdc
Gate-Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	-0.5	-4.0	-10	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ① (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	0.5	8.0	20	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance ① (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{fs}\|$	500	3000	–	μmhos
Output Admittance ① (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	–	20	–	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	4.5	–	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	1.5	–	pF

① Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.



CASE 29 (5)
TO-92

Drain and Source may be Interchanged.

MPF112 (SILICON)

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

Depletion Mode (Type A) device designed for VHF amplifier and mixer applications.

- Low Cross-Modulation Distortion
- Low Transfer Capacitance — C_{rss} = 3.0 pF (Typ) @ V_{DS} = 10 Vdc
- Low Input Capacitance — C_{iss} = 8.0 pF (Typ) @ V_{DS} = 10 Vdc
- Unibloc Plastic Encapsulated Package

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

(Type A)



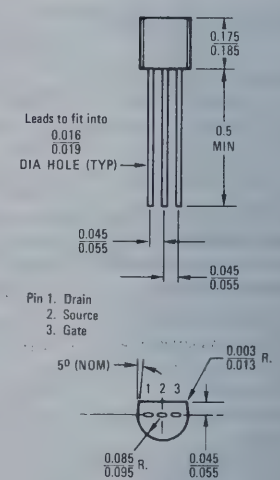
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	25	Vdc
Gate-Source Voltage	V_{GS}	-25	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Operating Junction Temperature	T_J	125	°C
Storage Temperature Range	T_{stg}	-65 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)	BV_{GSS}	-25	–	–	Vdc
Gate Reverse Current (V_{GS} = -10 Vdc, V_{DS} = 0)	I_{GSS}	–	–	100	nAdc
Gate-Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	-0.5	–	-10	Vdc
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current ① (V_{DS} = 10 Vdc, V_{GS} = 0)	I_{DSS}	1.0	–	25	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 kHz) ① (V_{DS} = 10 Vdc, V_{GS} = 0, f = 100 MHz)	$\lvert y_{fs} \rvert$	1000 800	– –	7500 –	μmhos
Input Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	8.0	–	pF
Reverse Transfer Capacitance (V_{DS} = 10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	3.0	–	pF

① Pulse Test: Pulse Width ≤ 630 ms; Duty Cycle ≤ 10%.



CASE 29 (5)
TO-92

Drain and Source may be Interchanged.

MPF120 (SILICON)
MPF121
MPF122

N-CHANNEL DUAL-GATE SILICON-NITRIDE PASSIVATED MOS FIELD-EFFECT TRANSISTORS

... depletion mode (Type B) dual gate transistors designed for VHF amplifier and mixer applications. These types are specified as follows:

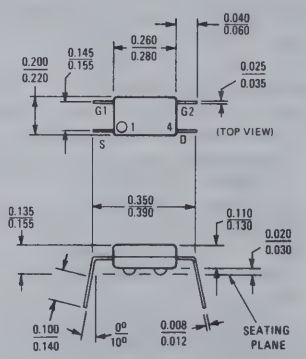
- MPF120 – RF Amplifier @ 105 MHz
  MPF121 – RF Amplifier @ 60 and 200 MHz
  MPF122 – Mixer @ 60 and 200 MHz
- Silicon Nitride Passivation for Excellent Long Term Stability
- Diode Protected Gates
- Low Cost Plastic Package

N–CHANNEL
DUAL GATE MOS FIELD–EFFECT TRANSISTORS
Type B



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	+25	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25^oC$ (Package Limitation)	P_D	500	mW
Derate above 25^oC		5.0	$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +175	^oC



PLASTIC PACKAGE
CASE 206
Weight ≈ 0.23 gram

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) Substrate Connected to Source

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_S = 0, V_{G1} = -4.0 Vdc, V_{G2} = +4.0 Vdc)		$V_{(BR)DSX}$	25	–	–	Vdc
Gate 1 – Source Breakdown Voltage (I_{G1} = ±10 μAdc, V_{G2S} = 0)		$V_{(BR)G1SO}$	±7.0	–	±20	Vdc
Gate 2 – Source Breakdown Voltage (I_{G2} = ±10 μAdc, V_{G2S} = 0)		$V_{(BR)G2SO}$	±7.0	–	±20	Vdc
Gate 1 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 200 μAdc)		$V_{G1S(off)}$	–	–	-4.0	Vdc
Gate 2 to Source Cutoff Voltage (V_{DS} = 15 Vdc, V_{G1S} = 0, I_D = 200 μAdc)		$V_{G2S(off)}$	–	–	-4.0	Vdc
Gate 1 Reverse Leakage Current (V_{G1S} = +6.0 Vdc, V_{G2S} = 0, V_{DS} = 0)		I_{G1SS}	–	–	20	nAdc
Gate 2 Reverse Leakage Current (V_{G2S} = +6.0 Vdc, V_{G1S} = 0, V_{DS} = 0)		I_{G2SS}	–	–	20	nAdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{G1S} = 0, V_{G2S} = 4.0 Vdc)	MPF120	I_{DSS}	2.0	7.0	18	mAdc
	MPF121		5.0	10	30	
	MPF122		2.0	9.0	20	
SMALL-SIGNAL CHARACTERISTICS						
Forward Transadmittance (Gate 1 to Drain) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 10 mAdc, f = 1.0 kHz)	MPF120, 22	$\|y_{fs}\|$	8000	–	18,000	μmhos
	MPF121		10,000	–	20,000	
Input Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	MPF120, 22	C_{iss}	–	4.5	7.0	pF
	MPF121		–	4.5	6.0	
Output Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = I_{DSS}, f = 1.0 MHz)	MPF120, 22	C_{oss}	–	2.5	4.0	pF
	MPF121		–	2.5	3.5	
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, f = 1.0 MHz)		C_{rss}	–	0.023	–	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF)		NF				dB
(f = 105 MHz – Figure 1)	MPF120		–	2.9	5.0	
(f = 60 MHz – Figure 2)	MPF121		–	2.6	5.0	
(f = 200 MHz – Figure 2)	MPF121		–	2.6	5.0	
Common-Source Power Gain (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc, Z_S is optimized for NF)		G_{ps}				dB
(f = 105 MHz – Figure 1)	MPF120		17	19.6	–	
(f = 60 MHz – Figure 2)	MPF121		20	27.8	–	
(f = 200 MHz – Figure 2)	MPF121		17	18.6	–	
Level of Unwanted Signal for 1.0% Cross Modulation (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)		–	–	100	–	mV
Common-Source Conversion Power Gain (Gate 1 Injection, Figure 3) (V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, Local Oscillator Voltage = 925 mVrms)		G_c				dB
(Signal Frequency = 60 MHz, Local Oscillator Frequency = 104 MHz)	MPF122		15	16.5	–	
(Signal Frequency = 200 MHz, Local Oscillator Frequency = 244 MHz)	MPF122		12	13.3	–	

FIGURE 1 – 105 MHz TEST CIRCUIT

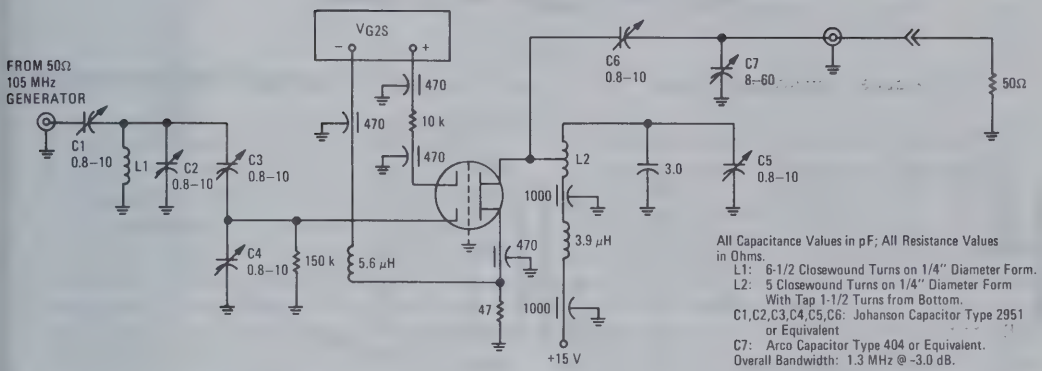


FIGURE 2 – 60 AND 200 MHz TEST CIRCUIT

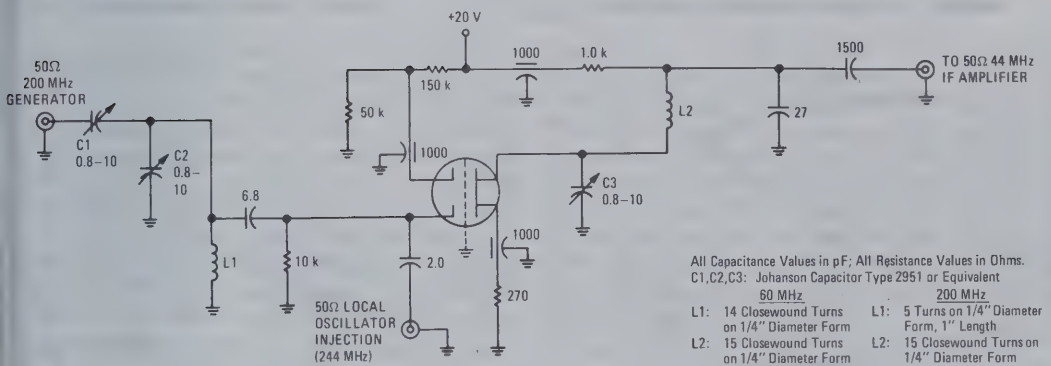
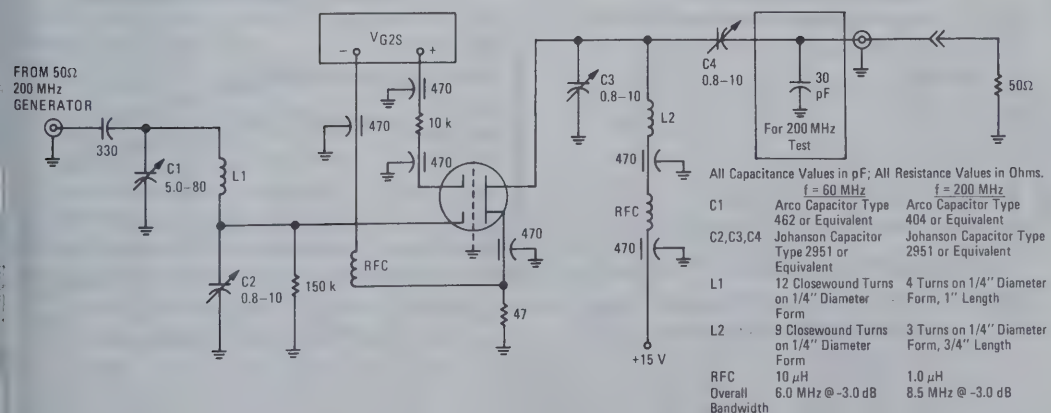


FIGURE 3 – 60 AND 200 MHz CONVERSION POWER GAIN



COMMON-SOURCE ADMITTANCE PARAMETERS
(V_{DS} = 15 Vdc, V_{G2S} = 4.0 Vdc, I_D = 6.0 mAdc)

FIGURE 4 – INPUT ADMITTANCE

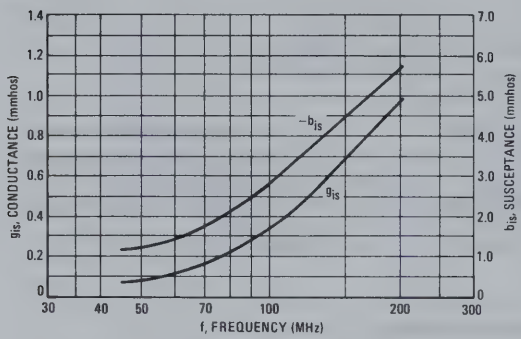


FIGURE 5 – REVERSE TRANSFER ADMITTANCE

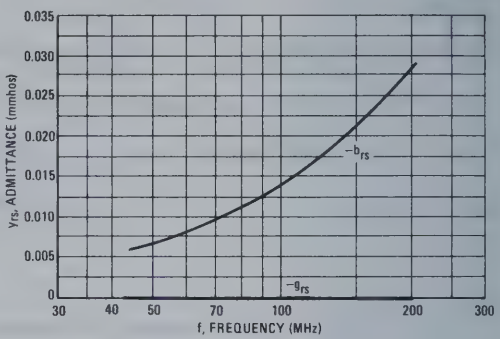


FIGURE 6 – FORWARD TRANSFER ADMITTANCE

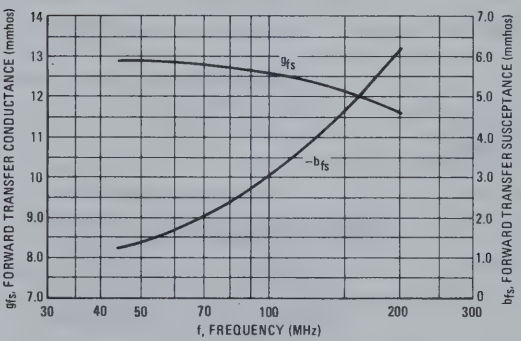


FIGURE 7 – OUTPUT ADMITTANCE

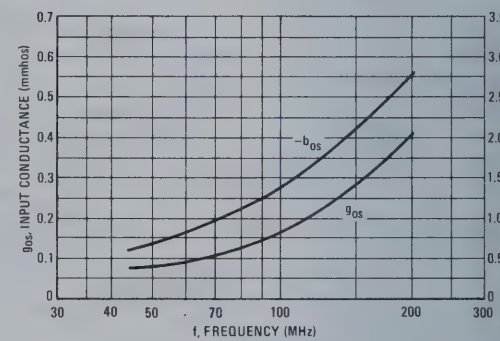


FIGURE 8 – GAIN REDUCTION

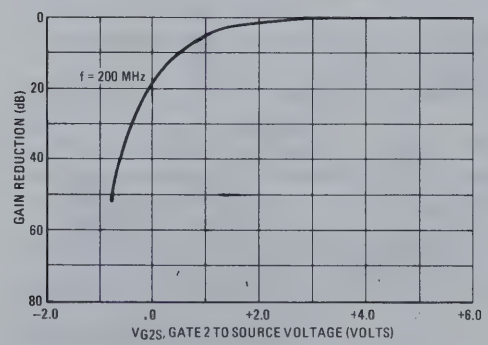
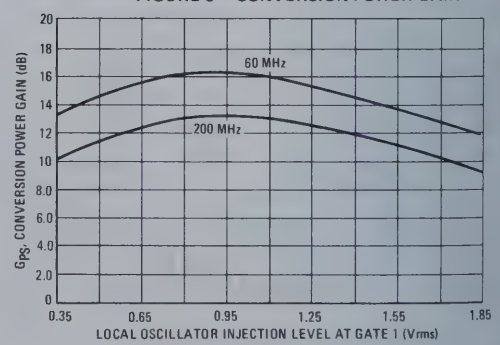


FIGURE 9 – CONVERSION POWER GAIN



MPF161 (SILICON)

P-channel junction field-effect transistors depletion mode (Type A) designed for general-purpose amplifier applications.



CASE 29 (7)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Drain Current	I_D	20	mAdc
Forward Gate Current	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Operating Junction Temperature Range	T_J	-65 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Cutoff Voltage* (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$*	0.2	8.0	Vdc
Gate Reverse Current (V_{GS} = 30 Vdc, V_{DS} = 0)	I_{GSS}	-	10	nAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	0.5	14	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{fs}\|$*	800	6000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	-	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	-	2.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 M ohm, f = 1.0 kHz, BW = 1.0 Hz)	NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz, BW = 1.0 Hz)	e_n	-	115	$nV/\sqrt{Hz}$

*To characterize these devices to narrower limits, regarding $V_{GS(off)}$, I_{DSS} and $|y_{fs}|$, the entire production lot is tested and divided into color-coded groups, with each color dot representing a relatively small range compared with the total min-max limit of the whole distribution. The color codes and their associated limits are given in the following table.

When packaged for shipment, the colors are randomly selected and no specific color distribution is implied or guaranteed.

Color	$V_{GS(off)}$	I_{DSS}	$\|y_{fs}\|$
White	0.2 Vdc Min, 2.0 Vdc Max	0.5 mAdc Min, 1.0 mAdc Max	800 to 3200 μmhos
Red	0.4 Vdc Min, 4.0 Vdc Max	0.8 mAdc Min, 1.6 mAdc Max	1000 to 4000 μmhos
Orange	0.4 Vdc Min, 4.0 Vdc Max	1.5 mAdc Min, 3.0 mAdc Max	1000 to 4000 μmhos
Yellow	1.0 Vdc Min, 6.0 Vdc Max	2.5 mAdc Min, 5.0 mAdc Max	1500 to 5000 μmhos
Green	1.0 Vdc Min, 6.0 Vdc Max	4.0 mAdc Min, 8.0 mAdc Max	1500 to 5000 μmhos
Blue	2.0 Vdc Min, 8.0 Vdc Max	7.0 mAdc Min, 14 mAdc Max	2000 to 6000 μmhos

DRAIN CURRENT versus GATE-SOURCE VOLTAGE

FIGURE 1

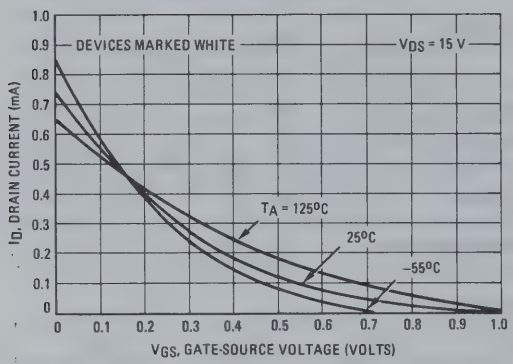


FIGURE 2

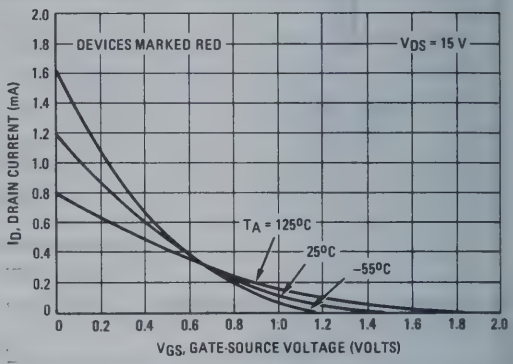


FIGURE 3

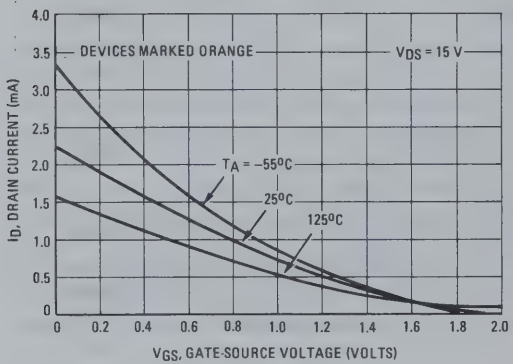


FIGURE 4

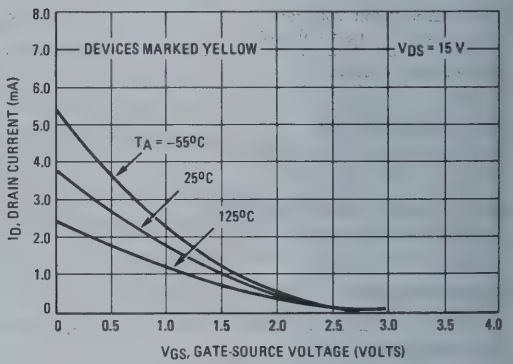


FIGURE 5

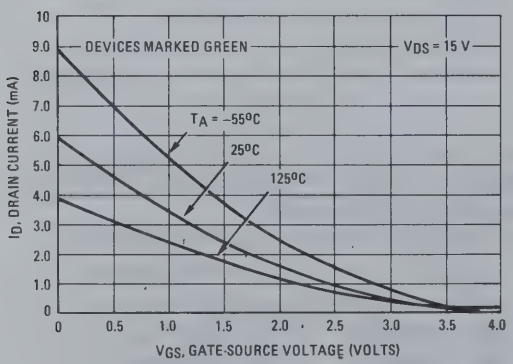


FIGURE 6

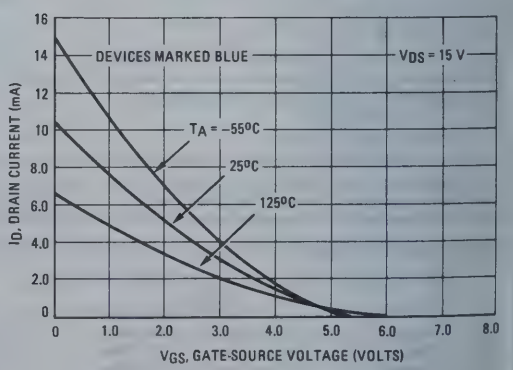


FIGURE 7 – OUTPUT RESISTANCE versus DRAIN CURRENT

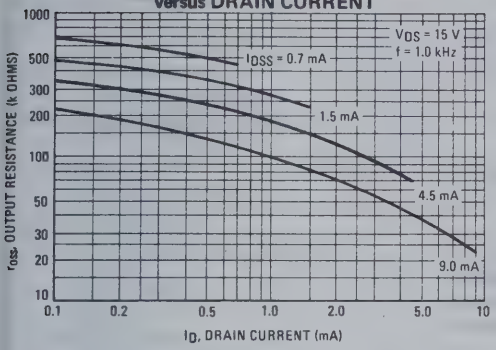


FIGURE 8 – NORMALIZED TRANSADMITTANCE versus NORMALIZED DRAIN CURRENT

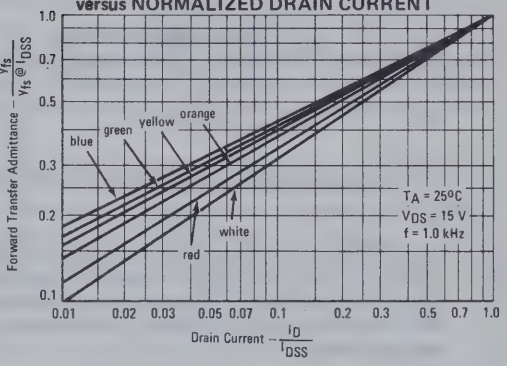


FIGURE 9 – NOISE FIGURE versus FREQUENCY

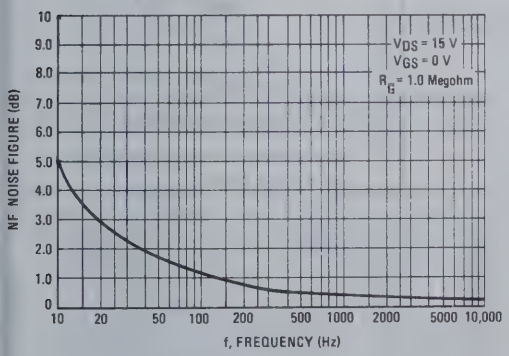


FIGURE 10 – NOISE FIGURE versus SOURCE RESISTANCE

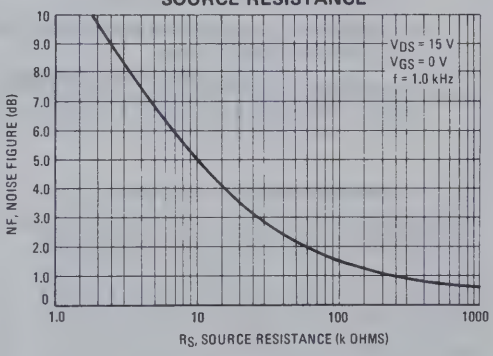
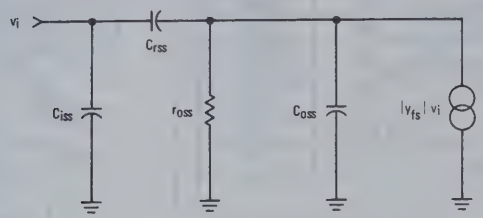


FIGURE 11 – EQUIVALENT LOW FREQUENCY CIRCUIT



Common Source
y Parameters for Frequencies
Below 30 MHz

$y_{is} = j\omega C_{iss}$

$y_{os} = j\omega C_{osp}^{*} + 1/r_{oss}$

$y_{fs} = |y_{fs}|$

$y_{rs} = -j\omega C_{rss}$

*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

NOTE:

Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS}.

MPN3202 (SILICON)

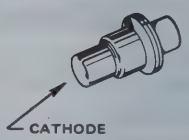


POWER MICROWAVE PIN SWITCHING DIODE

. . . designed using the P-I-N silicon oxide passivated construction that enables the diode to operate over a wide range of series resistance and have very low capacitance. The fast switching time capability makes this device ideal for R-F power control, such as phase shifter, R-F switches, duplexers, voltage-controlled attenuators, modulators and many more.

- Supplied in Popular Pill With Prongs Package for Microwave Frequencies
- Very Low Capacitance — 0.4 pF (Maximum)
- Wide Dynamic Range of R-F Series Resistance — 0.75 to 100 Ohms (Typical)
- Long Minority Carrier Lifetime — 150 ns (Typical)

MICROWAVE PIN SWITCHING DIODE

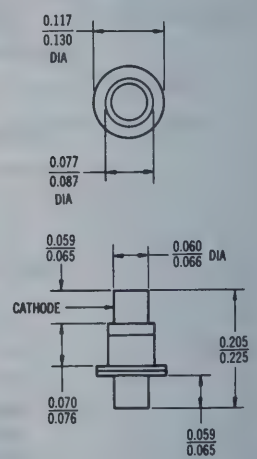


Pill with prongs package

Special package configurations available upon special request.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	200	Volts
Forward Current	I_F	1.0	Amp
Total Device Dissipation @ $T_C = 75^oC$ Derate above 75^oC	P_D	3.0 40	Watts $mW/^oC$
Operating Junction Temperature	T_J	-55 to +150	^oC
Storage Temperature	T_{stg}	-65 to +175	^oC



CASE 46

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	200	230	–	Volts
Total Device Capacitance (V_R = 50 V, f = 1.0 MHz) (Note 1)	C_T	–	0.33	0.40	pF
Series Resistance (I_F = 100 mAdc, f = 1.0 GHz)	R_S	–	0.75	1.0	Ohm
Minority Carrier Lifetime (I_F = 50 mAdc)	τ	–	150	–	ns
Case Capacitance (f = 1.0 MHz) (Note 1)	C_C	–	0.18	–	pF
Series Inductance (f = 250 MHz) (Note 2)	L_S	–	0.85	–	nH
Thermal Resistance, Junction to Case	θ_{JC}	–	–	25	°C/W

PARAMETER TEST METHODS

1. C_T, and C_C CAPACITANCE
($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge Boonton Electronics Model 75A or equivalent).

2. L_S, SERIES INDUCTANCE
L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter).

FIGURE 1 – SERIES RESISTANCE

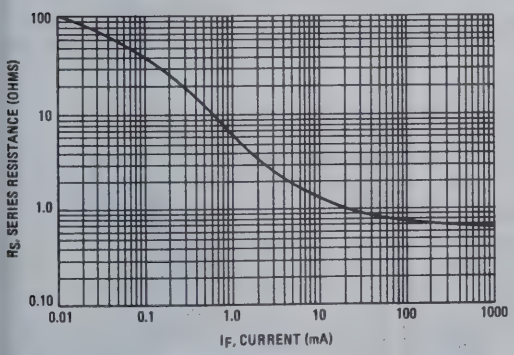
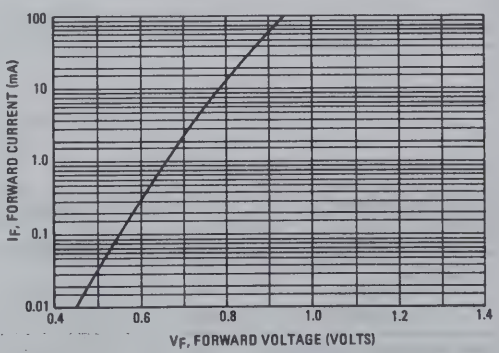


FIGURE 2 – FORWARD VOLTAGE



MPN3208 (SILICON)
MPN3209

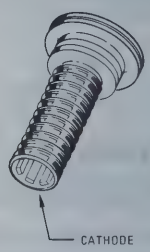


HIGH-POWER MICROWAVE SWITCHING DIODES

. . . designed primarily for high-power, phase-shifter applications through S-band, but also readily adaptable to other R-F power control applications. The unique silicon-dioxide-passivated junction provides excellent stability and very low leakage. The low forward series resistance and extremely low reverse leakage current results in minimal circuit losses. The diode package mounts easily into a standard 8-32 tapped hole, facilitating mechanical design of the circuit.

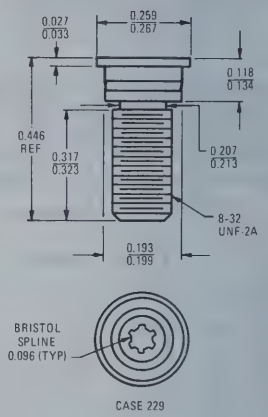
- Low RF Forward R_S – 0.30 Ohms (Typ)
- Very Low Reverse Leakage – 100 nA (Max), 35 nA (Typ)
- High Reverse Breakdown Voltages – to 900 Volts
- Low Thermal Resistance – 4.0°C/Watt (Max)

HIGH-POWER MICROWAVE PIN SWITCHING DIODES



MAXIMUM RATINGS (T_J = +125°C unless otherwise specified)

Rating	Symbol	Value	Unit
Reverse Voltage MPN3208 MPN3209	V_R	 800 900	Volts
Power Dissipation @ T_C = 25°C Derate Above 25°C, Figure 7	P_D	25 250	Watts mW/°C
Operating Junction Temperature	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque	–	80	oz. in



ELECTRICAL CHARACTERISTICS (T_C = +25°C unless otherwise specified)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc) MPN3208 / MPN3209	$V_{(BR)R}$	800 / 900	– / –	– / –	Volts
Forward Series Resistance (I_F = 150 mAdc, f = S-Band, Figure 1)	R_S	–	0.30	0.4	ohm
Total Device Capacitance (Note 1) (V_R = 250 Vdc, f = 1.0 MHz, Figure 3)	C_T	–	0.36	4.0	pF
Reverse Leakage (V_R = 500 Vdc, Figure 2)	I_R	–	–	100	nAdc
Reverse Recovery Time (I_F = 150 mAdc, I_R = 75 mAdc)	t_{rr}	–	6.0	–	μs
Series Inductance (Measured @ 3.0 GHz, Figure 8)	L_S	–	0.55	–	nH
Case Capacitance (Note 1) (f_T = 1.0 MHz)	C_c	–	1.1	–	pF
Thermal Resistance, Junction to Case	θ_{JC}	–	3.0	4.0	°C/Watt

PARAMETER TEST METHODS

1. **C_T, and C_C CAPACITANCE**
($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge Boonton Electronics Model 75A or equivalent).

2. **L_S (SERIES INDUCTANCE)**
L_S is measured at ≈3.0 GHz on test set of Figure 8).

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – FORWARD SERIES RESISTANCE

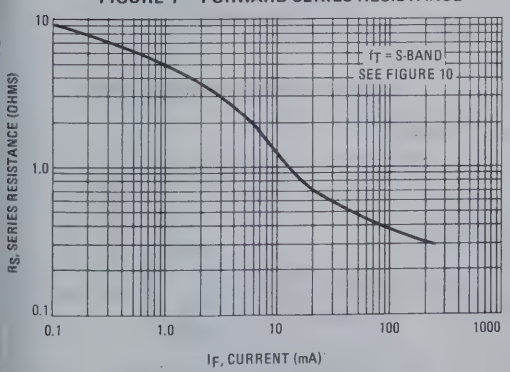


FIGURE 2 – REVERSE LEAKAGE CURRENT

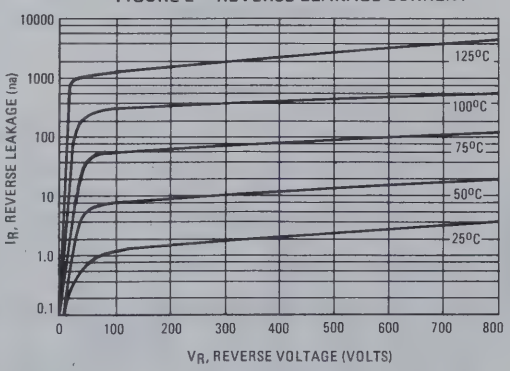


FIGURE 3 – TOTAL CAPACITANCE

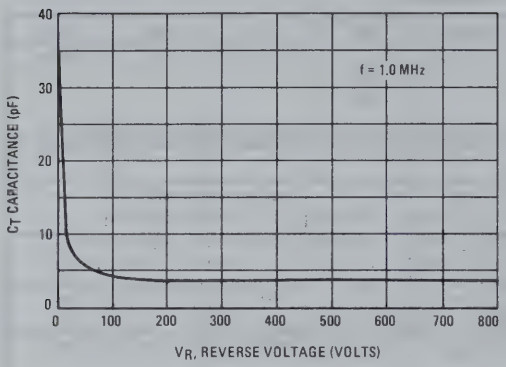


FIGURE 4 – STORED CHARGE

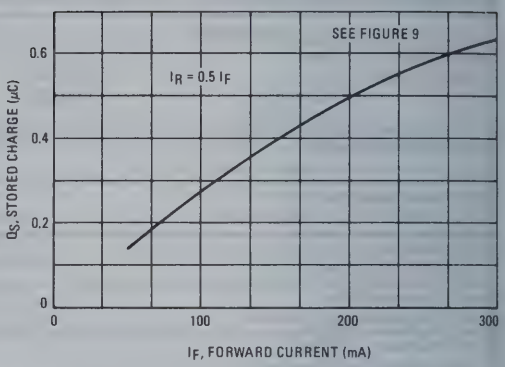


FIGURE 5 – FORWARD VOLTAGE

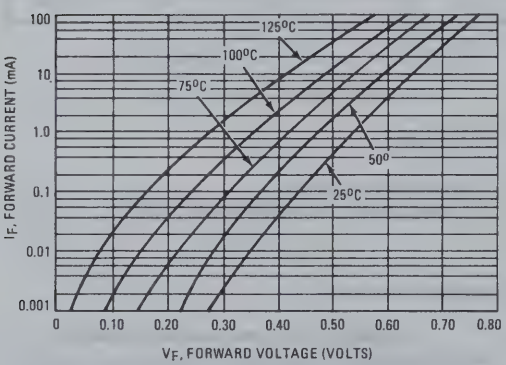


FIGURE 6 – IMPEDANCE COORDINATES

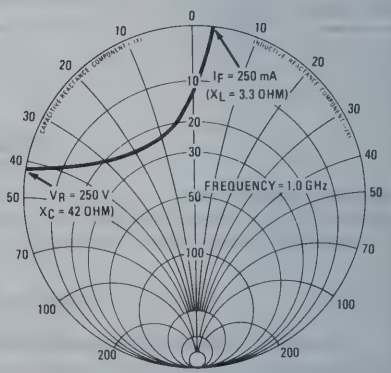


FIGURE 7 – POWER DERATING

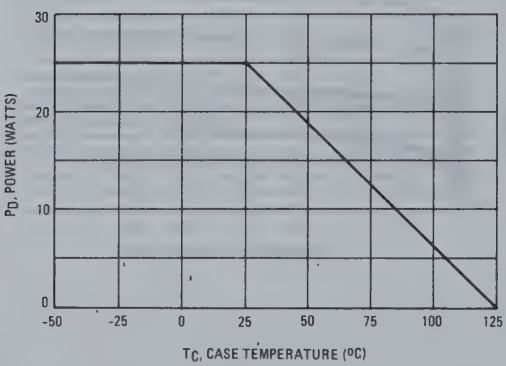
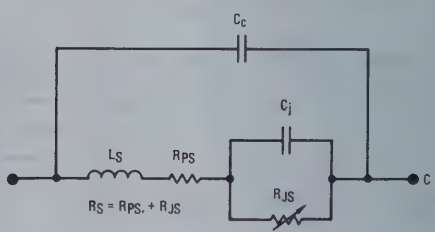


FIGURE 8 – DIODE EQUIVALENT CIRCUIT



R_{JS} = VARIABLE JUNCTION SERIES RESISTANCE
C_J = JUNCTION CAPACITANCE
R_{PS} = PARASITIC SERIES RESISTANCE
L_S = SERIES INDUCTANCE
C_C = CASE CAPACITANCE

GENERAL INFORMATION

FIGURE 9 STORED CHARGE (Q_S) TEST CIRCUIT

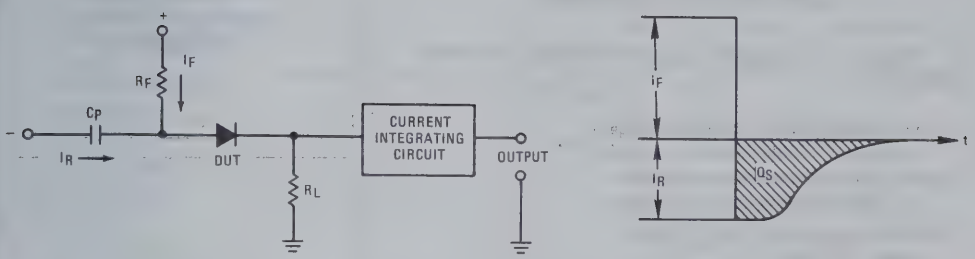


FIGURE 10 – FORWARD SERIES RESISTANCE (R_S) TEST CIRCUIT

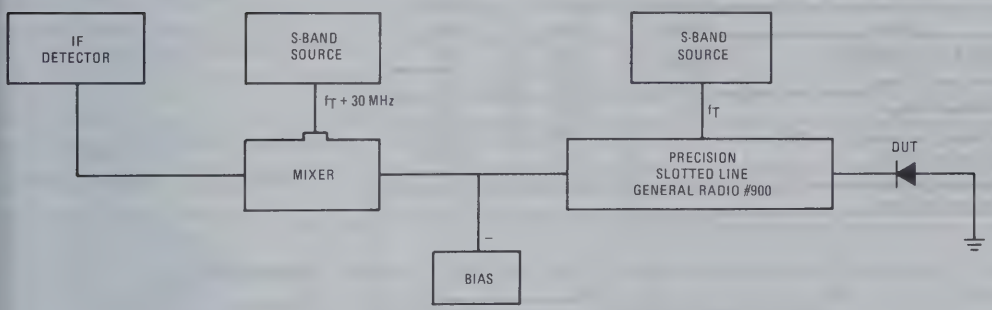
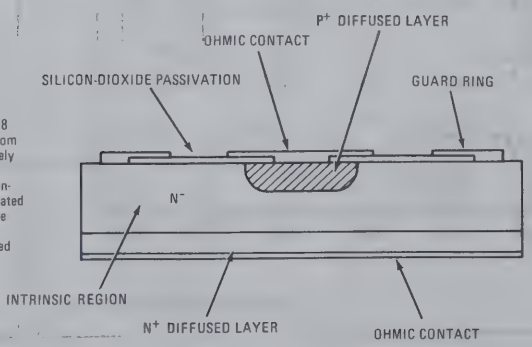


FIGURE 11 – DIE CONSTRUCTION

The die structure of the MPN3208 and 3209 is a radical departure from the current mesa technology widely used in high voltage, high power, PIN diode fabrication. The silicon-dioxide-passivated surface terminated junction technique provides stable characteristics and lower leakage currents not possible in an exposed junction mesa structure.



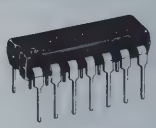
MPQ3303 (SILICON)

NPN SILICON ANNULAR QUAD CORE DRIVER TRANSISTOR

. . . designed for high-speed, high-current switching and driver applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.0 Adc
- High Current-Gain–Bandwidth Product –
  f_T = 400 MHz (Min) @ I_C = 100 mAdc
- Fast Switching Speeds at High Currents –
  t_{on} = 15 ns (Max) @ I_C = 1.0 Adc
  t_{off} = 20 ns (Max) @ I_C = 1.0 Adc

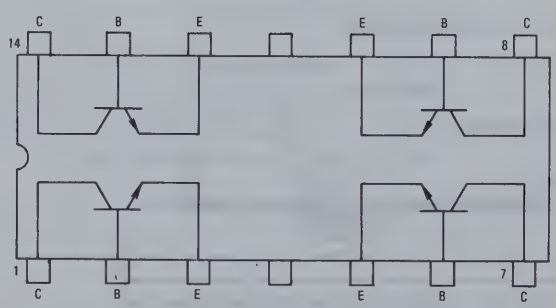
NPN SILICON QUAD CORE DRIVER TRANSISTOR

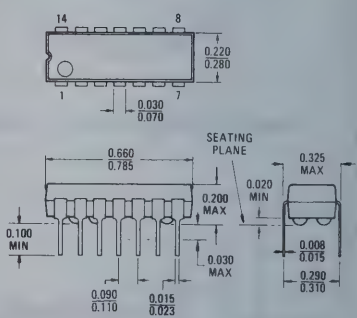


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	600 6.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +125	°C

CONNECTION DIAGRAM



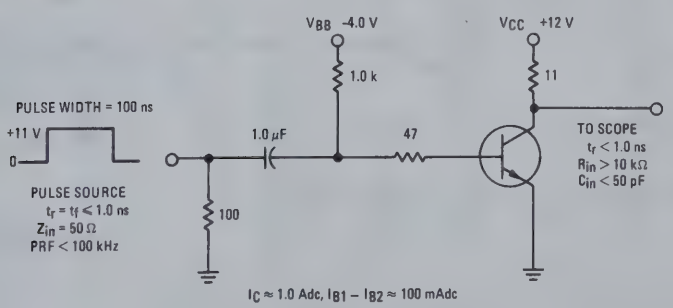


CASE 605-05
TO-116

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			–
(I_C = 300 mAdc, V_{CE} = 0.5 Vdc)		40	200	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)		30	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)		–	0.33	
(I_C = 1.0 Adc, I_B = 0.1 Adc)		–	0.7	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)		–	1.1	
(I_C = 1.0 Adc, I_B = 0.1 Adc)		–	1.4	
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	30	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (Figure 1) (I_C = 1.0 Adc, I_{B1} = 100 mAdc)	t_{on}	–	15	ns
Turn-Off Time (Figure 1) (I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_{off}	–	20	ns

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



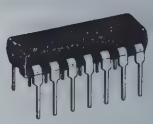
MPQ3725 (SILICON)

NPN SILICON ANNULAR QUAD CORE DRIVER TRANSISTOR

. . . designed for medium-current, high-speed switching and driver applications.

- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Fast Switching Times —
  t_{on} = 20 ns (Typ) @ I_C = 500 mAdc
  t_{off} = 50 ns (Typ) @ I_C = 500 mAdc

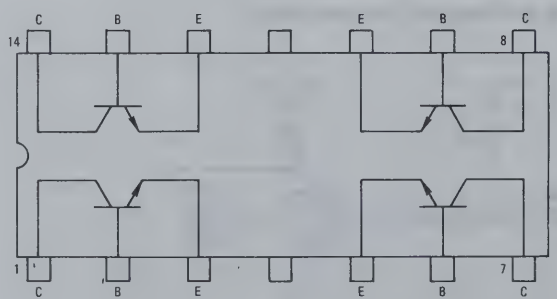
NPN SILICON QUAD CORE DRIVER TRANSISTOR

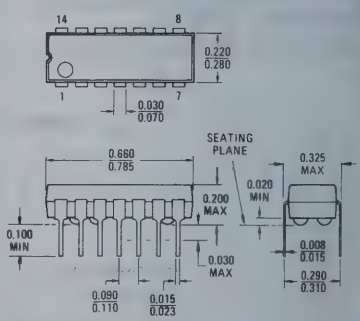


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	600 6.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +125	°C

CONNECTION DIAGRAM



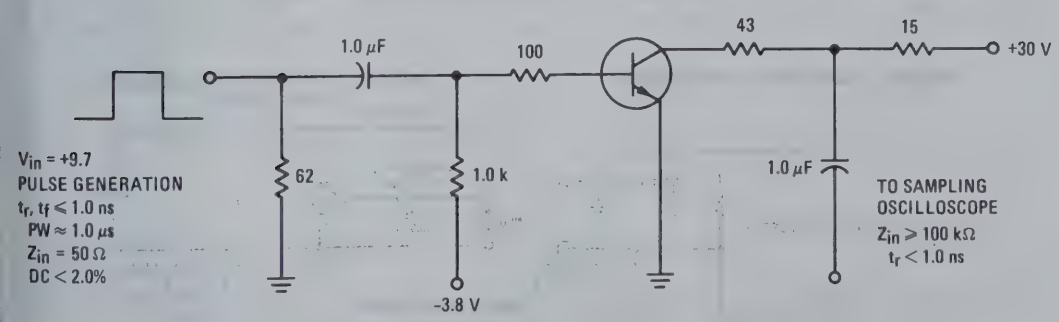


CASE 605-05
TO-116

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	–	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	35 25	– –	200 –	–
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	–	0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	–	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	–	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) (I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	–	20	35	ns
Turn-Off Time (Figure 1) (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	–	50	60	ns

FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



MPS404 (SILICON)
MPS404A

PNP silicon annular transistors encapsulated in plastic package designed for medium-speed switching applications in industrial and computer equipment. Intended for operation in applications using the 2N404 and 2N404A transistors.



CASE 29 (1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	MPS404	MPS404A	Unit
Collector-Emitter Voltage	V_{CEO}	24	35	Vdc
Collector-Base Voltage	V_{CB}	25	40	Vdc
Emitter-Base Voltage	V_{EB}	12	25	Vdc
Collector Current — Continuous	I_C	150		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

FIGURE 1 — SWITCHING TEST CIRCUIT

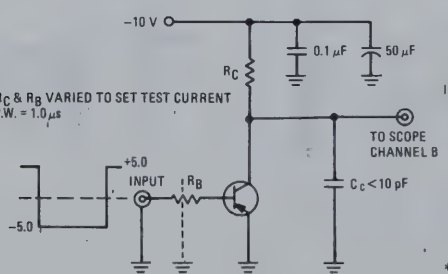
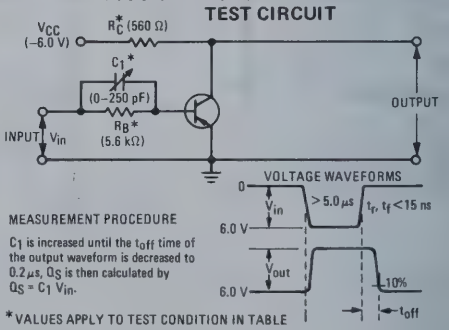


FIGURE 2 — STORED BASE CHARGE TEST CIRCUIT



MEASUREMENT PROCEDURE

C_1 is increased until the t_{off} time of the output waveform is decreased to 0.2 μs, Q_S is then calculated by $Q_S = C_1 V_{in}$.

*VALUES APPLY TO TEST CONDITION IN TABLE

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS404	BV_{CEO}	24	-	-	Vdc
	MPS404A		35	-	-	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS404	BV_{CBO}	25	-	-	Vdc
	MPS404A		40	-	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MPS404	BV_{EBO}	12	-	-	Vdc
	MPS404A		25	-	-	
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	-	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	-	-	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 12 mAdc, V_{CE} = 0.15 Vdc)		h_{FE}	30	-	400	-
Collector-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc)		$V_{CE(sat)}$	-	-	0.15	Vdc
(I_C = 24 mAdc, I_B = 1.0 mAdc)			-	-	0.20	
Base-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc)		$V_{BE(sat)}$	-	-	0.85	Vdc
(I_C = 24 mAdc, I_B = 1.0 mAdc)			-	-	1.0	
DYNAMIC CHARACTERISTICS						
Common-Base Cutoff Frequency (I_C = 1.0 mAdc, V_{CB} = 6.0 Vdc)		$f_{\alpha b}$	4.0	-	-	MHz
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0)		C_{ob}	-	-	20	pF
SWITCHING CHARACTERISTICS						
Delay Time	(I_C = 10 mAdc, I_{B1} = 1.0 mAdc) (Figure 1)	t_d	-	75	-	ns
Rise Time		t_r	-	190	-	ns
Storage Time	(I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) (Figure 1)	t_s	-	155	-	ns
Fall Time		t_f	-	230	-	ns
Total Control Charge (Figure 2) (I_C = 10 mAdc, I_B = 1.0 mAdc)		Q_S	-	-	1400	pC

FIGURE 3 – BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

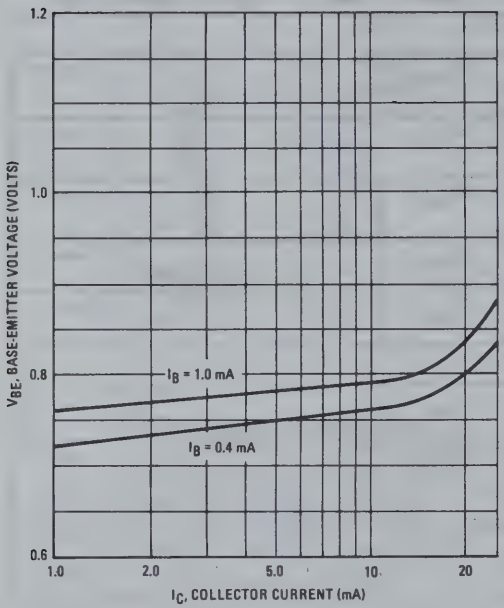


FIGURE 4 – BASE-EMITTER VOLTAGE versus TEMPERATURE

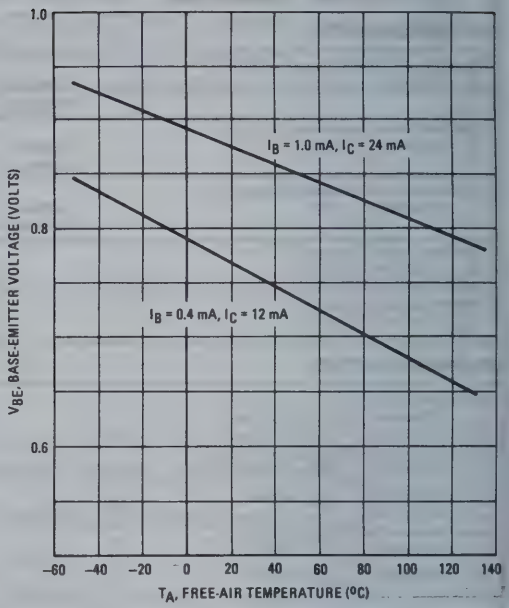


FIGURE 5 – COLLECTOR-EMITTER VOLTAGE versus COLLECTOR CURRENT

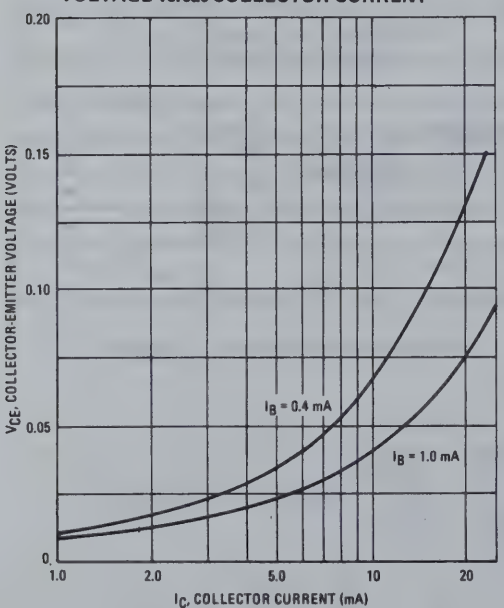


FIGURE 6 – COLLECTOR-EMITTER VOLTAGE versus TEMPERATURE

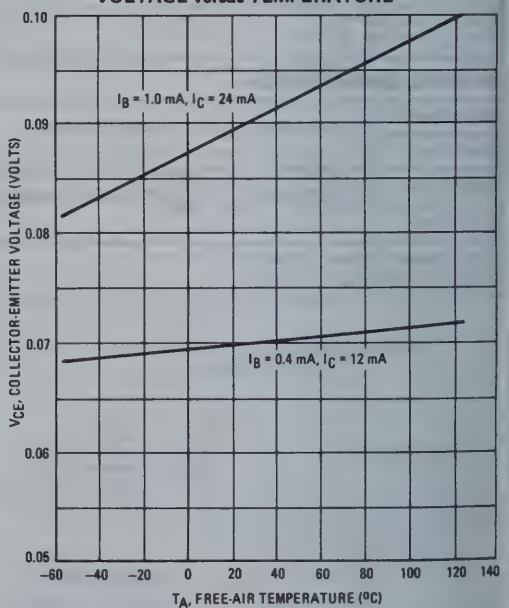


FIGURE 7 – NORMALIZED DC CURRENT GAIN

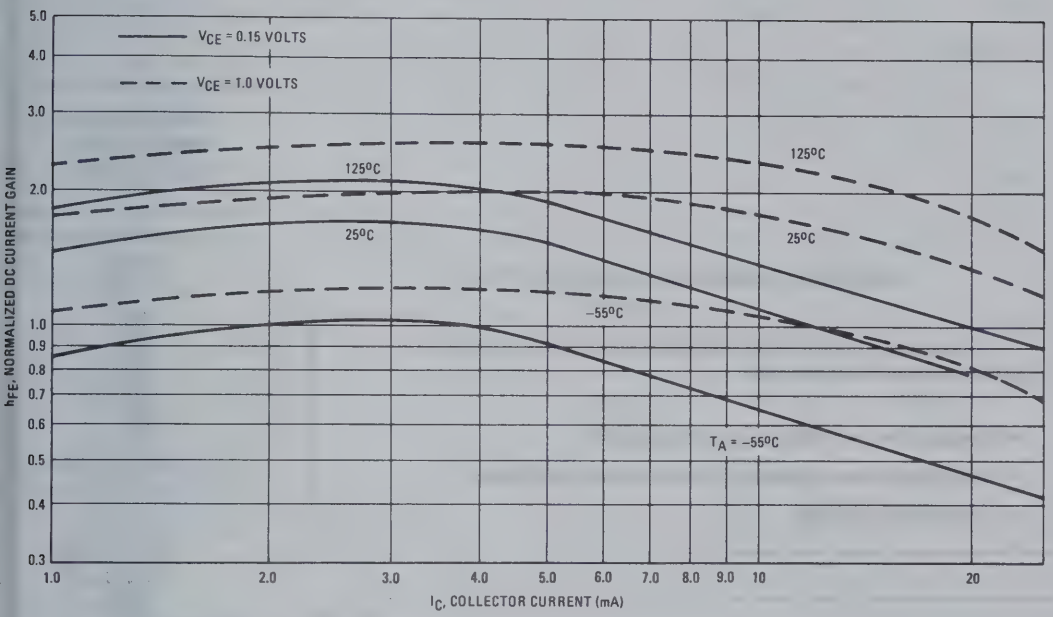


FIGURE 8 – COMMON-BASE CAPACITANCE

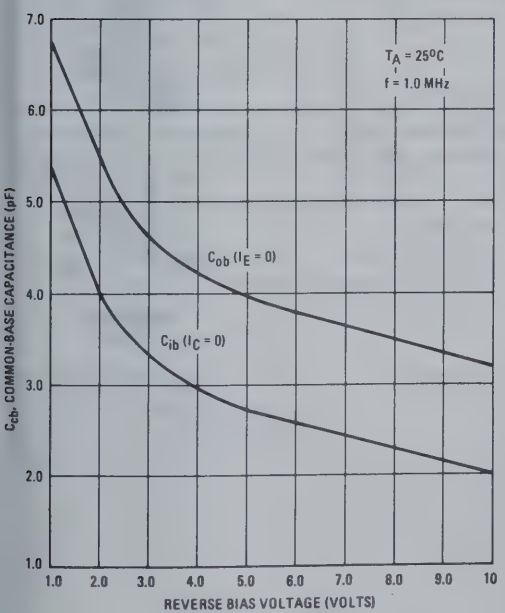
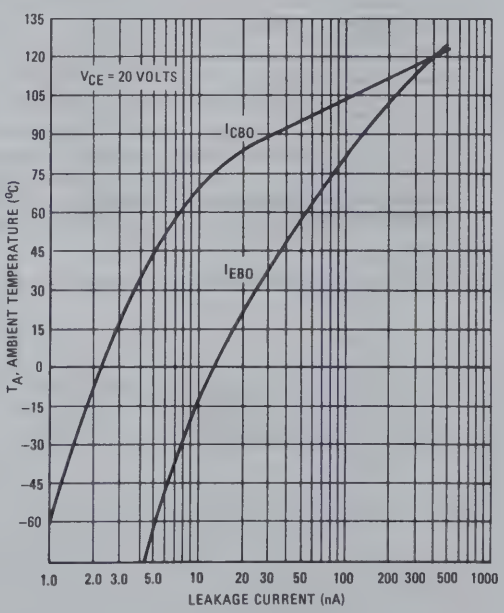


FIGURE 9 – TEMPERATURE versus LEAKAGE CURRENT



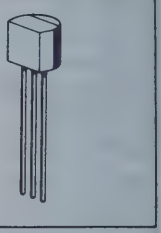
MPS706 (SILICON)
MPS706A

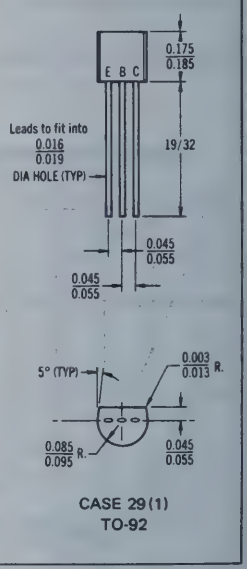
NPN SILICON SWITCHING TRANSISTORS

NPN SILICON ANNULAR TRANSISTORS

. . . designed for low-level, high-speed switching applications in a plastic encapsulated package.

- Standard In-Line EBC Lead Configurations
- High Resistance to Adverse Environmental Conditions
- Insensitivity to Light





CASE 29 (1)
TO-92

MAXIMUM RATINGS

Rating	Symbol	MPS706	MPS706A	Unit
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CER}	20		Vdc
Collector-Base Voltage	V_{CB}	25		Vdc
Emitter-Base Voltage	V_{EB}	3.0	5.0	Vdc
Total Device Dissipation@ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	15	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, R_{BE} = 10 Ohms)		BV_{CER}	20	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	-	0.5	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	10	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	MPS706 MPS706A	h_{FE}*	20 20	- 60	-
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$*	-	0.6	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	MPS706 MPS706A	$V_{BE(sat)}$*	- 0.7	0.9 0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)		f_T	200	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	6.0	pF
Base Resistance (I_E = 10 mAdc, V_{CE} = 15 Vdc, f = 300 MHz)		r'_b	-	50	Ohms
SWITCHING CHARACTERISTICS					
Turn-On Time (See Figure 1)		t_{on}**	-	40	ns
Turn-Off Time (See Figure 1)		t_{off}**	-	75	ns
Charge Storage Time Constant** (See Figure 2)	MPS706 MPS706A	τ_s**	- -	60 25	ns

*Pulse Test: Pulse Width ≤ 12 ns, Duty Cycle ≤ 2.0%.

**Measured with Tektronix Type R Plug-In (50-Ohm Internal Impedance) and circuits shown.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

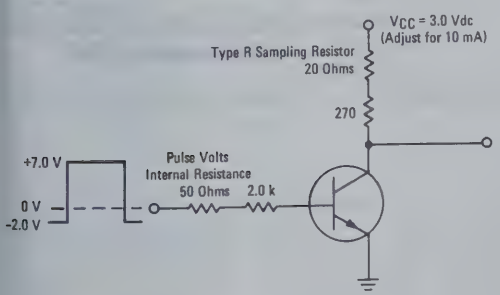
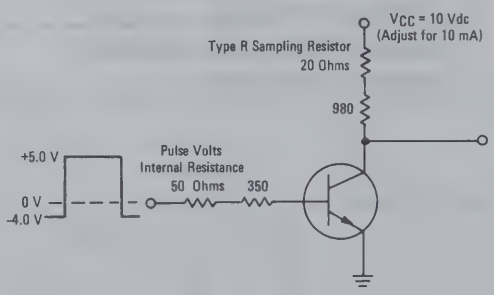


FIGURE 2 – STORAGE TIME TEST CIRCUIT



MPS834 (SILICON)



NPN silicon annular transistor designed for high-speed switching applications.

CASE 29 (1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	500 4.55	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

CHARACTERISTICS	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	-	10	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}*	25	-	-
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$*	-	0.25	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)		-	0.4	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$*	-	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	350	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	4.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc) See Figure 1	t_{on}	-	16	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc) See Figure 1	t_{off}	-	30	ns
Storage Time (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc) See Figure 2	t_s	-	25	ns

*Pulse Test: Pulse Width ≤ 12 ns, Duty Cycle ≤ 2.0%.

FIGURE 1 – TURN-ON AND TURN-OFF TIME MEASUREMENT CIRCUIT

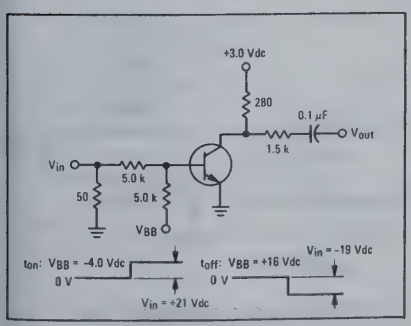
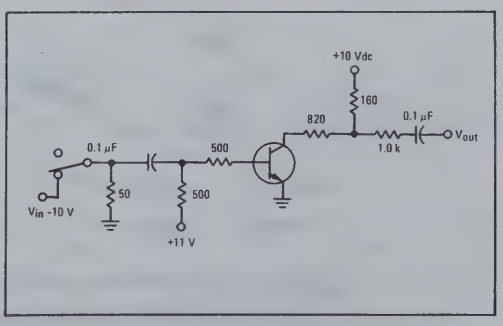


FIGURE 2 – CHARGE STORAGE TIME CONSTANT MEASUREMENT CIRCUIT



NOTE: ALL SWITCHING TIMES MEASURED WITH LUMATRON MODEL 420 SWITCHING TIME TEST SET OR EQUIVALENT.

MPS918 (SILICON)
MPS3563



NPN silicon annular, plastic encapsulated transistors for low-cost amplifier and oscillator applications at VHF and UHF.

CASE 29(1)
(TO-92)

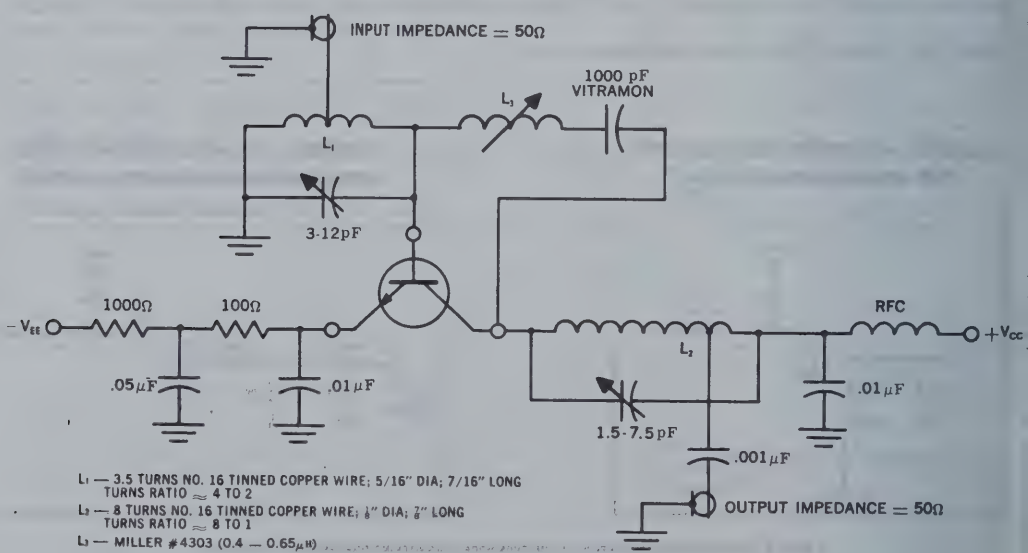
MAXIMUM RATINGS

Rating	Symbol	MPS918	MPS3563	Unit
Collector-Base Voltage	V_{CB}	30	30	Volts
Collector-Emitter Voltage	V_{CEO}	15	12	Volts
Emitter-Base Voltage	V_{EB}	3.0	2.0	Volts
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	310 2.81		mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	$^oC/mW$

200 MC POWER GAIN TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = 15V, I_E = 0	MPS918 MPS3563	I_{CBO}	– –	10 50	nA
Collector-Base Breakdown Voltage I_C = 1.0 μA, I_E = 0 I_C = 100 μA, I_E = 0	 MPS918 MPS3563	BV_{CBO}	 30 30	 – –	Volts
Emitter-Base Breakdown Voltage I_E = 10 μA, I_C = 0	MPS918 MPS3563	BV_{EBO}	3.0 2.0	– –	Volts
Collector-Emitter Voltage* I_C = 3.0 mA, I_E = 0	MPS918 MPS3563	BV_{CEO}*	15 12	– –	Volts
DC Current Gain* V_{CE} = 1V, I_C = 3mA V_{CE} = 10V, I_C = 8mA	 MPS918 MPS3563	h_{FE}*	 20 20	 – 200	—
Collector-Emitter Saturation Voltage I_C = 10mA, I_B = 1mA	MPS918	$V_{CE(sat)}$	–	0.4	Volts
Base-Emitter Saturation Voltage I_C = 10mA, I_B = 1mA	MPS918	$V_{BE(sat)}$	–	1.0	Volts
Small Signal Current Gain I_C = 4mA, V_{CE} = 10V, f = 100 MHz I_C = 8mA, V_{CE} = 10V, f = 100 MHz I_C = 8mA, V_{CE} = 10V, f = 1 kHz	 MPS918 MPS3563 MPS3563	h_{fe}	 6.0 6.0 20	 – 15 250	—
Output Capacitance V_{CB} = 10V, I_E = 0, f = 140 kHz V_{CB} = 10V, I_E = 0, f = 1 MHz V_{CB} = 0V, I_E = 0, f = 140 kHz	MPS918 MPS3563 MPS918	C_{ob}	– – –	1.7 1.7 3.0	pF
Input Capacitance V_{BE} = 0.5V, I_C = 0	MPS918	C_{ib}	–	2.0	pF
Amplifier Power Gain I_C = 6mA, f = 200 MHz, V_{CB} = 12V I_C = 8mA, V_{CE} = 10V, f = 200 MHz $G_{fd} + G_{re}$ < -20 dB	MPS918 MPS3563	Gpe	15 14	– –	dB
Power Output I_C = 8mA, V_{CB} = 15V, f = 500 MHz	MPS918	Pout	30		mW
Collector Efficiency I_C = 8mA, V_{CB} = 15V, f = 500 MHz	MPS918	eff	25		%
Noise Figure I_C = 1mA, V_{CE} = 6V, f = 60 MHz Rg = 400	MPS918	NF	–	6.0	dB

*PW ≤ 300 μs. DC ≤ 1%

MPS2369 (SILICON)



CASE 29(1)
(TO-92)

NPN silicon annular switching transistor designed for use in high-speed, low-current switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current-Peak	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to + 135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.355	°C/mW

FIGURE 1 – t_{on} CIRCUIT

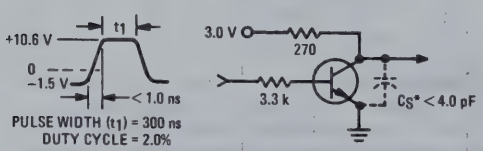


FIGURE 2 – t_{off} CIRCUIT

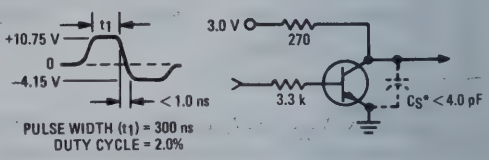
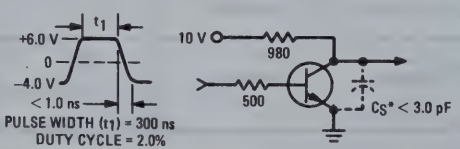


FIGURE 3 – STORAGE TEST CIRCUIT



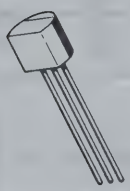
*Total shunt capacitance of test jig and connectors.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	15	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	0.4	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 125°C)		-	30	
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}*	40	120	-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		20	-	
(I_C = 100 mAdc, V_{CE} = 2.0 Vdc)		20	-	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$*	-	0.25	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$*	0.70	0.85	Vdc
SMALL SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	4.0	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	5.0	-	-
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc) (Figure 1)	t_{on}	-	12	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc) (Figure 2)	t_{off}	-	18	ns
Storage Time (I_{B1} = I_{B2} = I_C = 10 mAdc) (Figure 3)	t_s	-	13	ns

* Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%

MPS2711 (SILICON)
MPS2712



NPN silicon epitaxial plastic encapsulated transistor designed for low-power, small-signal audio applications.

CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	310	mW
Total Device Dissipation @ $T_C = 60^oC$	P_D	210	mW
Operating Junction Temperature Range	T_J	135	^oC
Storage Temperature Range	T_{stg}	-55 to +135	^oC

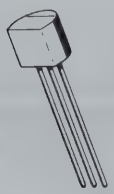
THERMAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	$^oC/W$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0) (V_{CB} = 18 V_{dc} I_E = 0, T_A = 100°C)		I_{CBO}	- -	0.5 1.5	μAdc
Emitter-Base Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)		I_{EBO}	-	0.5	μAdc
DC Current Gain (V_{CE} = 4.5 Vdc, I_C = 2 mAdc)	MPS2711 MPS2712	h_{FE}	30 75	90 225	-
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)		C_{ob}	-	4.0	pF
Small Signal Current Gain (V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 1 kHz)	MPS2711 MPS2712	h_{fe}	30 80	120 200	-

MPS2713 (SILICON)
MPS2714



CASE 29(1)
(TO-92)

NPN Silicon annular transistor, designed for general purpose low-level switching applications. Features one-piece, injection-molded plastic package for high reliability.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	18	Vdc
Collector-Emitter Voltage	V_{CE}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 60°C	P_D	210	mW
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW
Junction Operating Temperature	T_J	135	°C
Storage Temperature Range	T_{stg}	-55 to +135	°C

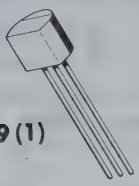
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0) (V_{CB} = 18 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	— —	— —	0.5 15	μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	—	—	0.5	μAdc

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain (I_C = 2 mAdc, V_{CE} = 4.5 Vdc)	MPS2713	h_{FE}	30	60	90	—
	MPS2714		75	150	225	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 3 mAdc)		$V_{CE(sat)}$	—	0.16	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 3 mAdc)		$V_{BE(sat)}$	0.6	0.75	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS						
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 4.5 Vdc, f = 1 kHz)	MPS2713	h_{fe}	30	—	120	—
	MPS2714		80	—	300	
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	—	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	2.5	—	pF
Input Impedance (I_C = 0.5 mAdc, V_{CE} = 1 Vdc, f = 1 kHz)		h_{ie}	—	3000	—	ohms
SWITCHING CHARACTERISTICS						
Delay Time	I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 10 V	t_d	—	7.0	—	ns
Rise Time		t_r	—	6.0	—	ns
Storage Time	I_C = 10 mA, I_{B1} = 3 mA, I_{B2} = 1 mA, V_{CC} = 10 V	t_s	—	12	—	ns
Fall Time		t_f	—	9.0	—	ns

MPS2923 thru MPS2925 (SILICON)



CASE 29 (1)
(TO-92)

NPN silicon annular, plastic encapsulated transistors for low-cost, medium-speed, general-purpose amplifier and oscillator applications.

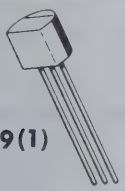
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector dc Current	I_C	100	mAdc
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor above 25°C	P_D	200 2.67	mW mW/°C
Total Device Dissipation @ 55°C Ambient Temperature Derating Factor above 25°C	P_D	120 2.67	mW mW/°C
Junction Temperature-Operating	T_J	100	°C
Storage Temperature Range	T_{stg}	-30 to +125	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = 25 V, I_E = 0 V_{CB} = 25 V, I_E = 0, T_A = 100°C	I_{CBO}	– –	0.5 15	μA μA
Emitter Cutoff Current V_{EB} = 5 V	I_{EBO}	–	0.5	μA
Small Signal Current Gain (f = 1 kHz) V_{CE} = 10 V, I_C = 2 mA MPS2923 MPS2924 MPS2925	h_{fe}	 90 150 235	 180 300 470	–
Collector Capacitance V_{CB} = 10 V, I_E = 0, f = 1 MHz	C_{ob}	–	12	pF

MPS2926 (SILICON)
MPS3721



CASE 29(1)
(TO-92)

NPN silicon epitaxial plastic encapsulated transistors designed for general-purpose applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ 25°C Ambient Temperature	P_D	310	mW
Total Device Dissipation @ 60°C Ambient Temperature	P_D	210	mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW
Junction Temperature, Operating	T_J	135	°C
Storage Temperature Range	T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0)	I_{CBO}	—	—	0.5	μA
(V_{CB} = 18 Vdc, I_E = 0, T_A = 100°C)		—	—	15	
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	—	—	0.5	μA
Current Gain — Bandwidth Product (I_C = 4 mA, V_{CE} = 5 V) MPS2926	f_T	—	300	—	MHz
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}	—	—	3.5	pF
Small Signal Current Gain (V_{CE} = 10 V, I_C = 2 mA, f = 1 kHz)	h_{fe}				—
MPS2926		35	—	470	
MPS3721		60	—	660	

Each unit will be branded with the MPS2926 type and also by color code to identify the different A-C beta categories. A-C beta is broken down into five groups, and typical values of DC beta are listed for guidance.

MPS2926 Color Code	h_{fe} (V_{CE} = 10 V, I_C = 2 mA, f = 1 KHz)		h_{FE} (V_{CE} = 4.5 V, I_C = 2 mA)
	Min	Max	Typ
Brown	35	70	36
Red	55	110	62
Orange	90	180	115
Yellow	150	300	155
Green	235	470	215

MPS3392 thru MPS3395 (SILICON)



NPN silicon annular plastic encapsulated transistors designed for small-signal, low power audio applications.

CASE 29(1)
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	310	mW
Total Device Dissipation @ $T_C = 60^oC$	P_D	210	mW
Operating Junction Temperature Range	T_J	135	^oC
Storage Temperature Range	T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)		BV_{CEO}	25	-	Vdc
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0)		I_{CBO}	-	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)		I_{EBO}	-	0.1	μAdc
DC Current Gain (V_{CE} = 4.5 Vdc, I_C = 2 mAdc)	MPS3392	h_{FE}	150	300	-
	MPS3393		90	180	
	MPS3394		55	110	
	MPS3395		150	500	
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)		C_{ob}	-	3.5	pF
Small Signal Current Gain (V_{CE} = 4.5 V, I_C = 2 mA, f = 1 kHz)	MPS3392	h_{fe}	150	500	-
	MPS3393		90	400	
	MPS3394		55	300	
	MPS3395		150	800	

MPS3563

For Specifications, See MPS918 Data.

MPS3638 (SILICON)
MPS3638A



CASE 29(1)
(TO-92)

PNP silicon epitaxial transistor designed for high-current digital applications. Features one-piece, injection-molded plastic package for high reliability.

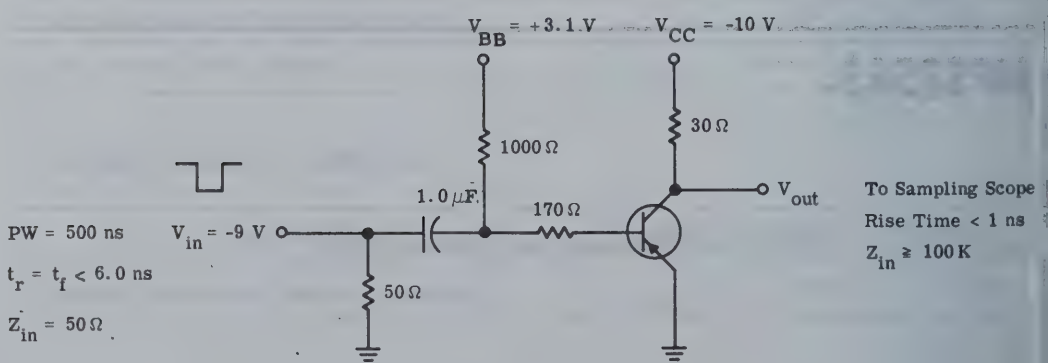
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

FIGURE 1

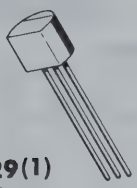


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	25	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		BV_{CES}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	-	Vdc
Collector Reverse Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	-	0.035	μAdc
(V_{CE} = 15 Vdc, V_{BE} = 0, T_A = +65°C)			-	2.0	
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_B	-	0.035	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 1 mAdc, V_{CE} = 10 Vdc)	MPS3638A	h_{FE}*	80	-	-
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS3638		20	-	
	MPS3638A		100	-	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	MPS3638		30	-	
	MPS3638A		100	-	
(I_C = 300 mAdc, V_{CE} = 2 Vdc)	MPS3638		20	-	
	MPS3638A		20	-	
Collector-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 2.5 mAdc)		$V_{CE(sat)}$*	-	0.25	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)			-	1.0	
Base-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 2.5 mAdc)		$V_{BE(sat)}$*	-	1.1	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)			0.80	2.0	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (V_{CE} = 3 Vdc, I_C = 50 mAdc, f = 100 MHz)	MPS3638	f_T	100	-	MHz
	MPS3638A		150	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	MPS3638	C_{ob}	-	20	pF
	MPS3638A		-	10	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	MPS3638	C_{ib}	-	65	pF
	MPS3638A		-	25	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638	h_{fe}	25	180	-
	MPS3638A		100	-	
Output Conductance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	-	1.2	mmhos
Input Resistance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638	h_{ie}	-	1500	Ohms
	MPS3638A		-	2000	
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638	h_{re}	-	26	$X10^{-4}$
	MPS3638A		-	15	
SWITCHING CHARACTERISTICS					
Delay Time	V_{CC} = 10 Vdc, I_C = 300 mAdc,	t_d	-	20	ns
Rise Time	I_{B1} = 30 mAdc, $V_{BE(off)}$ = 3.1 Vdc	t_r	-	70	ns
Storage Time	V_{CC} = 10 Vdc, I_C = 300 mAdc,	t_s	-	140	ns
Fall Time	I_{B1} = 30 mAdc, I_{B2} = 30 mAdc	t_f	-	70	ns
Turn-On Time	I_C = 300 mAdc, I_{B1} = 30 mAdc	t_{on}	-	75	ns
Turn-Off Time	I_C = 300 mAdc, I_{B1} = 30 mAdc, I_{B2} = 30 mAdc	t_{off}	-	170	ns

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 1%.

MPS3639 (SILICON)



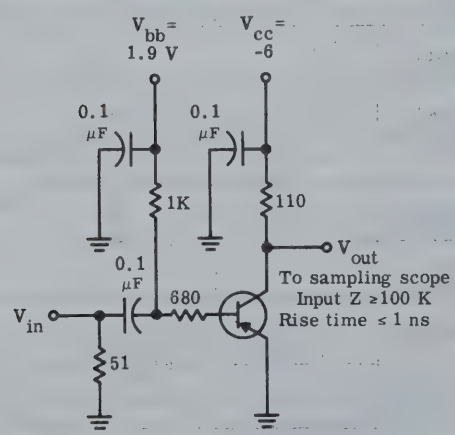
CASE 29(1)
(TO-92)

PNP silicon annular, plastic encapsulated transistor for low-cost, low-level, high-speed switching applications.

MAXIMUM RATINGS

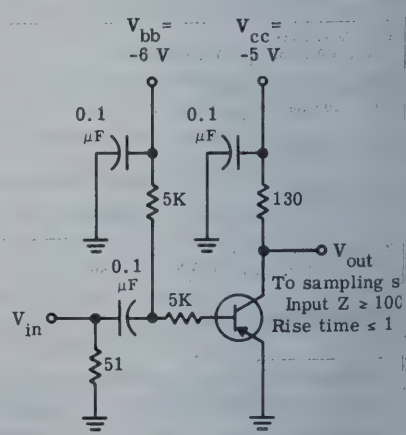
Rating	Symbol	Value	Unit
Collector Current	I_C	80	mAdc
Collector-Base Voltage	V_{CB}	6.0	Vdc
Collector-Emitter Voltage	V_{CEO}	6.0	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ 25° Ambient Temperature	P_D	0.2	Watts
Derate above 25° C		2.0	mW/°C
Total Device Dissipation @ 25° C Case Temperature	P_D	0.5	Watts
Derate above 25° C		5.0	mW/°C
Operating Junction Temperature	T_J	125	°C
Storage Temperature Range	T_{stg}	-55 to +125	°C

SWITCHING TIME TEST CIRCUITS



PULSE SOURCE
Rise time ≤ 1 ns
PW ≥100 ns
Z_{in} = 50Ω
Fall time ≤1 ns

NOTES: (1) Collector Current = 50 mA
(2) Turn-On and Turn-Off Base Currents = 5 mA



PULSE SOURCE
Rise time ≤ 1 ns
PW ≥ 200 ns
Z_{in} = 50Ω
Fall time ≤1 s

NOTES: (1) Collector Current = 10 mA
(2) Turn-On and Turn-Off Base Currents = 0.5 mA

MPS3639 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CE} = 3 V, V_{EB} = 0 V_{CE} = 3 V, V_{EB} = 0, T_A = +65°C	I_{CES}	– –	0.01 1.0	μA
Base Current V_{CE} = 3 V, V_{EB} = 0	I_B	–	10	nA
Collector-Emitter Breakdown Voltage I_C = 100 μA, V_{BE} = 0	BV_{CES}	6.0	–	V
Collector-Base Breakdown Voltage I_C = 100 μA, I_E = 0	BV_{CBO}	6.0	–	V
Emitter-Base Breakdown Voltage I_E = 100 μA, I_C = 0	BV_{EBO}	4.0	–	V
Collector-Emitter Sustaining Voltage * I_B = 0, I_C = 10 mA	$V_{CEO(sus)}$ *	6.0	–	V
Collector-Emitter Saturation Voltage * I_C = 10 mA, I_B = 1 mA I_C = 50 mA, I_B = 5 mA I_C = 10 mA, I_B = 1 mA, T_A = +65°C	$V_{CE(sat)}$ *	– – –	0.16 0.5 0.23	V
Base-Emitter Saturation Voltage * I_C = 10 mA, I_B = 0.5 mA I_C = 10 mA, I_B = 1 mA I_C = 50 mA, I_B = 5 mA	$V_{BE(sat)}$ *	0.75 0.8 –	0.95 1.0 1.5	V
Forward Current Transfer Ratio * V_{CE} = 0.3 V, I_C = 10 mA V_{CE} = 1.0 V, I_C = 50 mA	h_{FE} *	30 20	120 –	–

*Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 1.0%.

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Small-Signal Current Transfer Ratio V_{CE} = 5 V, I_C = 10 mA, f = 100 MHz V_{CB} = 0, I_C = 10 mA, f = 100 MHz	h_{fe}	 5.0 3.0	 – –	–
Output Capacitance I_E = 0, V_{CB} = 5 V, f = 140 kHz	C_{ob}	–	3.5	pF
Input Capacitance V_{BE} = 0.5 V, I_C = 0, f = 140 kHz	C_{ib}	–	3.5	pF
Delay Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = 5 mA $V_{BE(off)}$ = 1.9 V	t_d	–	10	ns
Rise Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = 5 mA, $V_{BE(off)}$ = 1.9 V	t_r	–	30	ns
Storage Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = I_{B2} = 5 mA	t_s	–	20	ns
Fall Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = I_{B2} = 5 mA	t_f	–	12	ns
Turn-On Time I_C = 50 mA, I_{B1} = 5 mA, V_{OB} = 1.9 V I_C = 10 mA, I_{B1} = 0.5 mA	t_{on}	 – –	 25 60	ns
Turn-Off Time I_C = 50 mA, V_{OB} = 1.9 V, I_{B1} = I_{B2} = 5 mA I_C = 10 mA, I_{B1} = I_{B2} = 0.5 mA	t_{off}	 – –	 25 60	ns

MPS3640 (SILICON)



CASE 29(1)
(TO-92)

PNP silicon annular transistors designed for general-purpose low-level switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current - Continuous	I_C	80	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

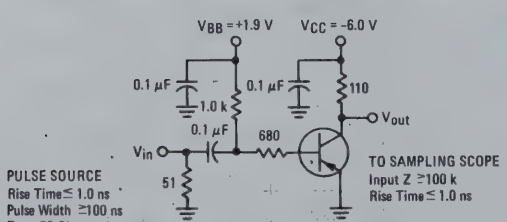
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	12	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	12	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	12	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CE} = 6.0 Vdc, V_{BE} = 0) (V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = 65°C)	I_{CES}	- -	0.01 1.0	μAdc

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain*	h_{FE}*			-
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)		30	120	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		20	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		-	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)*		-	0.6	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 65°C)		-	0.25	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 0.5 mAdc)		0.75	0.95	
(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.8	1.0	
(I_C = 50 mAdc, I_B = 5.0 mAdc)*		-	1.5	
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product	f_T			MHz
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		500	-	
Output Capacitance	C_{ob}			pF
(V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		-	3.5	
Input Capacitance	C_{ib}			pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		-	3.5	
SWITCHING CHARACTERISTICS				
Turn-On Time	t_{on}			ns
($V_{BE(off)}$ = 1.9 Vdc, V_{CC} = 6.0 Vdc, I_C = 50 mAdc, I_{B1} = 5.0 mAdc)(See Figure 1)		-	25	
(I_C = 10 mAdc, V_{CC} = 1.5 Vdc, I_{B1} = 0.5 mAdc) (See Figure 2)		-	60	
Delay Time (V_{CC} = 6.0 Vdc, $V_{BE(off)}$ = 1.9 Vdc,	t_d	-	10	ns
Rise Time I_C = 50 mAdc, I_{B1} = 5.0 mAdc) (See Figure 1)	t_r	-	30	ns
Turn-Off Time	t_{off}			ns
($V_{BE(off)}$=1.9Vdc, V_{CC}=6.0Vdc, I_C=50mAdc, I_{B1}=I_{B2}=5.0mAdc)(See Figure 1)		-	35	
(I_C = 10 mAdc, V_{CC} = 1.5 Vdc, I_{B1} = I_{B2} = 0.5 mAdc) (See Figure 2)		-	75	
Storage Time (V_{CC} = 6.0 Vdc, I_C = 50 mAdc,	t_s	-	20	ns
Fall Time I_{B1} = I_{B2} = 5.0 mAdc) (See Figure 1)	t_f	-	12	ns

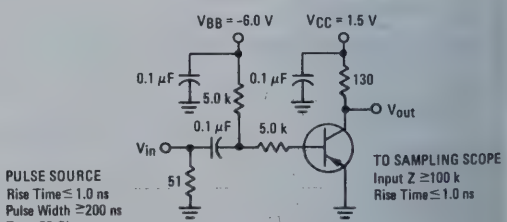
*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



NOTES: Collector Current = 50 mA, Turn-On and Turn-Off Time
Base Currents = 5.0 mA.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



NOTES: Collector Current = 10 mA, Turn-On and Turn-Off Time
Base Currents = 0.5 mA.

MPS3646 (SILICON)



CASE 29(1)
(TO-92)

NPN silicon annular transistor designed for high-speed saturated switching applications. Features one-piece, injection-molded plastic package for high reliability.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage Applicable 0.01-200 mA	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mA
Collector Current (10 μs pulse)	I_C	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	500 5.0	mW mW/°C
Operating Junction Temperature	T_J	125	°C
Storage Temperature Range	T_{stg}	-55 to +125	°C

FIGURE 1 — t_{on} and t_{off} TEST CIRCUIT

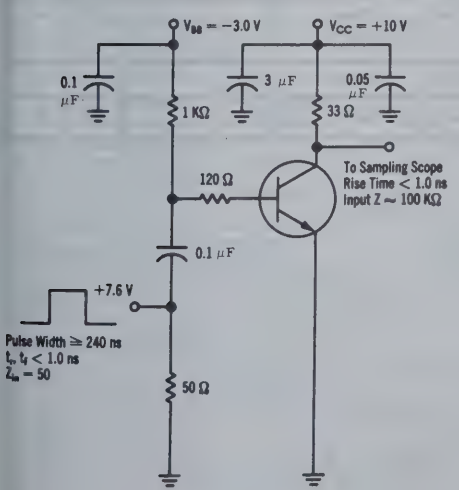
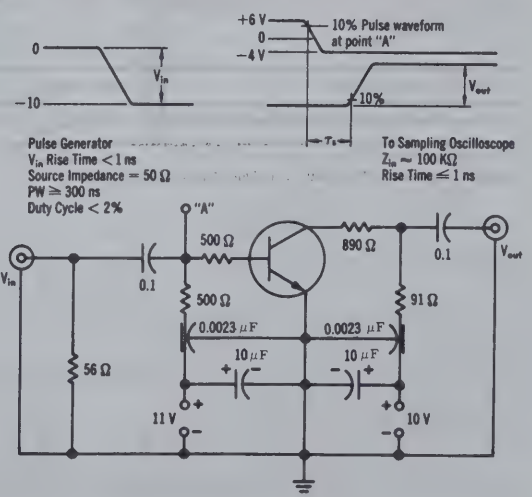


FIGURE 2 — CHARGE STORAGE TIME MEASUREMENT CIRCUIT



ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise specified.)

Characteristic	Conditions	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage	I_C = 100 μAdc, I_E = 0	BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage	I_C = 100 μAdc, V_{BE} = 0	BV_{CES}	40	—	Vdc
Collector-Emitter Sustaining Voltage*	I_C = 10 mAdc	$V_{CEO(sus)}$*	15	—	Vdc
Emitter-Base Breakdown Voltage	I_E = 100 μAdc, I_C = 0	BV_{EBO}	5.0	—	Vdc
Collector-Emitter Saturation Voltage*	I_C = 30 mAdc, I_B = 3.0 mAdc I_C = 30 mAdc, I_B = 3.0 mAdc, T_A = +65 C I_C = 100 mAdc, I_B = 10 mAdc I_C = 300 mAdc, I_B = 30 mAdc	$V_{CE(sat)}$*	— — — —	0.2 0.3 0.28 0.5	Vdc
Base-Emitter Saturation Voltage*	I_C = 30 mAdc, I_B = 3.0 mAdc I_C = 100 mAdc, I_B = 10 mAdc I_C = 300 mAdc, I_B = 30 mAdc	$V_{BE(sat)}$*	0.75 — —	0.95 1.2 1.7	Vdc
DC Current Gain*	I_C = 30 mAdc, V_{CE} = 0.4 Vdc I_C = 100 mAdc, V_{CE} = 0.5 Vdc I_C = 300 mAdc, V_{CE} = 1.0 Vdc	h_{FE}*	30 25 15	120 — —	—
Collector Reverse Current	V_{CE} = 20 Vdc, V_{EB} = 0 V_{CE} = 20 Vdc, V_{EB} = 0, T_A = +65 C	I_{CES}	— —	0.5 3.0	μAdc
Base Current	V_{CE} = 20 Vdc, V_{EB} = 0	I_B	—	0.5	μAdc
Output Capacitance	V_{CB} = 5.0 V, I_E = 0, f = 140 kHz	C_{ob}	—	5.0	pF
Input Capacitance	V_{BE} = 0.5 V, I_C = 0, f = 140 kHz	C_{ib}	—	8.0	pF
Small-Signal Current Gain	I_C = 30 mA, V_{CE} = 10 V, f = 100 MHz	$\|h_{fe}\|$	3.5	—	—
Turn-On Delay Time (Figure 1)	V_{CC} = +10 V, I_{CS} 300 mA, I_{B1} 30 mA, $V_{BE(off)}$ = -3.0 V	t_d	—	10	ns
Rise Time (Figure 1)	V_{CC} = +10 V, I_{CS} 300 mA, I_{B1} 30 mA, $V_{BE(off)}$ = -3.0 V	t_r	—	15	ns
Turn-On Time (Figure 1)	I_C 300 mA, I_{B1} 30 mA, $V_{BE(off)}$ -3.0 V	t_{on}	—	18	ns
Storage Time (Figure 1)	V_{CC} = +10 V, I_{CS} 300 mA, I_{B1} 30 mA, I_{B2} -30 mA	t_s	—	20	ns
Fall Time (Figure 1)	V_{CC} = +10 V, I_{CS} 300 mA, I_{B1} 30 mA, I_{B2} -30 mA	t_f	—	15	ns
Turn-Off Time (Figure 1)	I_C 300 mA, I_{B1} 30 mA, I_{B2} -30 mA	t_{off}	—	28	ns
Charge Storage Time Constant (Figure 2)	I_C 10 mA, I_{B1} 10 mA, I_{B2} -10 mA	τ_s	—	18	ns

*Pulse Conditions: PW ≤ 300 μs: Duty Cycle ≤1%

MPS3693 (SILICON)
MPS3694



CASE 29 (1)
(TO-92)

NPN silicon annular amplifier transistors designed for general purpose RF amplifier applications in frequency range to 50 MHz. These devices are particularly well suited for use in AM/FM receivers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	45	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	45	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0) (V_{CB} = 35 Vdc, I_E = 0, T_A = 65°C)	I_{CBO}	- -	- -	50 5.0	nAdc μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) MPS3693 MPS3694	h_{FE}	40 100	- -	160 400	-
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	200	-	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	-	3.5	pF
Collector-Base Time Constant (I_E = 10 mAdc, V_{CB} = 15 Vdc, f = 31.8 MHz)	r'_bC_c	-	-	55	ps
Noise Figure (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, R_S = 300 ohms, f = 1.0 MHz)	NF	-	4.0	-	dB

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.

MPS3702 (SILICON)
MPS3703

PNP silicon annular plastic encapsulated transistors designed for low-power, large-signal audio applications.



CASE 29 (1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	MPS3702	MPS3703	Unit
Collector-Emitter Voltage	V_{CEO}	25	30	Vdc
Collector-Base Voltage	V_{CB}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MPS3702 MPS3703	BV_{CEO}*	25 30	- -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS3702 MPS3703	BV_{CBO}	40 50	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)		I_{EBO}	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 50 mAdc, V_{CE} = 5 Vdc)	MPS3702 MPS3703	h_{FE}*	60 30	300 150	-
Collector-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$*	-	0.25	Vdc
Base-Emitter On Voltage* (I_C = 50 mAdc, V_{CE} = 5 Vdc)		$V_{BE(on)}$*	0.6	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)		f_T	100	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, f = 1 MHz)		C_{ob}	-	12	pF

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

MPS3704 (SILICON)
MPS3705
MPS3706

NPN silicon annular plastic encapsulated transistors designed for low-power, large-signal audio applications.



CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	MPS3704 MPS3705	MPS3706	Unit
Collector-Emitter Voltage	V_{CEO}	30	20	Vdc
Collector-Base Voltage	V_{CB}	50	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current - Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

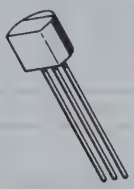
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_E = 0)	MPS3704 MPS3705 MPS3706	BV_{CEO}*	 30 30 20	 - - -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS3704 MPS3705 MPS3706	BV_{CBO}	 50 50 40	 - - -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)		I_{EBO}	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 50 mAdc, V_{CE} = 2 Vdc)	MPS3704 MPS3705 MPS3706	h_{FE}*	100 50 30	300 150 600	-
Collector-Emitter Saturation Voltage* (I_C = 100 mAdc, I_B = 5 mAdc)	MPS3704 MPS3705 MPS3706	$V_{CE(sat)}$*	- - -	0.6 0.8 1.0	Vdc
Base-Emitter On Voltage* (I_C = 100 mAdc, V_{CE} = 2 Vdc)		$V_{BE(on)}$*	0.5	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2 Vdc, f = 20 MHz)		f_T	100	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	-	12	pF

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

MPS3707 (SILICON)
MPS3708
MPS3709
MPS3710
MPS3711



CASE 29(1)
(TO-92)

NPN silicon epitaxial plastic encapsulated transistors designed for general-purpose, low-level amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	310	mW
Total Device Dissipation @ $T_C = 60^oC$	P_D	210	mW
Operating Junction Temperature Range	T_J	135	^oC
Storage Temperature Range	T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)		BV_{CEO}	30	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{EB} = 6 Vdc, I_C = 0)		I_{EBO}	-	100	nAdc
DC Current Gain		h_{FE}			-
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	MPS3707		100	400	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	MPS3708		45	660	
	MPS3709		45	165	
	MPS3710		90	330	
	MPS3711		180	660	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Voltage (I_C = 1 mAdc, V_{CE} = 5 Vdc)		V_{BE}	0.5	1.0	Vdc
Small Signal Current Gain		h_{FE}			-
(I_C = 100 μAdc, V_{CE} = 5 Vdc, f = 1 kHz)	MPS3707		100	550	
(I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	MPS3708		45	800	
	MPS3709		45	250	
	MPS3710		90	450	
	MPS3711		180	800	
Noise Figure		NF			dB
(V_{CE} = 5 V, I_C = 100 μA,	MPS3707		-	5.0	
R_G = 5 kΩ, Noise Bandwidth = 15.7 kHz)					
Note 1					

Note 1 Average Noise Figure is measured in an amplifier with low frequency response down 3 dB at 10 Hz.

MPS3721 (SILICON)

For Specifications, See MPS2926 Data.

MPS5172 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose, low-level amplifier applications.

- High DC Current Gain —
  h_{FE} = 100 - 500 @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 10 mAdc
- One-Piece, Injection-Molded Unibloc Package

NPN SILICON
AMPLIFIER TRANSISTOR

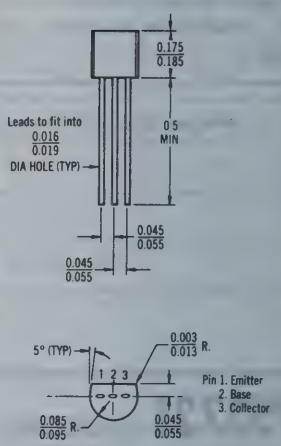


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	210 1.91	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.524	°C/mW

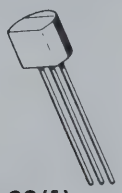


CASE 29 (1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	25	–	–	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 0)	I_{CES}	–	–	100	nAdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 25 Vdc, I_E = 0)		–	–	100	nAdc
(V_{CB} = 25 Vdc, I_E = 0, T_A = 100°C)		–	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	100	–	500	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	–	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	0.75	–	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	0.5	–	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 5.0 Vdc)	f_T	–	120	–	MHz
Collector-Base Capacitance (V_{CB} = 0, I_E = 0, f = 1.0 MHz)	C_{cb}	1.6	–	10	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	100	–	750	–

MPS6507 (SILICON)



CASE 29(1)
(TO-92)

NPN silicon transistor designed as a VHF mixer in TV applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Volts
Collector-Emitter Voltage	V_{CEO}	20	Volts
Emitter-Base Voltage	V_{EB}	3.0	Volts
Collector Current	I_C	100	mA
Total Device Dissipation @ T_A = 60°C @ T_A = 25°C	P_D	210 310	mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW
Junction Temperature	T_J	135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	20	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, V_{EB} = 0)	BV_{CES}*	30	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 60 °C)	I_{CBO}	— —	— —	0.05 1.0	μAdc
DC Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—	—
High Frequency Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 44 MHz)	$\|h_{fe}\|$	20	—	—	dB
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	—	2.5	pF
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc)	f_T	700	—	—	MHz
Conversion Gain (See Figures 7, 8, 9) (I_C = 3 mAdc, V_{CE} = 10 Vdc, 213 to 44 MHz)		—	23	—	dB

* Pulse Test: Pulse Width ≤ 300 μs , Duty Cycle ≤ 2%

FIGURE 1 — COLLECTOR CURRENT versus COLLECTOR-EMITTER VOLTAGE

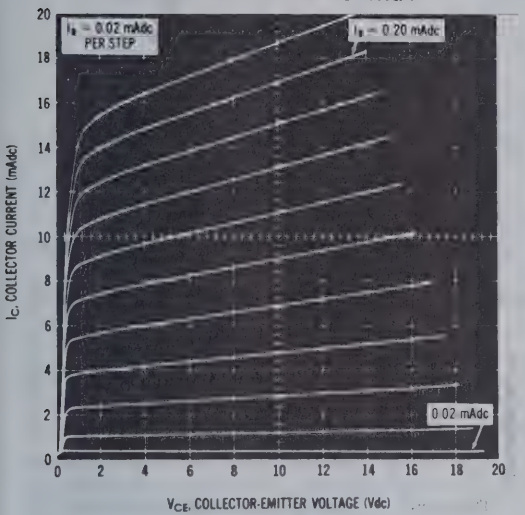
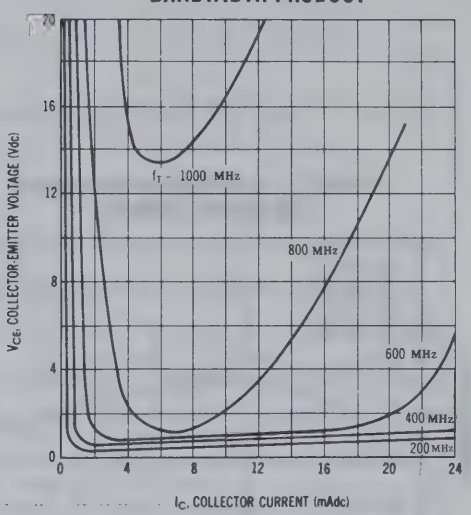


FIGURE 2 — CONTOURS OF CONSTANT GAIN–BANDWIDTH PRODUCT



y PARAMETER VARIATIONS
(V_{CE} = 10 Vdc, I_C = 3 mAdc, T_A = 25°C)

FIGURE 3 — y_{ie}, INPUT ADMITTANCE versus FREQUENCY

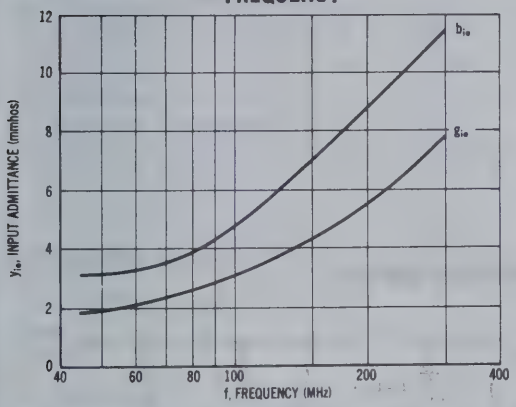


FIGURE 4 — y_{re}, REVERSE TRANSFER ADMITTANCE versus FREQUENCY

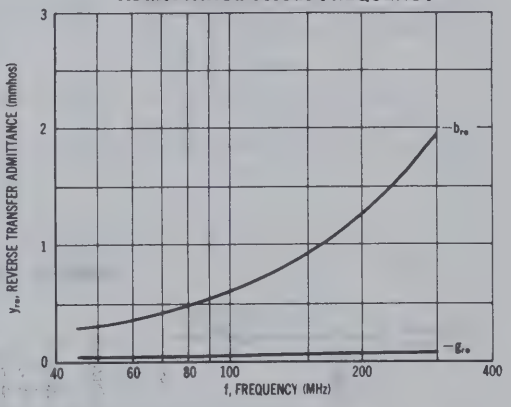


FIGURE 5 — y_{fe}, FORWARD TRANSFER ADMITTANCE versus FREQUENCY

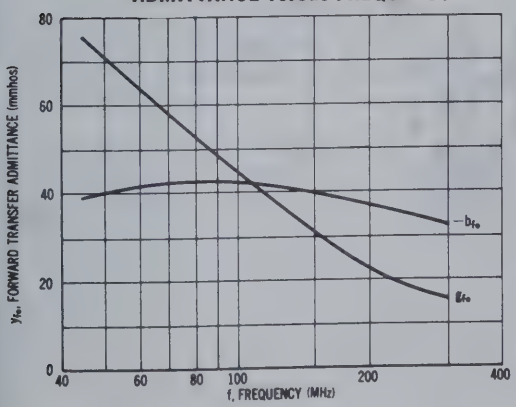


FIGURE 6 — y_{oe}, OUTPUT ADMITTANCE versus FREQUENCY

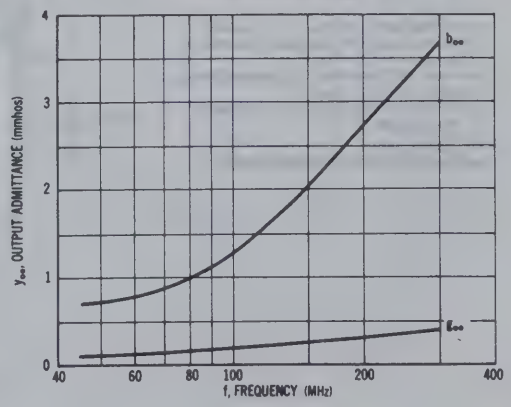


FIGURE 7 — CONVERSION GAIN versus COLLECTOR CURRENT

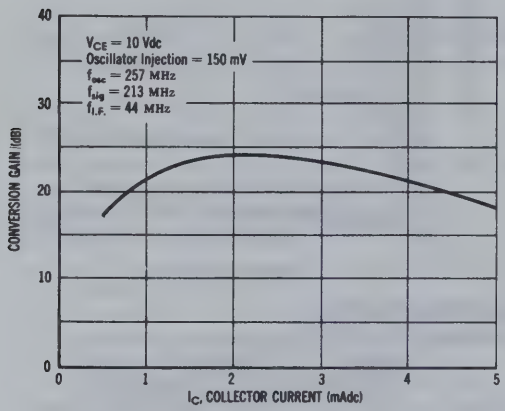


FIGURE 8 — CONVERSION GAIN versus OSCILLATOR INJECTION

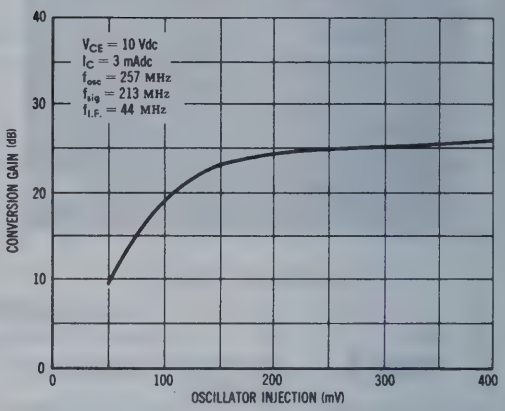
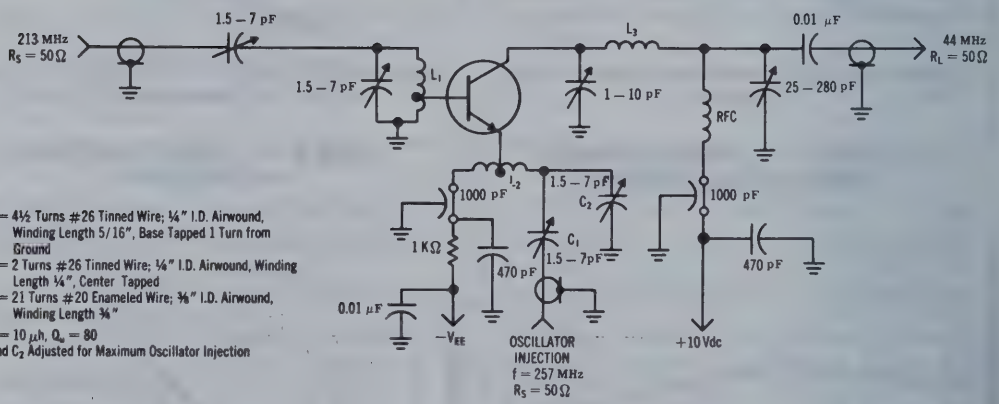


FIGURE 9 — MIXER TEST CIRCUIT



L_1 = 4½ Turns #26 Tinned Wire; ¼" I.D. Airwound, Winding Length 5/16", Base Tapped 1 Turn from Ground
L_2 = 2 Turns #26 Tinned Wire; ¼" I.D. Airwound, Winding Length ¼", Center Tapped
L_3 = 21 Turns #20 Enameled Wire; ⅜" I.D. Airwound, Winding Length ¾"
RFC = 10 μh, Q_u = 80
C_1 and C_2 Adjusted for Maximum Oscillator Injection

MPS6511 (SILICON)



CASE 29(1)
(TO-92)

NPN silicon transistor designed for use in non-AGC IF applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Volts
Collector-Emitter Voltage	V_{CES}	30	Volts
Collector-Emitter Voltage	V_{CEO}	20	Volts
Emitter-Base Voltage	V_{EB}	3.0	Volts
Collector Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 60°C$ @ $T_A = 25°C$	P_D	210 310	mW
Junction Temperature	T_J	135	°C

THERMAL RESISTANCE

$\theta_{JA(air)} = 0.357°C/mW$

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Max	Unit
Collector-Emitter Breakdown Voltage*	BV_{CES}*	$I_C = 10$ mAdc, $V_{EB} = 0$	30	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	$I_C = 0.5$ mAdc, $I_B = 0$	20	—	Vdc
Collector Cutoff Current	I_{CBO}	$V_{CB} = 15$ Vdc, $I_E = 0$ $V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 60°C$	— —	0.05 1.0	μAdc
Current Gain	h_{FE}	$V_{CE} = 10$ Vdc, $I_C = 10$ mAdc	25	—	—
Output Capacitance	C_{ob}	$V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kHz	—	2.5	pF
Power Gain	G_{pe}	$V_{CC} = 12$ Vdc, $I_C = 10$ mAdc, f = 45 MHz (Figure 1)	30	—	dB

*Pulse Test: PW ≤ 300 μs, duty cycle ≤ 2%.

FIGURE 1 – 45 MHz POWER GAIN TEST CIRCUIT

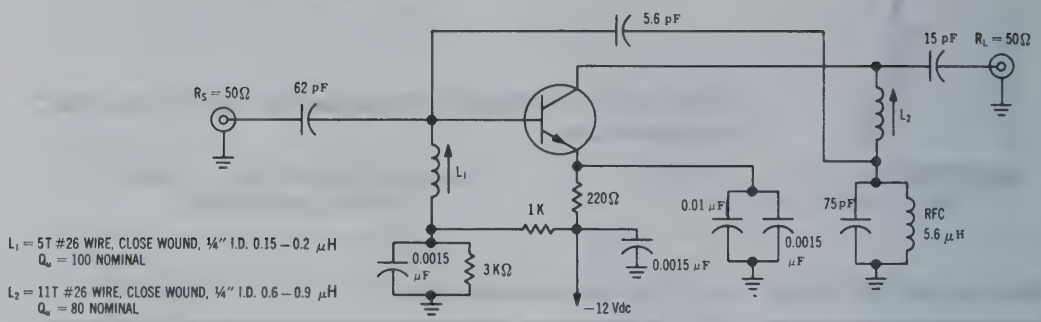


FIGURE 2 — CONTOURS OF CONSTANT GAIN — BANDWIDTH PRODUCT

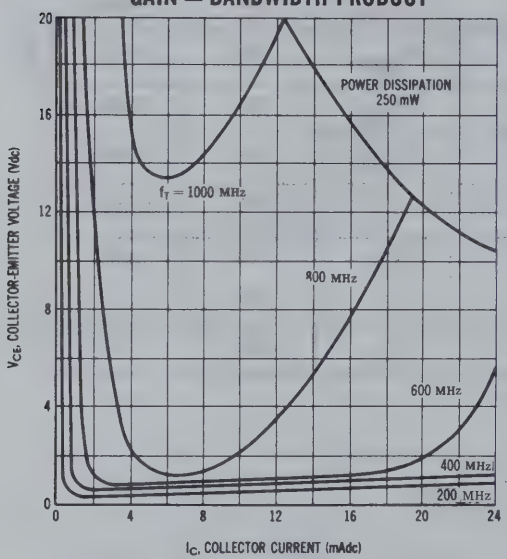


FIGURE 3 — COLLECTOR CURRENT versus COLLECTOR-EMITTER VOLTAGE

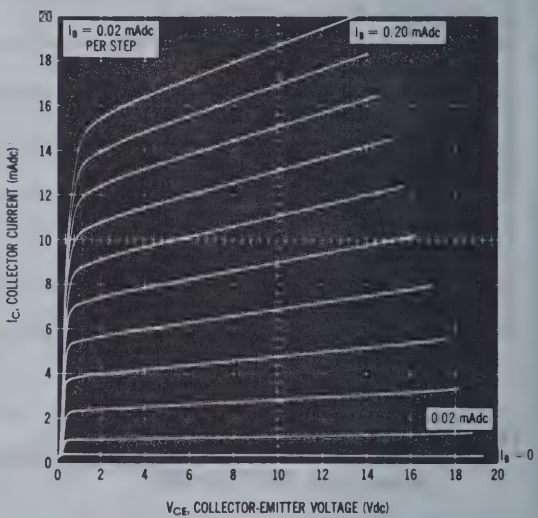


FIGURE 4 — INPUT ADMITTANCE versus COLLECTOR CURRENT

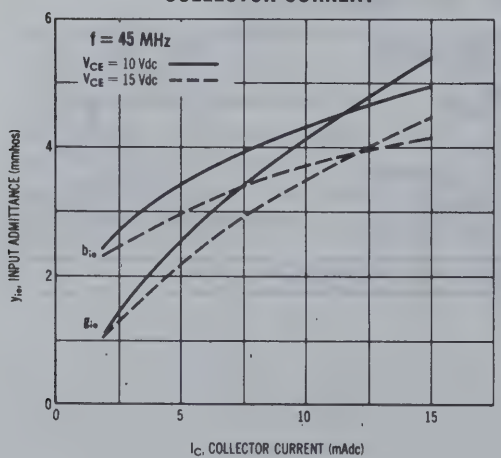


FIGURE 5 — REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT

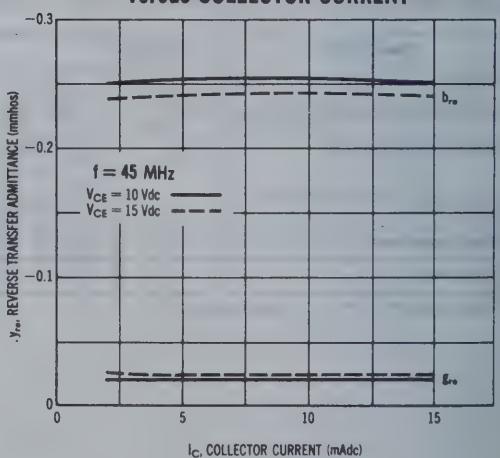


FIGURE 6 — FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

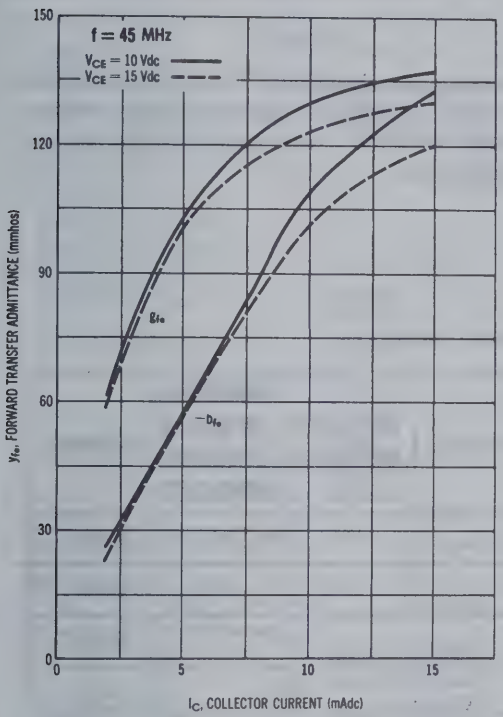


FIGURE 7 — OUTPUT ADMITTANCE versus COLLECTOR CURRENT

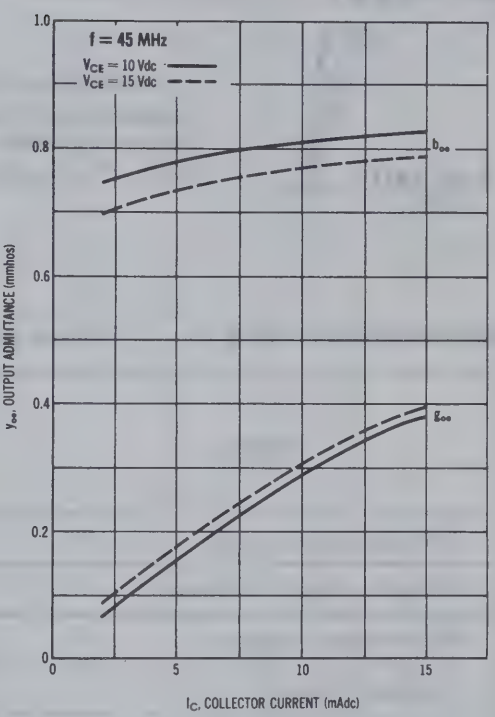
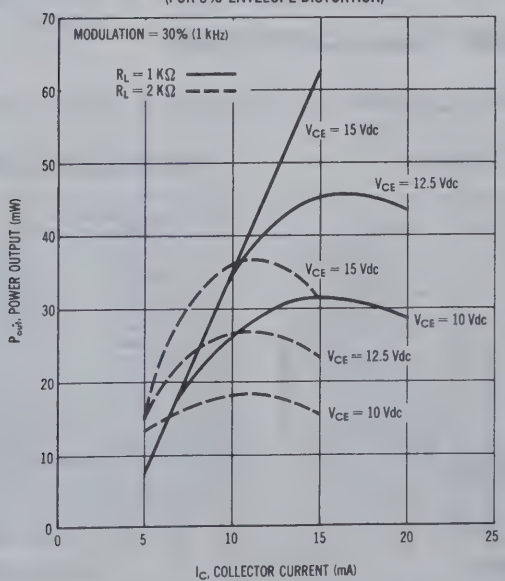


FIGURE 8 — POWER OUTPUT versus COLLECTOR CURRENT

(FOR 3% ENVELOPE DISTORTION)



MPS6512 thru MPS6515 (SILICON)
MPS6520
MPS6521



CASE 29(1)
(TO-92)

NPN silicon transistors designed for use in general-purpose audio and low-frequency amplifier applications. Types MPS6520 and MPS6521 are particularly suited for low-noise applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	MPS6512 MPS6513	MPS6514 MPS6515 MPS6520 MPS6521	Unit
Collector-Base Voltage	V_{CB}	40	40	Volts
Collector-Emitter Voltage	V_{CEO}	30	25	Volts
Emitter-Base Voltage	V_{EB}	4.0		Volts
Collector Current	I_C	100		mA
Total Device Dissipation @ $T_A = 60°C$ @ $T_A = 25°C$	P_D	210 310		mW
Junction Temperature	T_J	135		°C

THERMAL RESISTANCE $\theta_{JA(air)} = 0.357°C/mW$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)	MPS6512, MPS6513	BV_{CEO}	30	—	—	Vdc
	MPS6514, MPS6515		25	—	—	
	MPS6520, MPS6521		25	—	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	0.05	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)			—	—	1.0	
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6520	h_{FE}	100	—	—	—
	MPS6521		150	—	—	
(I_C = 2 mAdc, V_{CE} = 10 Vdc)	MPS6512		50	—	100	
	MPS6513		90	—	180	
	MPS6514		150	—	300	
	MPS6515		250	—	500	
	MPS6520		200	—	400	
	MPS6521		300	—	600	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)*	MPS6512		30	—	—	
	MPS6513		60	—	—	
	MPS6514		90	—	—	
	MPS6515		150	—	—	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$	—	—	0.5	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	—	3.5	pF
Current Gain - Bandwidth Product (I_C = 2 mAdc, V_{CE} = 10 Vdc)	MPS6512, MPS6513	f_T	—	250	—	MHz
	MPS6514, MPS6515		—	390	—	
	MPS6520, MPS6521		—	390	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS6512, MPS6513		—	330	—	
	MPS6514, MPS6515		—	480	—	
	MPS6520, MPS6521		—	480	—	
Wideband Noise Figure (V_{CE} = 5 Vdc, I_C = 10 μAdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3 dB points @ 10 Hz and 10 kHz)	MPS6512 thru MPS6515	NF	—	2.0	—	dB
	MPS6520, MPS6521		—	1.8	3.0	

*Pulse Test: PW ≤ 30 μs, duty cycle ≤ 2%

WIDEBAND NOISE FIGURE versus SOURCE IMPEDANCE

FIGURE 1 — MPS6512 thru MPS6515

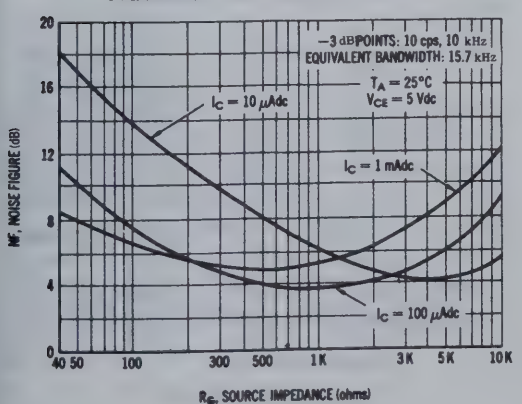
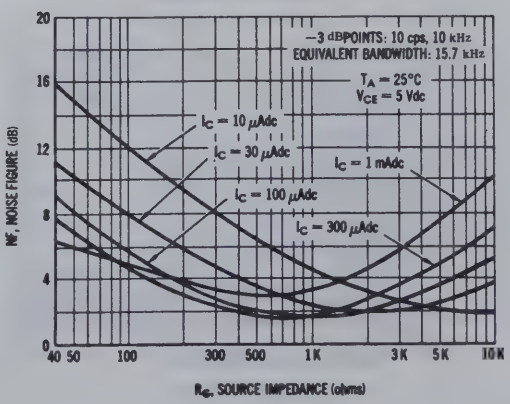


FIGURE 2 — MPS6520, MPS6521



COLLECTOR CHARACTERISTICS — COMMON EMITTER

FIGURE 3 — MPS6512

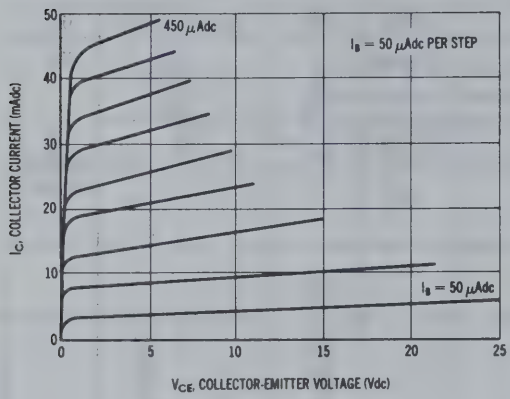


FIGURE 4 — MPS6513

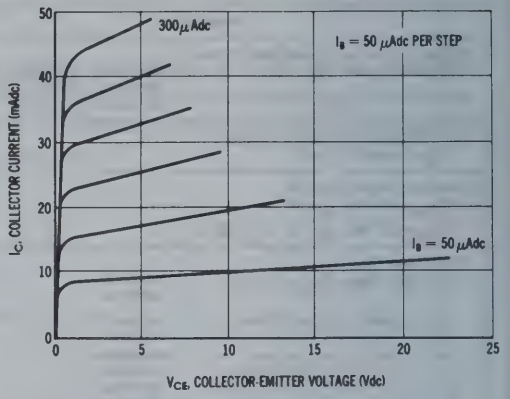


FIGURE 5 — MPS6514, MPS6520

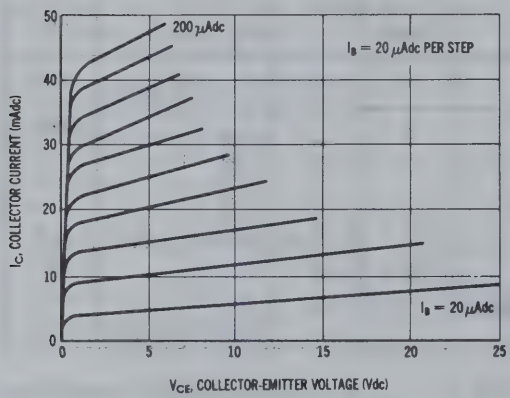


FIGURE 6 — MPS6515, MPS6521

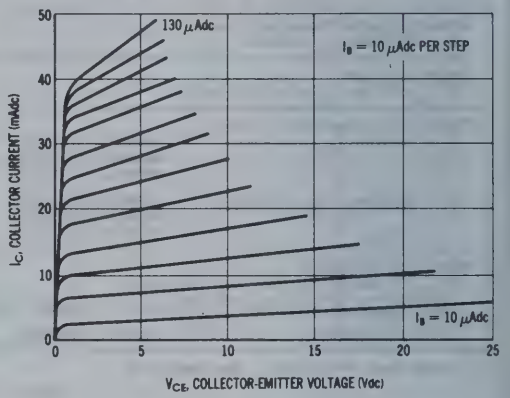


FIGURE 7 — SPOT NOISE FIGURE versus FREQUENCY

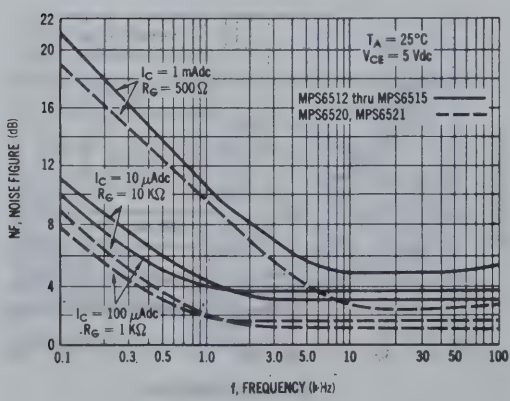
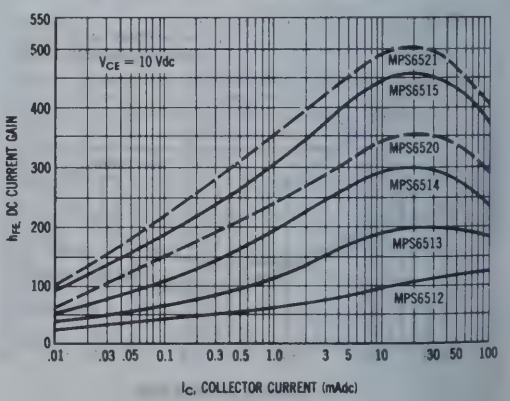


FIGURE 8 — DC CURRENT GAIN versus COLLECTOR CURRENT



h PARAMETER VARIATIONS
($f = 1$ MHz , $T_A = 25°C$)

FIGURE 9 — INPUT IMPEDANCE versus COLLECTOR CURRENT

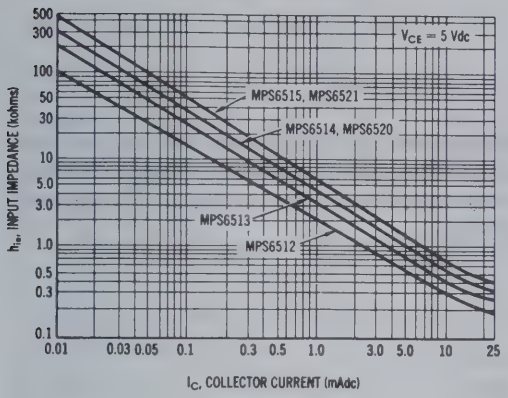


FIGURE 10 — REVERSE VOLTAGE TRANSFER RATIO versus COLLECTOR CURRENT

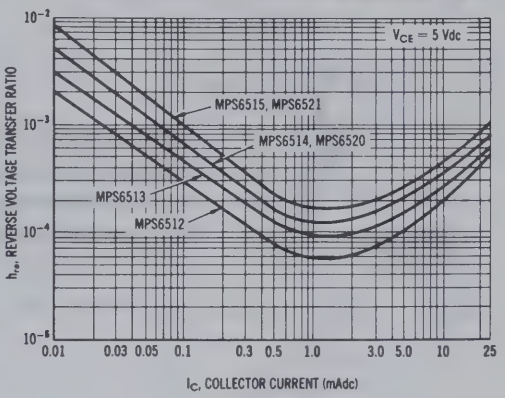


FIGURE 11 — SMALL SIGNAL CURRENT GAIN versus COLLECTOR CURRENT

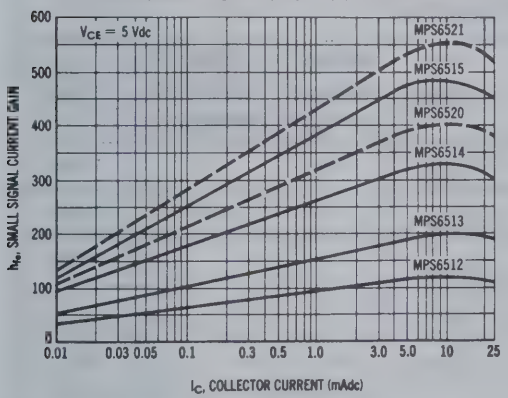


FIGURE 12 — OUTPUT ADMITTANCE versus COLLECTOR CURRENT

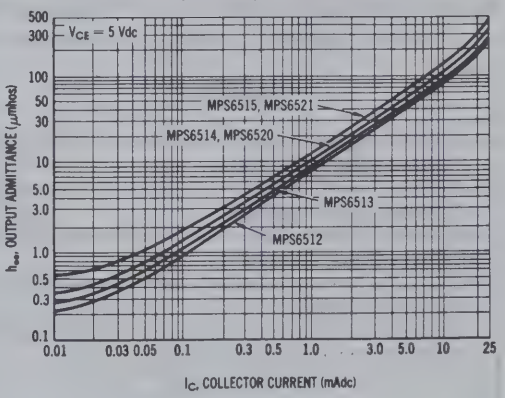


FIGURE 13 — GAIN — BANDWIDTH PRODUCT versus COLLECTOR CURRENT

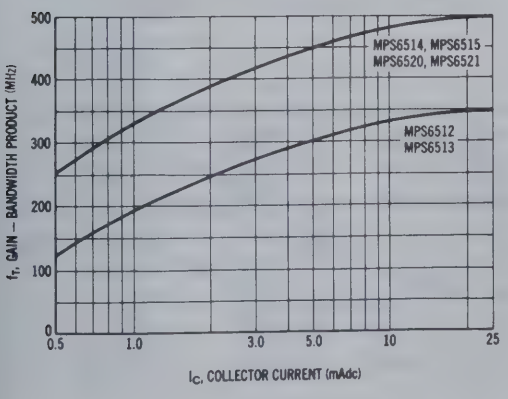
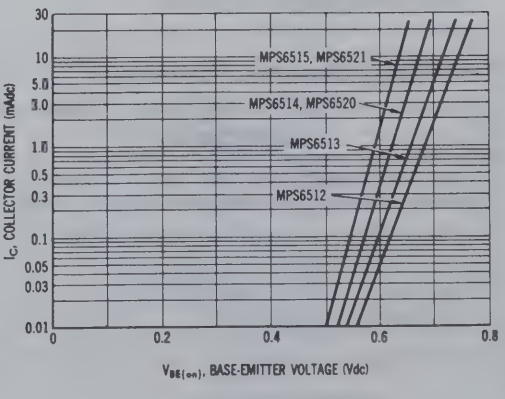


FIGURE 14 — COLLECTOR CURRENT versus BASE-EMITTER TURN-ON VOLTAGE



MPS6516 thru MPS6519 (SILICON)
MPS6522
MPS6523



CASE 29(1)
(TO-92)

PNP silicon transistors designed for use in general purpose audio and low-frequency amplifier applications. Types MPS6522 and MPS6523 are particularly suited for low-noise applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	MPS6516 MPS6517 MPS6518	MPS6519 MPS6522 MPS6523	Unit
Collector-Emitter Voltage	V_{CEO}	40	25	Volts
Collector-Base Voltage	V_{CB}	40	25	Volts
Emitter Base Voltage	V_{EB}	4.0		Volts
Collector Current	I_C	100		mA
Total Device Dissipation @ $T_A = 60°C$ @ $T_A = 25°C$	P_D	210 310		mW
Junction Temperature	T_J	135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)	MPS6516 thru MPS6518 MPS6519, MPS6522, MPS6523	BV_{CEO}	40 25	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 Vdc, I_E = 0)	MPS6516 thur MPS6518		—	—	0.05	
(V_{CB} = 20 Vdc, I_E = 0)	MPS6519, MPS6522, MPS6523		—	—	0.05	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)	MPS6516 thru MPS6518		—	—	1.0	
(V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)	MPS6519, MPS6522, MPS6523		—	—	1.0	
DC Current Gain		h_{FE}				—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6522 MPS6523		100 150	— —	— —	
(I_C = 2 mAdc, V_{CE} = 10 Vdc)	MPS6516 MPS6517 MPS6518 MPS6519 MPS6522 MPS6523		50 90 150 250 200 300	— — — — — —	100 180 300 500 400 600	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)*	MPS6516 MPS6517 MPS6518 MPS6519		30 60 90 150	— — — —	— — — —	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$	—	—	0.5	Vdc
Current Gain — Bandwidth Product		f_T				MHz
(I_C = 2 mAdc, V_{CE} = 10 Vdc)	MPS6516, MPS6517 MPS6518, MPS6519 MPS6522, MPS6523		— — —	200 340 340	— — —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS6516, MPS6517 MPS6518, MPS6519 MPS6522, MPS6523		— — —	270 420 420	— — —	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	MPS6516 thru MPS6519 MPS6522, MPS6523	C_{ob}	— —	— —	4.0 3.5	pF
Wideband Noise Figure (V_{CE} = 5 Vdc, I_C = 10 μAdc, R_S = 10 kohms, Power Bandwidth = 15.7 kHz, 3 dB points @ 10 Hz and 10 kHz)	MPS6516 thru MPS6519 MPS6522, MPS6523	NF	— —	2.0 1.8	— 3.0	dB

*Pulse Test: Pulse Width ≤ 30 μs, duty cycle ≤ 2%

WIDEBAND NOISE FIGURE versus SOURCE IMPEDANCE

FIGURE 1 — MPS6516 thru MPS6519

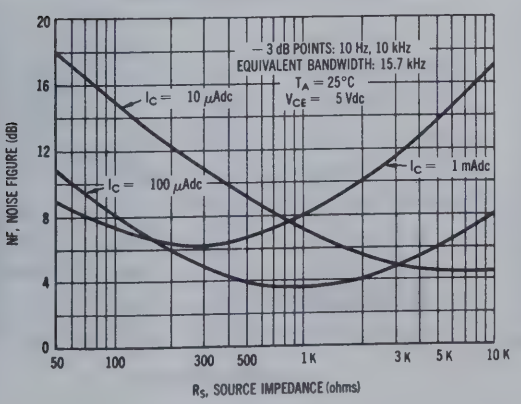
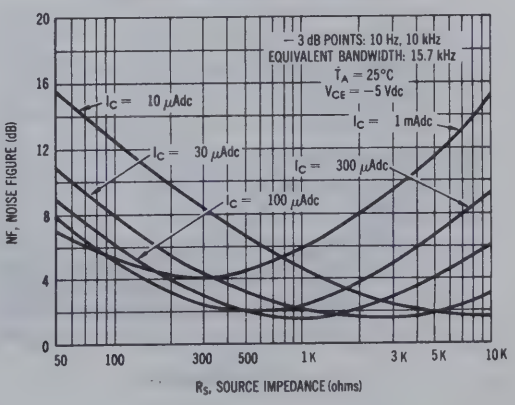


FIGURE 2 — MPS6522, MPS6523



COLLECTOR CHARACTERISTICS — COMMON EMITTER

FIGURE 3 — MPS6516

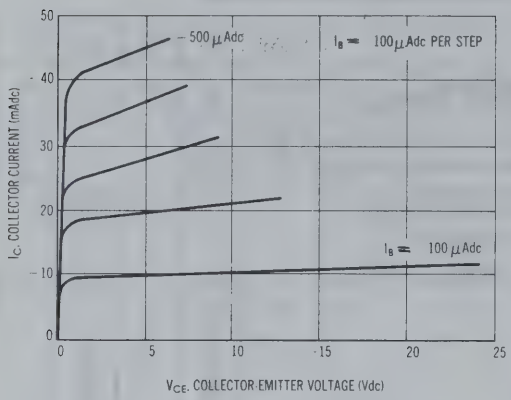


FIGURE 4 — MPS6517

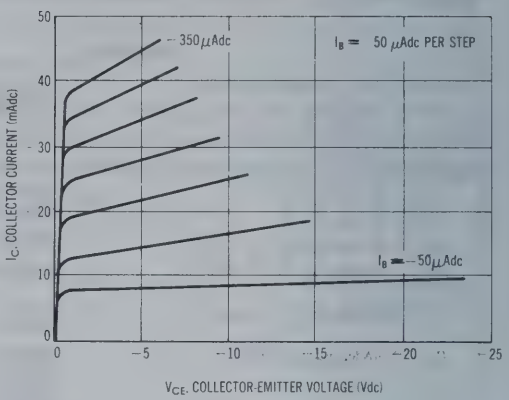


FIGURE 5 — MPS6518, MPS6522

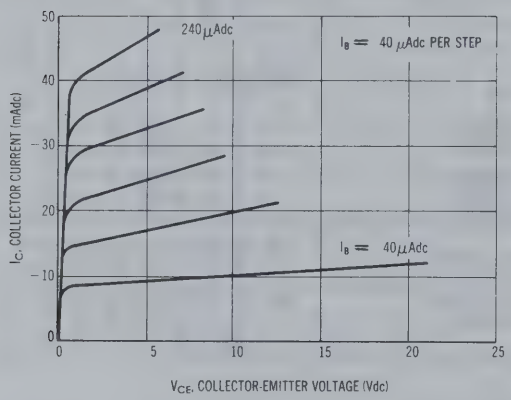


FIGURE 6 — MPS6519, MPS6523

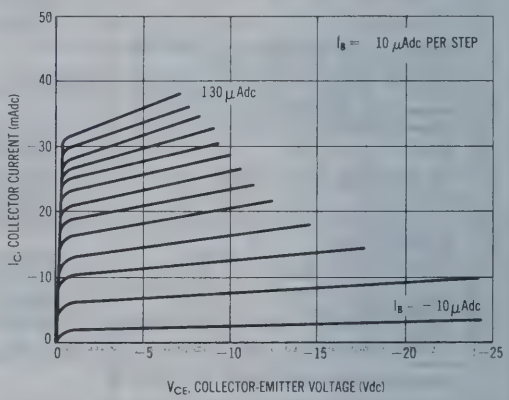


FIGURE 7 — SPOT NOISE FIGURE versus FREQUENCY

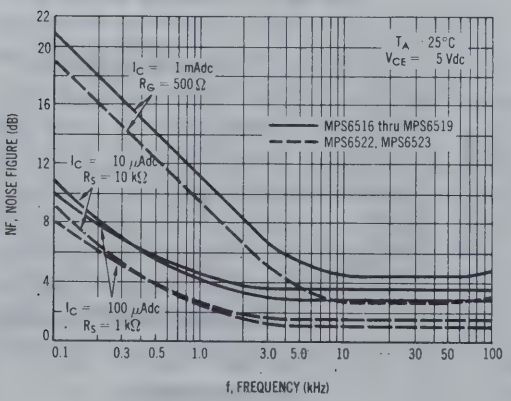
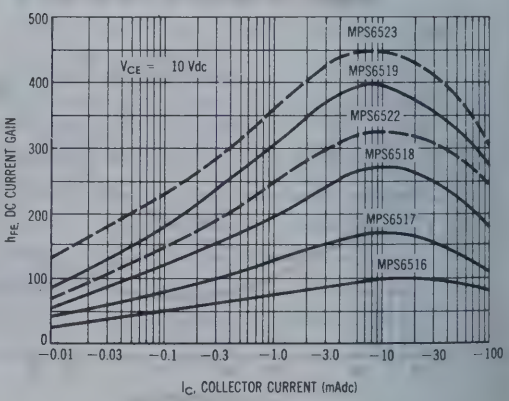


FIGURE 8 — DC CURRENT GAIN versus COLLECTOR CURRENT



h PARAMETER VARIATIONS
($f = 1$ kHz, $T_A = 25°C$)

FIGURE 9 — INPUT IMPEDANCE versus COLLECTOR CURRENT

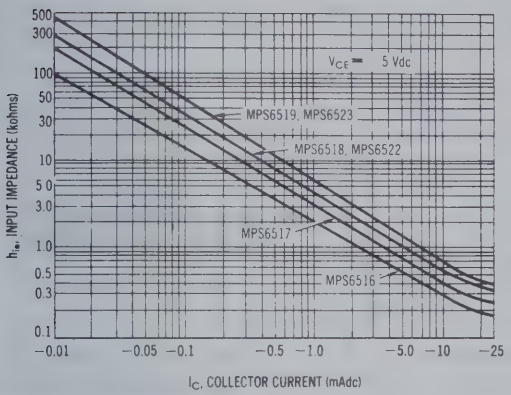


FIGURE 10 — REVERSE VOLTAGE TRANSFER RATIO versus COLLECTOR CURRENT

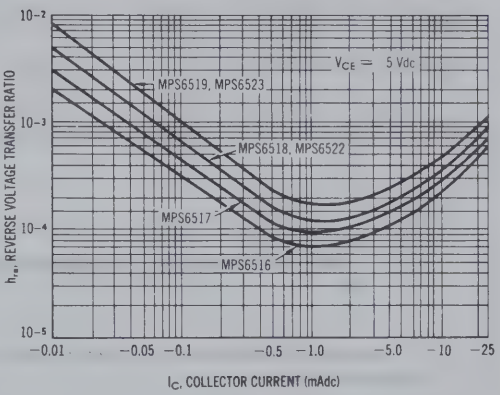


FIGURE 11 — SMALL-SIGNAL CURRENT GAIN versus COLLECTOR CURRENT

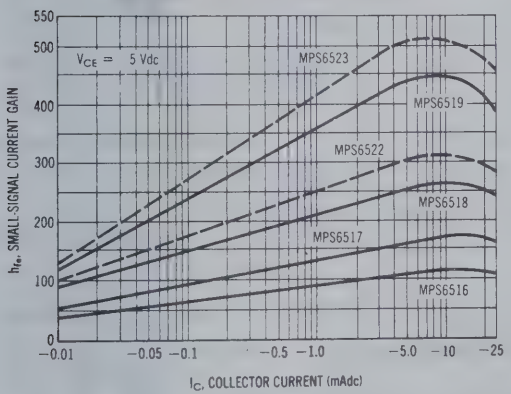


FIGURE 12 — OUTPUT ADMITTANCE versus COLLECTOR CURRENT

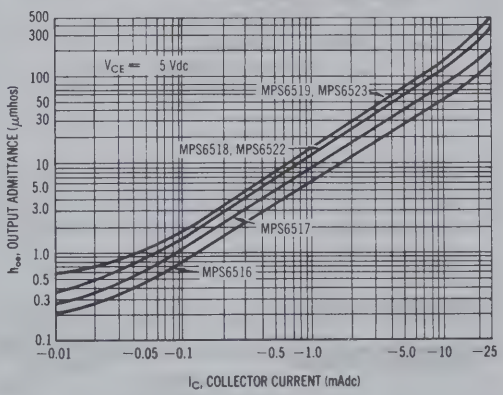


FIGURE 13 — GAIN — BANDWIDTH PRODUCT versus COLLECTOR CURRENT

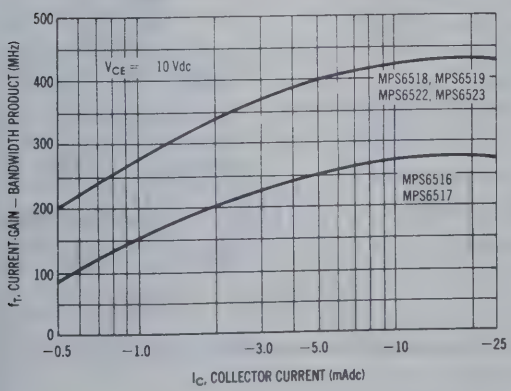
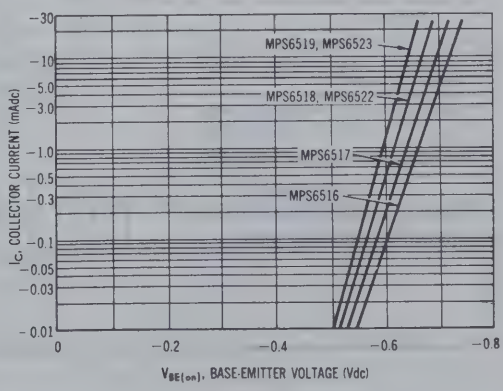


FIGURE 14 — COLLECTOR CURRENT versus BASE-EMITTER TURN-ON VOLTAGE



MPS6520, MPS6521 NPN (SILICON)
MPS6522, MPS6523 PNP

SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose amplifier applications and for complementary circuitry.

- High DC Current Gain –
  h_{FE} = 150 (Min) @ I_C = 100 μAdc – MPS6521, MPS6523
- Low Noise Figure –
  NF = 1.8 dB (Typ) @ I_C = 10 μAdc
- Low Output Capacitance –
  C_{ob} = 3.5 pF (Max) @ V_{CB} = 10 Vdc

SILICON COMPLEMENTARY AMPLIFIER TRANSISTORS

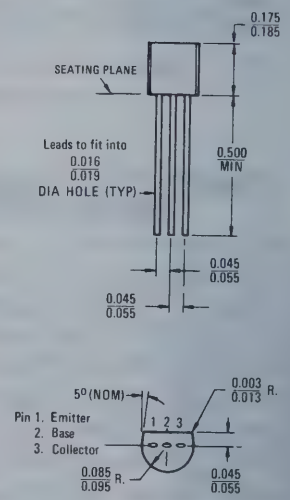


MAXIMUM RATING

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage MPS6520, MPS6521 MPS6522, MPS6523	V_{CEO}	25	25	Vdc
Collector-Base Voltage MPS6520, MPS6521 MPS6522, MPS6523	V_{CB}	40	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	Vdc
Collector Current	I_C	100	100	mAdc
Total Device Dissipation @ T_A = 25°C T_A = 60°C Derate above 25°C	P_D	310 210 2.81	310 210 2.81	mW mW/°C
Operating Junction Temperature Range	T_J	135	135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	θ_{JA}	0.357	°C/mW



CASE 29(1)
TO-92

MPS6520, MPS6521 (NPN)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)		BV_{CEO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 Vdc, I_E = 0)			–	–	0.05	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)			–	–	1.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6520		100	–	–	
	MPS6521		150	–	–	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6520		200	–	400	
	MPS6521		300	–	600	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)			–	390	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			–	480	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	–	1.8	3.0	dB

MPS6522, MPS6523 (PNP)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)		BV_{CEO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 20 Vdc, I_E = 0)			–	–	0.05	
(V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)			–	–	1.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6522		100	–	–	
	MPS6523		150	–	–	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6522		200	–	400	
	MPS6523		300	–	600	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)			–	340	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			–	420	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	–	1.8	3.0	dB

MPS6530
MPS6531
MPS6532
NPN (SILICON)

MPS6533
MPS6534
MPS6535
PNP



CASE 29(1)
(TO-92)

Silicon annular transistors designed for use in complementary amplifier circuits.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	NPN	PNP	Unit
Collector-Base Voltage	V_{CB}			Vdc
MPS6530, MPS6531 MPS6532		60 50		
MPS6533, MPS6534 MPS6535			40 30	
Collector-Emitter Voltage	V_{CEO}			Vdc
MPS6530, MPS6531 MPS6532		40 30		
MPS6533, MPS6534 MPS6535			40 30	
Emitter-Base Voltage	V_{EB}	5.0	4.0	Vdc
Collector Current	I_C	600	600	mAdc
Total Device Dissipation @ $T_A = 60°C$	P_D	210	210	mW
@ $T_A = 25°C$		310	310	
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	0.357	°C/mW
Junction Temperature	T_J	135	135	°C

MPS6530 thru MPS6532 (NPN)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS6530, MPS6531 MPS6532	BV_{CBO}	60 50	- -	- -	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS6530, MPS6531 MPS6532	BV_{CEO}	40 30	- -	- -	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 60°C) (V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)	 MPS6530, MPS6531 MPS6532 MPS6530, MPS6531 MPS6532	I_{CBO}	 - - - -	 - - - -	 0.05 0.1 2.0 5.0	μAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 100 mAdc, V_{CE} = 1 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	 MPS6530 MPS6531 MPS6530 MPS6531 MPS6532 MPS6530 MPS6531	h_{FE}	 30 60 40 90 30 25 50	 75 120 85 150 - 60 80	 - - 120 270 - - -	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6530, MPS6532 MPS6531	$V_{CE(sat)}$	- -	0.2 0.13	0.5 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6530, MPS6531 MPS6532	$V_{BE(sat)}$	- -	0.82 0.85	1.0 1.2	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	3.5	5.0	pF
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc)		f_T	-	390	-	MHz

MPS6533 thru MPS6535 (PNP)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS6533, MPS6534 MPS6535	BV_{CBO}	40 30	- -	- -	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS6533, MPS6534 MPS6535	BV_{CEO}	40 30	- -	- -	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C) (V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)	 MPS6533, MPS6534 MPS6535 MPS6533, MPS6534 MPS6535	I_{CBO}	 - - - -	 - - - -	 0.05 0.1 2.0 5.0	μAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 100 mAdc, V_{CE} = 1 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	 MPS6533 MPS6534 MPS6533 MPS6534 MPS6535 MPS6533 MPS6534	h_{FE}	 30 60 40 90 30 25 50	 70 110 85 140 - 55 70	 - - 120 270 - - -	-
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6533, MPS6535 MPS6534	$V_{CE(sat)}$	- -	0.2 0.13	0.5 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6533, MPS6534 MPS6535	$V_{BE(sat)}$	- -	0.84 0.87	1.0 1.2	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	4.8	6.0	pF
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc)		f_T	-	260	-	MHz

MPS6539 (SILICON)



CASE 29(2)
TO-92

NPN silicon epitaxial transistor designed for RF applications in FM receivers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 500 μAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	50	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 3.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	-	-
Base-Emitter On Voltage (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	-	0.85	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 mHz)	f_T	500	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	0.7	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	-	9.0	ps
Noise Figure (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, R_S = 75 ohms, f = 100 MHz)	NF	-	4.5	dB

MPS6540 (SILICON)

NPN silicon annular amplifier transistor designed for IF applications in FM radio receivers.



CASE 29(2)
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	-	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	-	-	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	-	-	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	-	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	-	0.65	pF
Real Part of Output Impedance (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 10.7 MHz)	R_{oep}	80	-	-	k ohms
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	-	4.5	-	ps
FUNCTIONAL TESTS					
Maximum Available Gain (f = 10.7 MHz)	MAG	-	48	-	dB

COMMON-EMITTER y PARAMETERS

(V_{CE} = 10 Vdc, f = 10.7 MHz, T_A = 25°C)

FIGURE 1 — INPUT ADMITTANCE

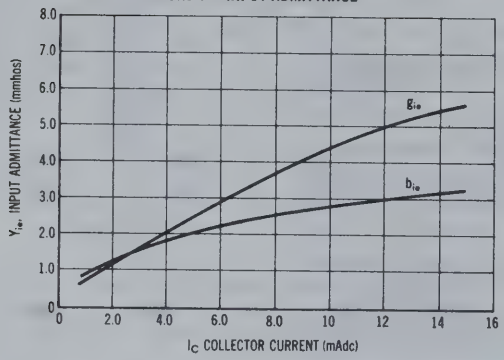


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

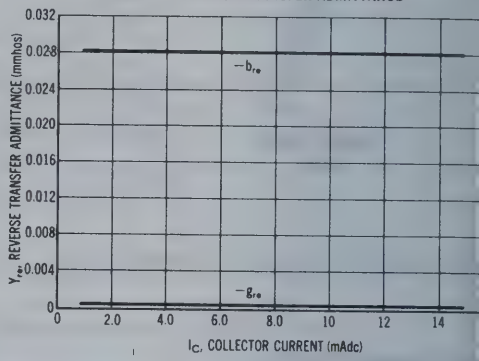


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

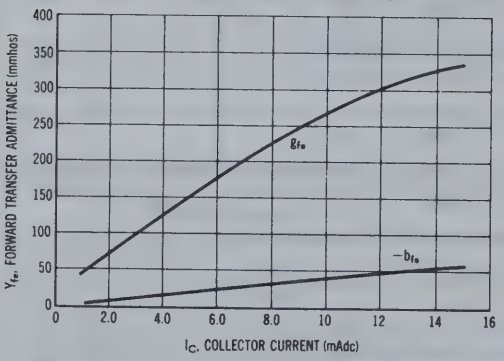


FIGURE 4 — OUTPUT ADMITTANCE

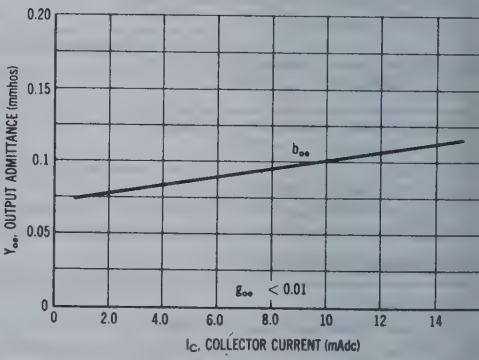


FIGURE 5 — CAPACITANCES

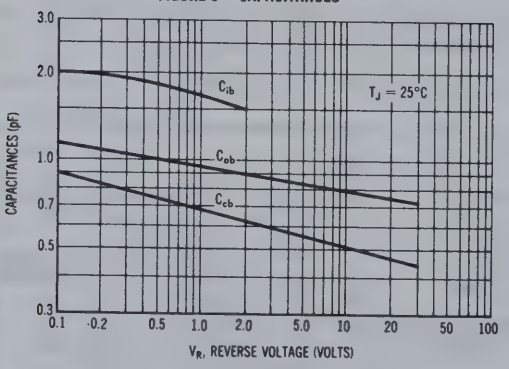
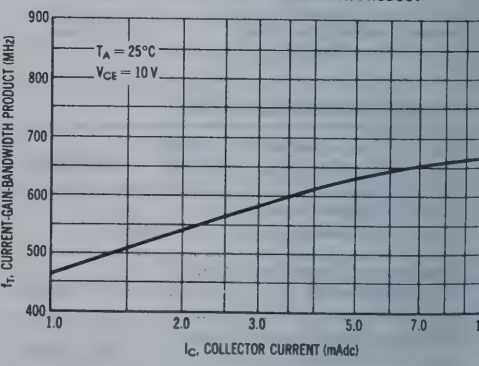


FIGURE 6 — CURRENT-GAIN—BANDWIDTH PRODUCT



MPS6542 (SILICON)



CASE 29(2)
TO-92

NPN silicon epitaxial transistor designed for VHF mixer applications in TV receivers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	310 2.81	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	$^oC/mW$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	20	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, V_{BE} = 0)	BV_{CES}*	30	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	—	0.05	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 60°C)		—	—	1.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—	—
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	700	—	—	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc)	C_{re}	—	0.33	—	pF
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	—	1.5	pF
High-Frequency Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 44 MHz)	h_{fe}	10	—	—	—
Conversion Gain (213 to 44 MHz) (I_C = 2.5 mAdc, V_{CE} = 10 Vdc, See Figures 1, 2, & 9)	—	20	23	—	dB

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

CONVERSION GAIN CHARACTERISTICS
(TEST CIRCUIT FIGURE 9)

FIGURE 1 — VARIATION WITH COLLECTOR CURRENT

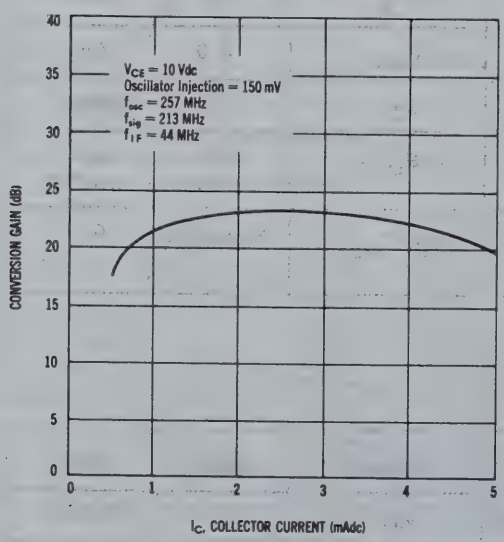
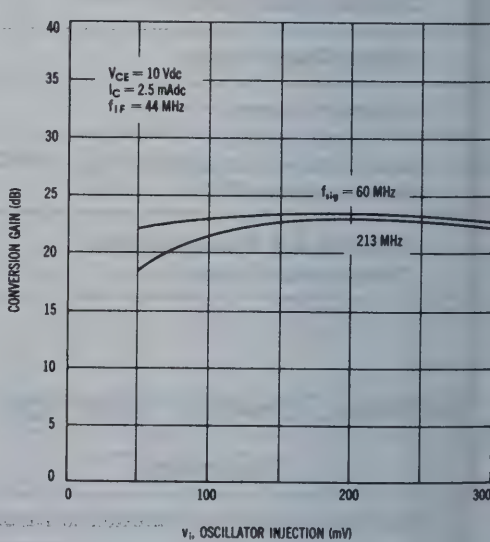


FIGURE 2 — VARIATION WITH INJECTION LEVEL



COMMON-EMITTER y PARAMETERS

$I_C = 2.5$ mAdc, $V_{CE} = 10$ Vdc, $T_A = 25°C$

FIGURE 3 — INPUT ADMITTANCE

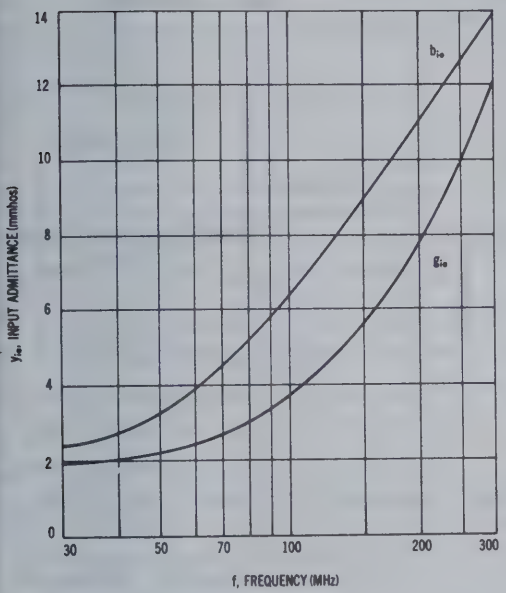


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

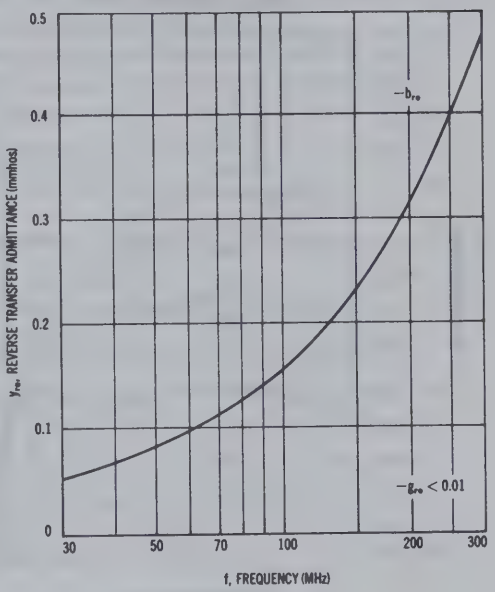


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

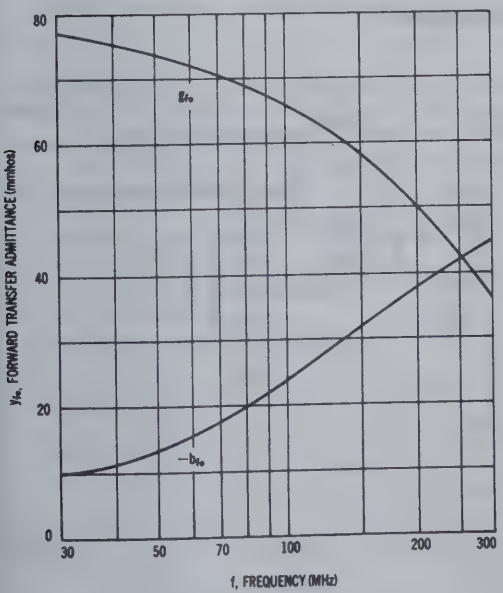


FIGURE 6 — OUTPUT ADMITTANCE

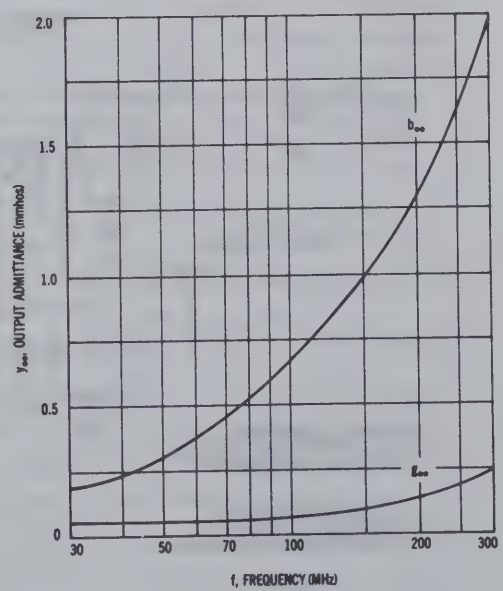


FIGURE 7 — DC CURRENT GAIN

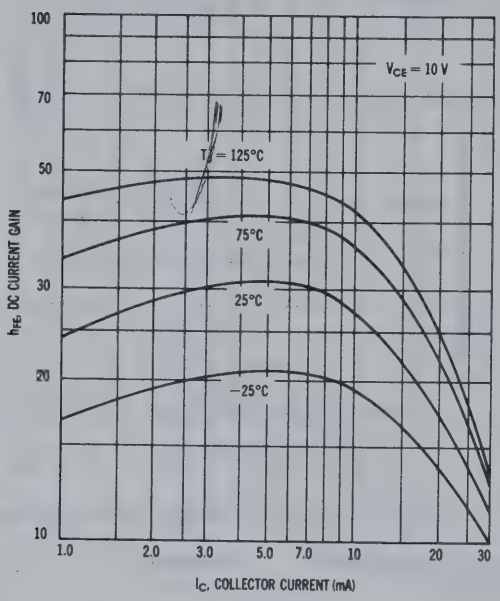


FIGURE 8 — CAPACITANCES

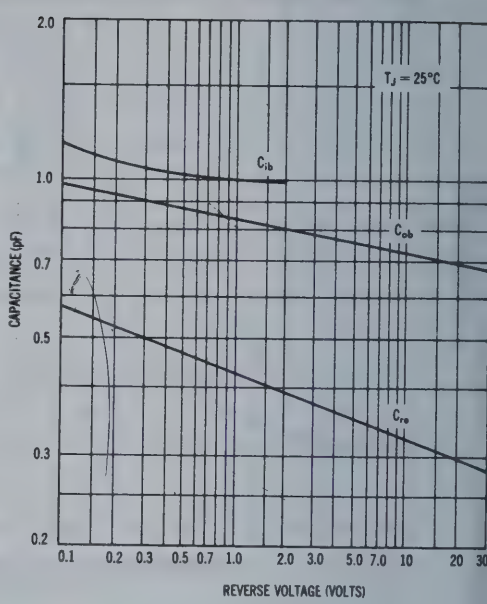
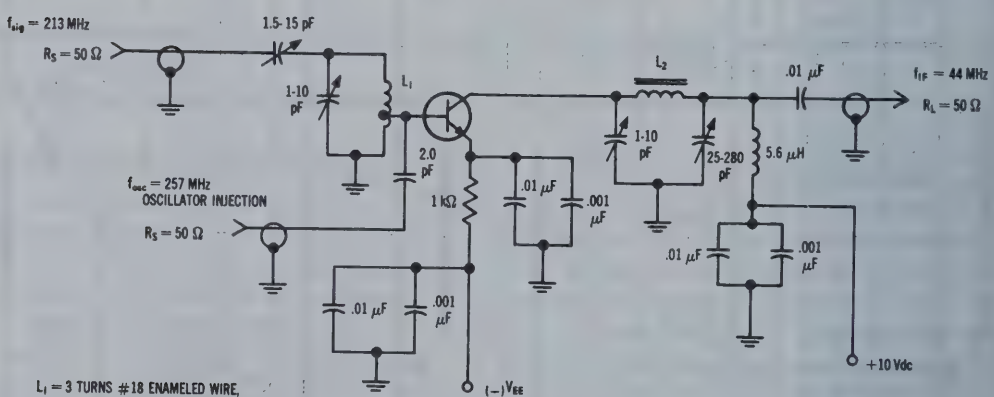


FIGURE 9 — MIXER TEST CIRCUIT



L_1 = 3 TURNS #18 ENAMELED WIRE, ¼" I.D., AIR WOUND, WINDING LENGTH ½"; BASE TAPPED 1 TURN FROM GROUND.

L_2 = 10 TURNS #26 INSULATED WIRE, WOUND ON ¼" I.D. COIL FORM, ARNOLD PART NO. A1-10 IRON POWDER CORE.

MPS6543 (SILICON)



CASE 29 (2)
(TO-92)

NPN silicon epitaxial transistor designed for use in UHF oscillator applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	25	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	35	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 2 Vdc, I_C = 0)	I_{EBO}	—	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	0.95	Vdc

MPS6543 (Continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	750	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	1.0	pF
Collector-Base Time Constant (I_E = 4 mAdc, V_{CE} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	—	9.5	ps

COMMON-BASE y PARAMETERS

V_{cb} = 10 Vdc, f = 930 MHz, T_A = 25°C

FIGURE 1—INPUT ADMITTANCE

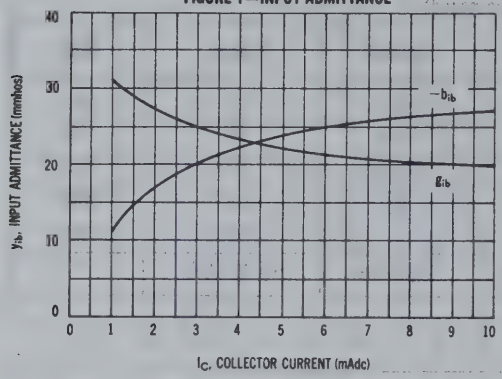


FIGURE 2—REVERSE TRANSFER ADMITTANCE

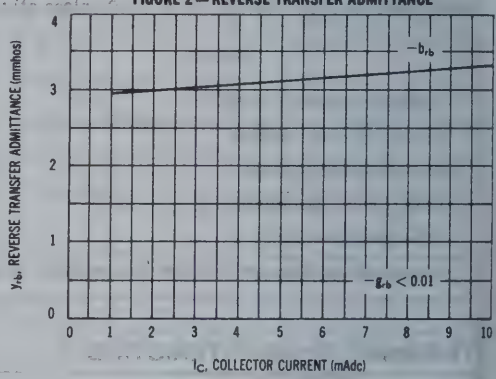


FIGURE 3—FORWARD TRANSFER ADMITTANCE

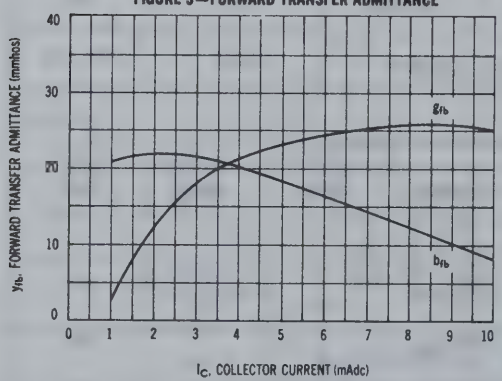


FIGURE 4—OUTPUT ADMITTANCE

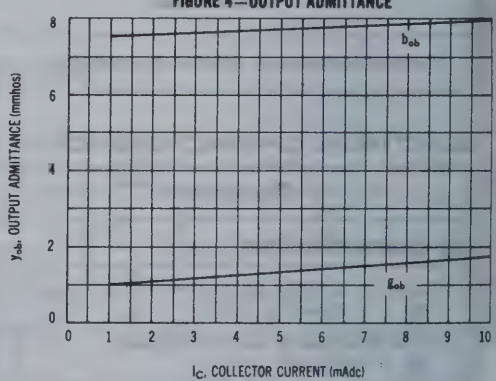


FIGURE 5—CAPACITANCES

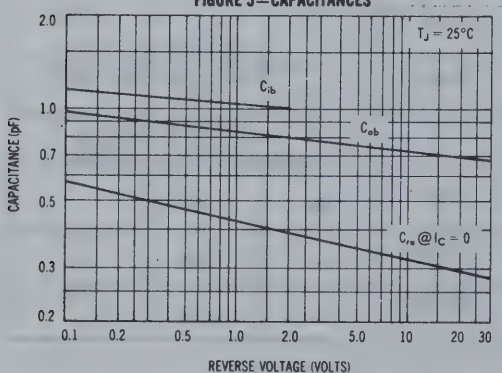
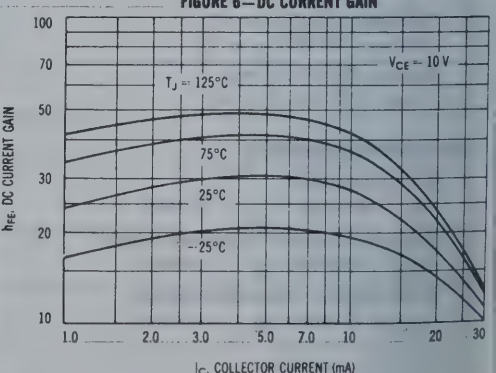


FIGURE 6—DC CURRENT GAIN



MPS6544 (SILICON)
MPS6545

CASE 29 (2)
TO-92



MPS6544

CASE 29A



MPS6545
TO-92 WITH SHIELD

NPN silicon annular amplifier transistors designed for third-stage video IF applications in television receivers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ T_A = 60°C	P_D	210	mW
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction Ambient - MPS6544	θ_{JA}	0.357	°C/mW
Thermal Resistance, Junction to Case - MPS6545	θ_{JC}	0.150	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_E = 0)	BV_{CEO}	45	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)	I_{CBO}	—	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
DYNAMIC CHARACTERISTICS				
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_C = 0, f = 100 kHz) MPS6544 MPS6545	C_{re}	— —	0.65 0.58	pF
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 45 MHz)	y_{oe}	—	0.10	mmhos
Output Voltage (Test Circuit Figure 6) ($V_{in(RMS)}$ =12 mV, f = 45 MHz)	V_{out}	1.0	—	Vdc

COMMON-EMITTER y PARAMETERS

V_{CE} = 20 Vdc, f = 45 MHz, T_A = 25°C

FIGURE 1 — INPUT ADMITTANCE

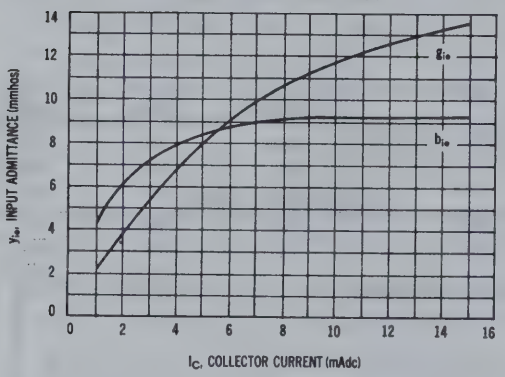


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

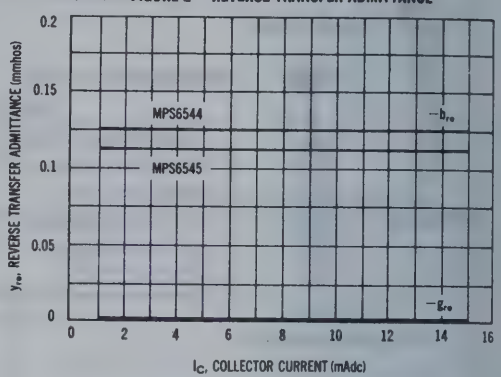


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

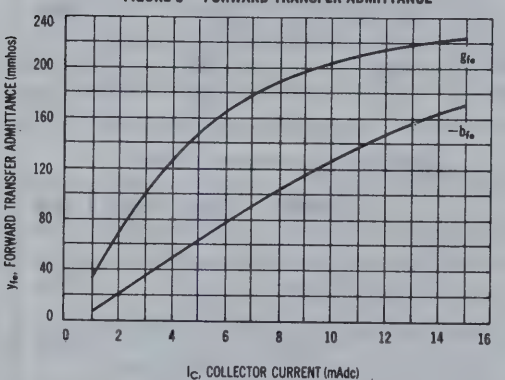


FIGURE 4 — OUTPUT ADMITTANCE

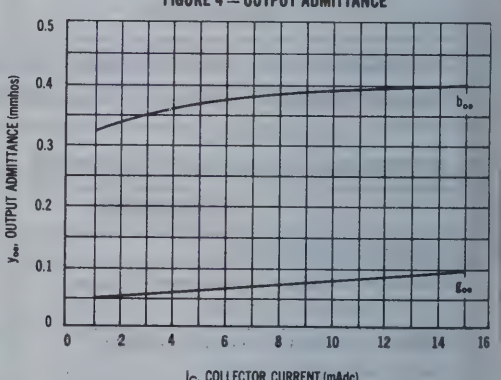


FIGURE 5 — CAPACITANCES

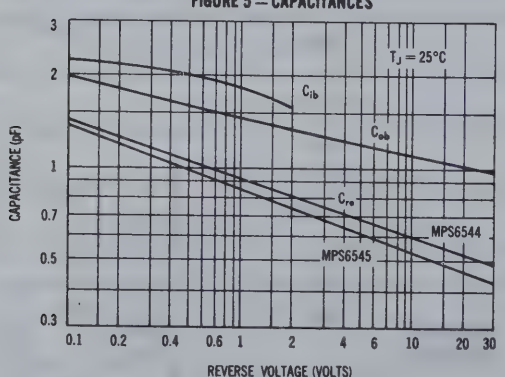
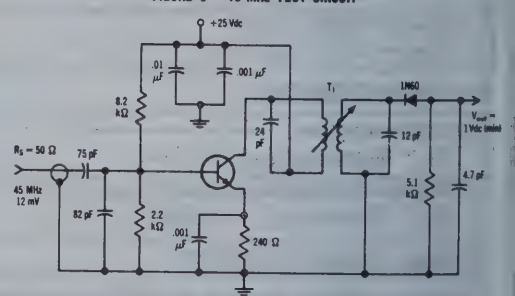


FIGURE 6 — 45 MHz TEST CIRCUIT



T_1 — PRIMARY: 7 TURNS #26 WIRE, ¼" I.D.
SECONDARY: 10 TURNS #26 WIRE, ¼" I.D.
CORE: ARNOLD IRON POWDER, PART NO. A1-10
FOR MPS6545 SHIELD IS CONNECTED TO GROUND

MPS6546 (SILICON)
MPS6547



Case 29(2)
TO-92

NPN silicon epitaxial transistors designed for FM radio applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current-Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	310 2.81	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	$^oC/mW$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	25	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	35	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 2 Vdc, I_C = 0)	I_{EBO}	—	—	1.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	—	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	—	0.35	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 100 mHz)	f_T	600	—	—	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz MPS6547	C_{re}	—	—	0.35	pF
MPS6546		—	—	0.45	
FUNCTIONAL TEST					
Conversion Gain (108 MHz to 10.7 MHz) (I_C = 2.5 mAdc, V_{CE} = 10 Vdc, Test Circuit Figure 7) MPS6547	—	—	28	—	dB
Oscillator Power Output (V_{EE} = 12.5 Vdc, f = 118 MHz, Test Circuit Figure 13) MPS6546	P_{out}	10	18	—	mW

CONVERSION GAIN CHARACTERISTICS

(TEST CIRCUIT FIGURE 7)

FIGURE 1—VARIATION WITH COLLECTOR CURRENT

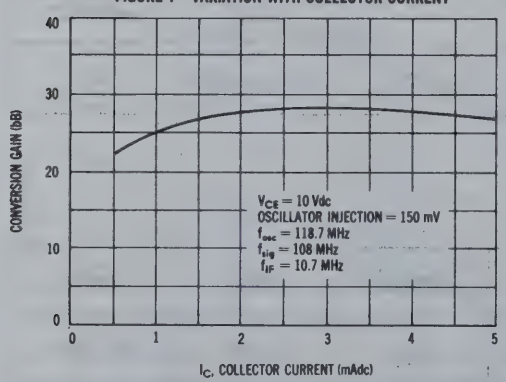
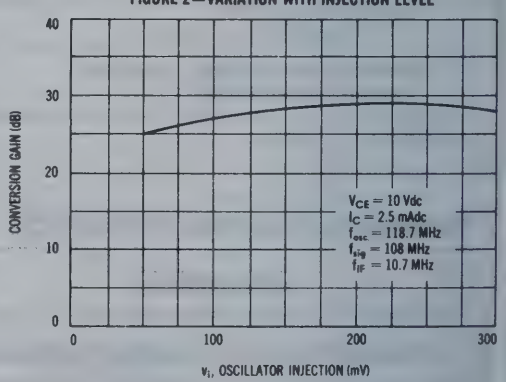


FIGURE 2—VARIATION WITH INJECTION LEVEL



COMMON-EMITTER y PARAMETERS

V_{CE} = 10 Vdc, f = 105 MHz, T_A = 25°C

FIGURE 3—INPUT ADMITTANCE

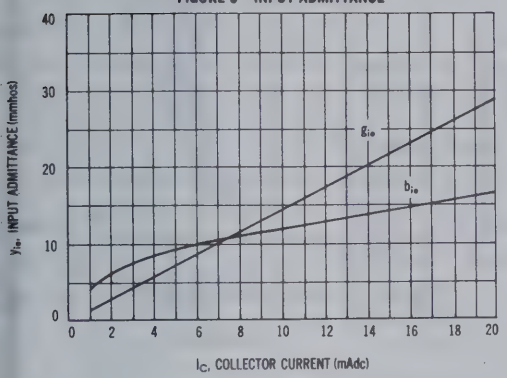


FIGURE 4—REVERSE TRANSFER ADMITTANCE

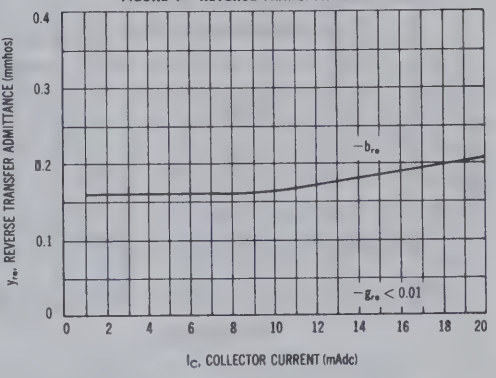


FIGURE 5—FORWARD TRANSFER ADMITTANCE

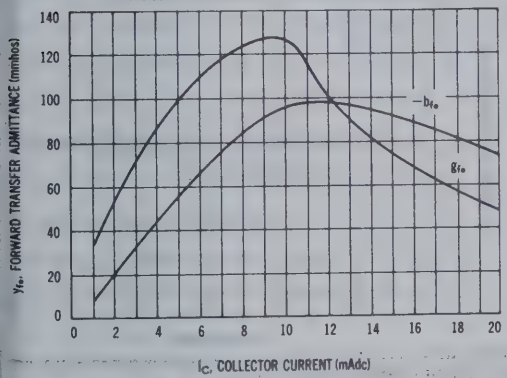


FIGURE 6—OUTPUT ADMITTANCE

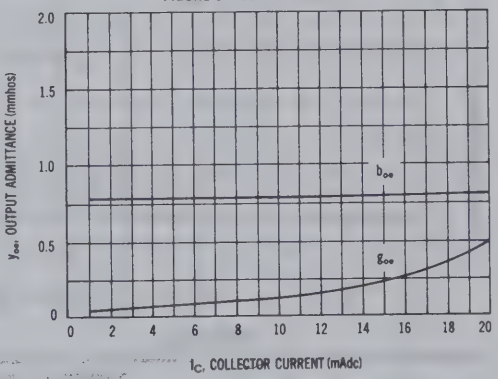


FIGURE 7—MIXER TEST CIRCUIT

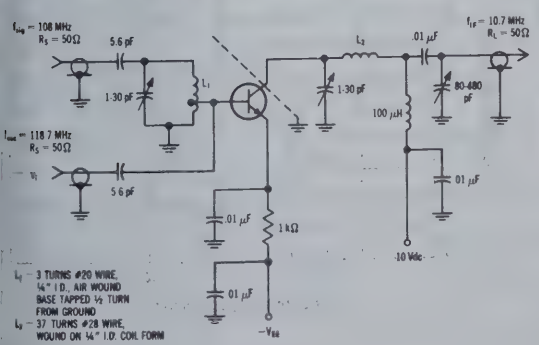
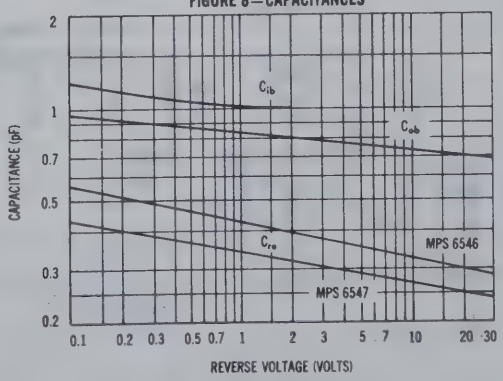


FIGURE 8—CAPACITANCES



COMMON-BASE y PARAMETERS

V_{CB} = 10 Vdc, I_C = 2.5 mAdc, T_A = 25°C

FIGURE 9—INPUT ADMITTANCE

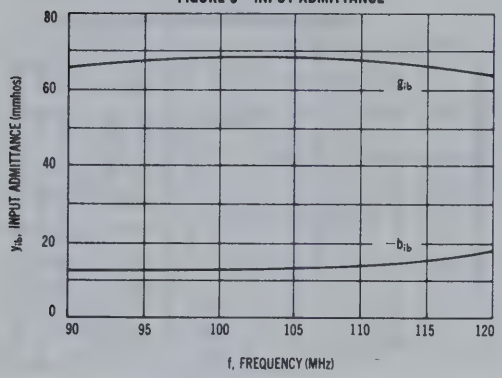


FIGURE 10—REVERSE TRANSFER ADMITTANCE

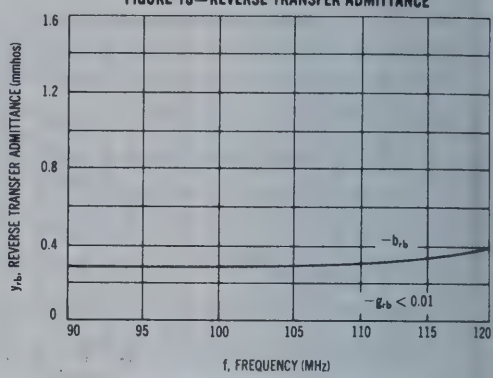


FIGURE 11—FORWARD TRANSFER ADMITTANCE

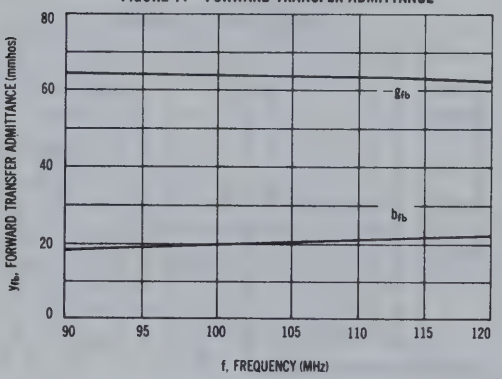
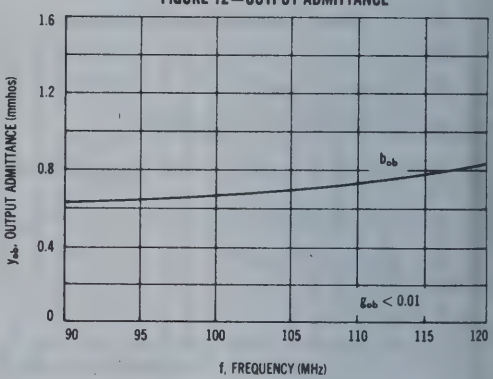


FIGURE 12—OUTPUT ADMITTANCE



TYPICAL OSCILLATOR PERFORMANCE

FIGURE 13—TEST CIRCUIT

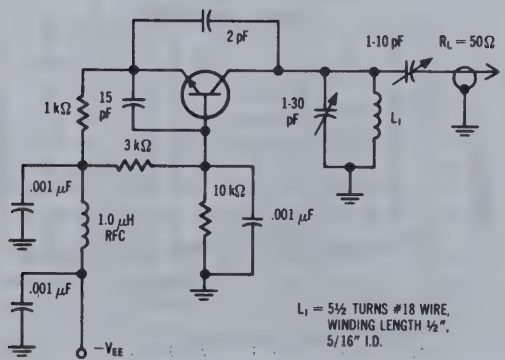
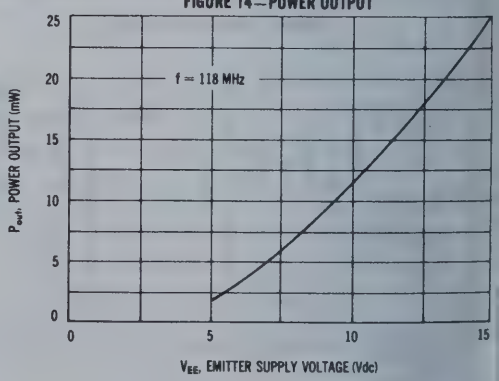


FIGURE 14—POWER OUTPUT



MPS6548 (SILICON)

NPN silicon epitaxial transistor designed for use in UHF oscillator applications.



CASE 29 (2)
TO-92

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	-	-
Collector-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)	$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)	$V_{BE(sat)}$	-	0.95	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	650	-	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	-	0.7	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	-	9.0	ps

MPS6560 MPS6561 NPN (SILICON)

MPS6562 MPS6563 PNP

Silicon annular audio transistors designed for complementary symmetry audio output applications.



CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	MPS6560 MPS6562	MPS6561 MPS6563	Unit
Collector-Emitter Voltage	V_{CEO}	25	20	Vdc
Collector-Base Voltage	V_{CB}	25	20	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current-Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.54		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	800 7.27		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction To Ambient	θ_{JA}	0.220	°C/mW
Thermal Resistance, Junction To Case	θ_{JC}	0.137	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	MPS6561, MPS6563	I_{CEO}	-	100	nAdc
(V_{CE} = 25 Vdc, I_B = 0)	MPS6560, MPS6562		-	100	
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)		I_{EBO}	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	35	-	-
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			50	-	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	MPS6560, MPS6562		50	200	
(I_C = 350 mAdc, V_{CE} = 1.0 Vdc)	MPS6561, MPS6563		50	200	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	MPS6560, MPS6562	$V_{CE(sat)}$	-	0.5	Vdc
(I_C = 350 mAdc, I_B = 35 mAdc)	MPS6561, MPS6563		-	0.5	
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	MPS6560, MPS6562	$V_{BE(on)}$	-	1.2	Vdc
(I_C = 350 mAdc, V_{CE} = 1.0 Vdc)	MPS6561, MPS6563		-	1.2	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)		f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	30	pF

TYPICAL CHARACTERISTICS

MPS6560
MPS6562

FIGURE 1 — DC CURRENT GAIN

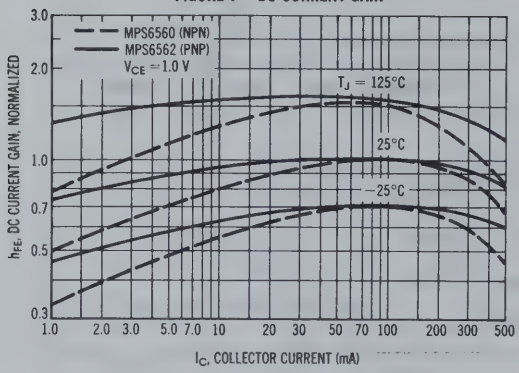


FIGURE 3 — COLLECTOR SATURATION REGION

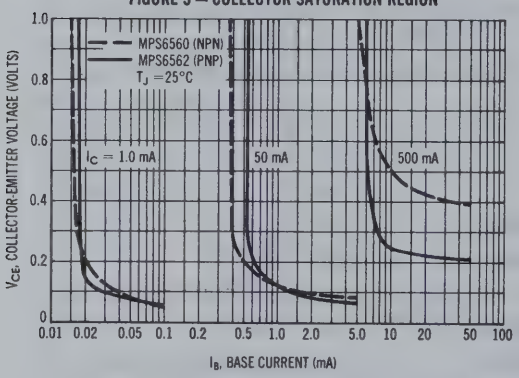
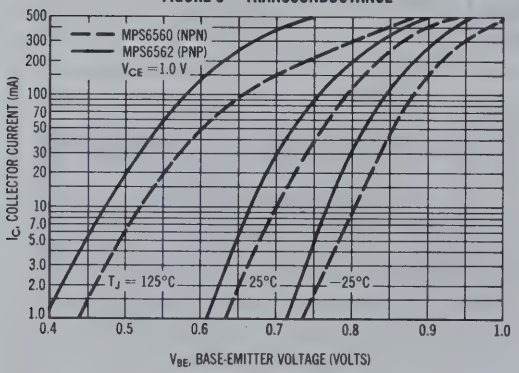


FIGURE 5 — TRANSCONDUCTANCE



MPS6561
MPS6563

FIGURE 2 — DC CURRENT GAIN

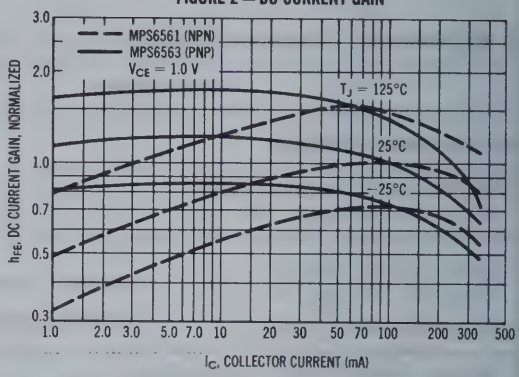


FIGURE 4 — COLLECTOR SATURATION REGION

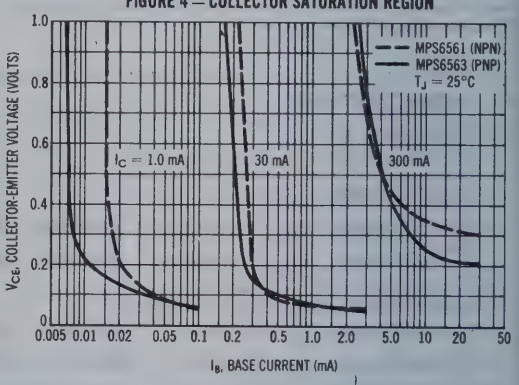
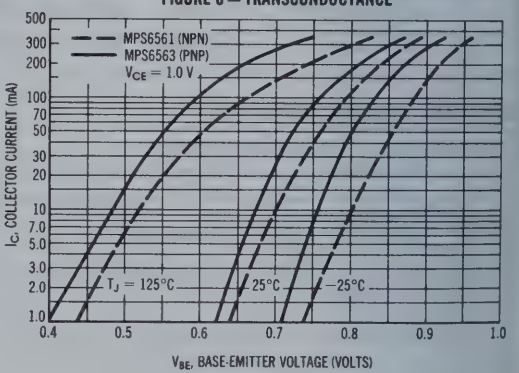


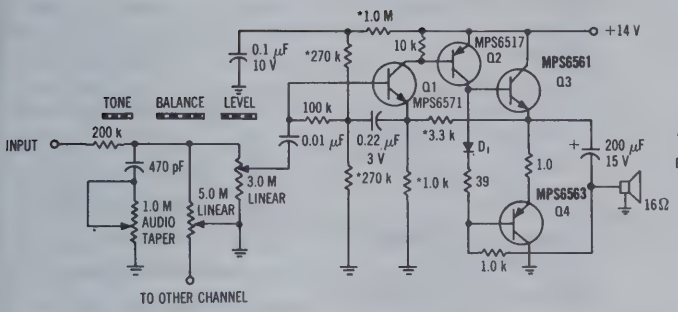
FIGURE 6 — TRANSCONDUCTANCE



TYPICAL AUDIO APPLICATIONS

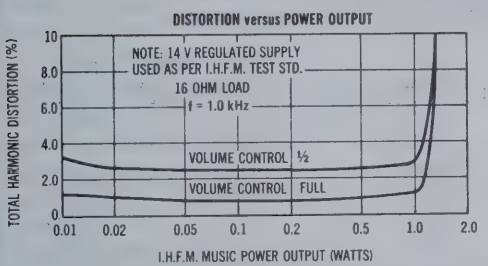
1-WATT STEREOPHONIC AUDIO AMPLIFIER

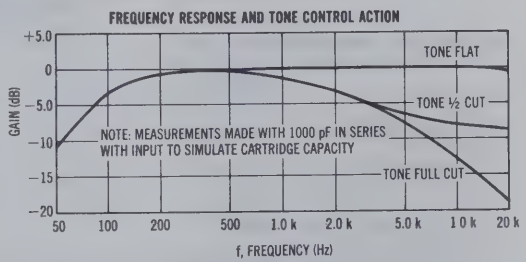
(ONE CHANNEL SHOWN)



All resistors are ½ Watt, ±10% ratings, except for parts preceded by an asterisk (*) where ±5% types are recommended.
D_1 = MSS1000

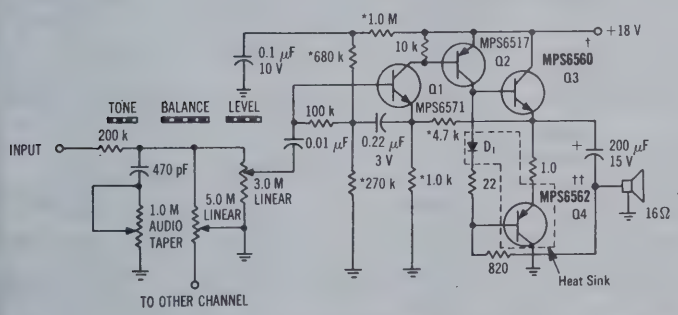
TYPICAL PERFORMANCE CURVES FOR 1-WATT/16-OHM AUDIO AMPLIFIER





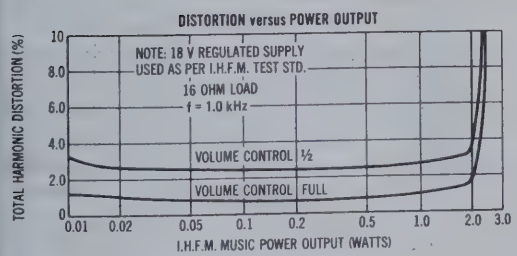
2-WATT STEREOPHONIC AUDIO AMPLIFIER

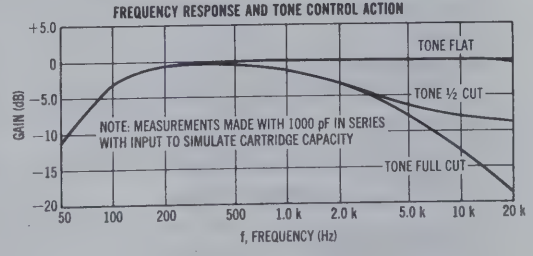
(ONE CHANNEL SHOWN)



All resistors are ½ Watt, ±10% ratings, except for parts preceded by an asterisk (*) where ±5% types are recommended.
D_1 = MSS1000
†Requires Heat Sink. Use Staver F1-7A (or equivalent).
††Requires Heat Sink. Use Staver F1-8. This Heat Sink allows D_1 and Q4 to be thermally connected, thus enhancing high temperature operation.

TYPICAL PERFORMANCE CURVES FOR 2-WATT/16-OHM AUDIO AMPLIFIER





MPS6565 (SILICON)
MPS6566

NPN silicon annular transistors designed for general-purpose, low-level amplifier applications.



CASE 29 (1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current-Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	310 2.81	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	$^oC/mW$

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)		BV_{CEO}	45	—	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	100	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS6565	h_{FE}	40	—	160	—
	MPS6566		100	—	400	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	—	0.1	0.4	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	—	3.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	3.7	—	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		h_{fe}	2.0	—	—	—
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		h_{oe}	—	60	—	μmhos
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		h_{ie}	—	500	—	ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		h_{re}	—	2.5	—	$X 10^{-4}$
Noise Figure (I_C = 100 μAdc, V_{CE} = 5 Vdc, R_S = 1000 ohms, f = 10 Hz to 15.7 kHz)		NF	—	4.0	—	dB

SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 5 Vdc, T_A = 25°C

FIGURE 1 — FREQUENCY EFFECTS

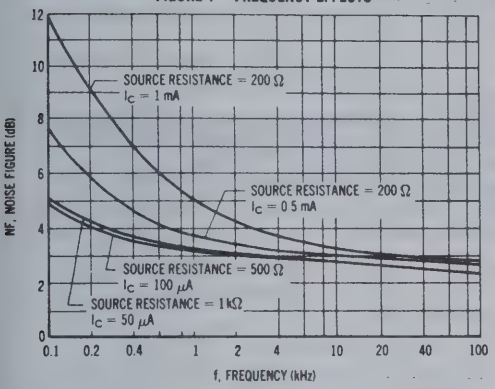
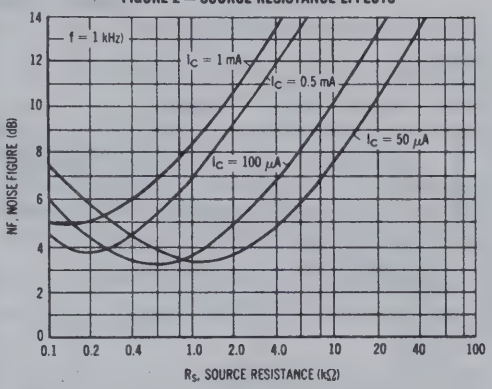


FIGURE 2 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 3 — CURRENT GAIN

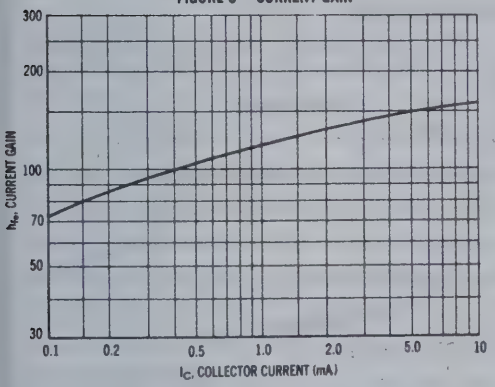


FIGURE 4 — OUTPUT ADMITTANCE

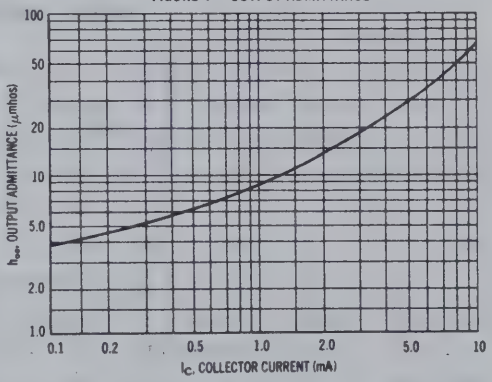


FIGURE 5 — INPUT IMPEDANCE

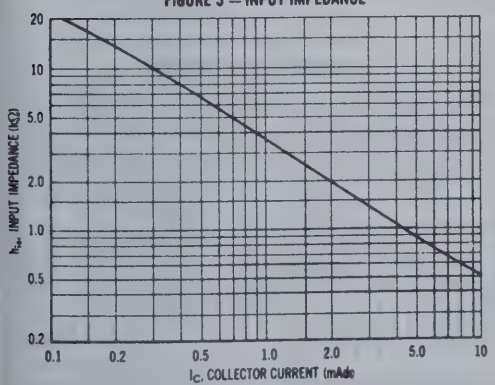
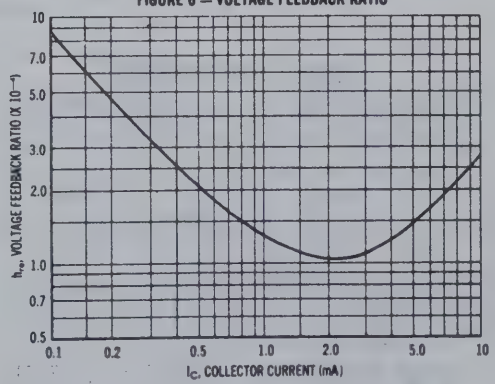


FIGURE 6 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 7 — NORMALIZED CURRENT GAIN

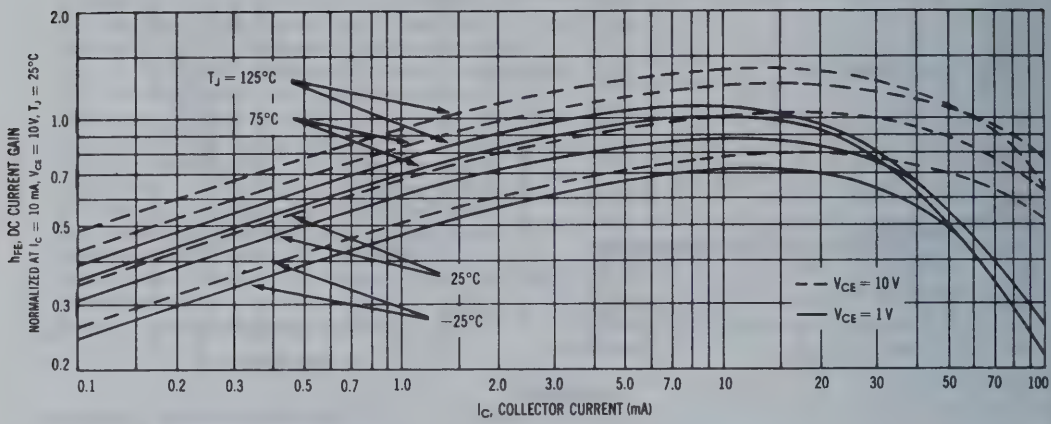


FIGURE 8 — COLLECTOR SATURATION REGION

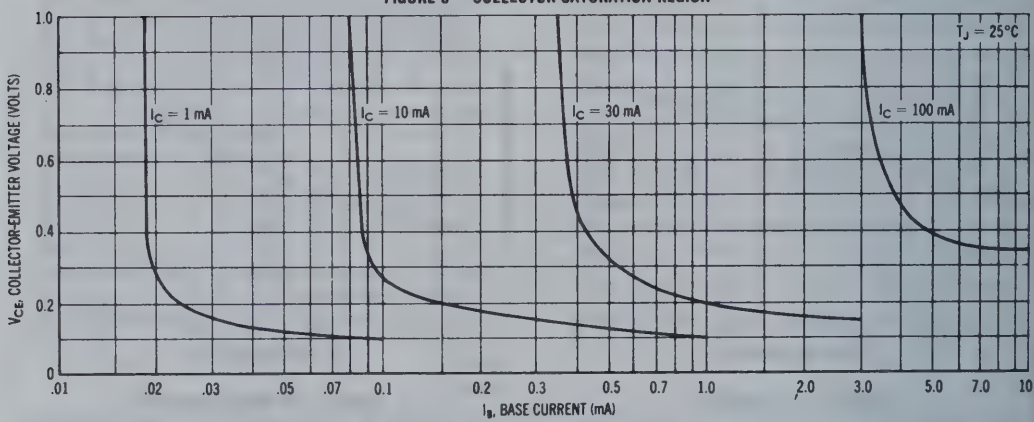


FIGURE 9 — TRANSCONDUCTANCE

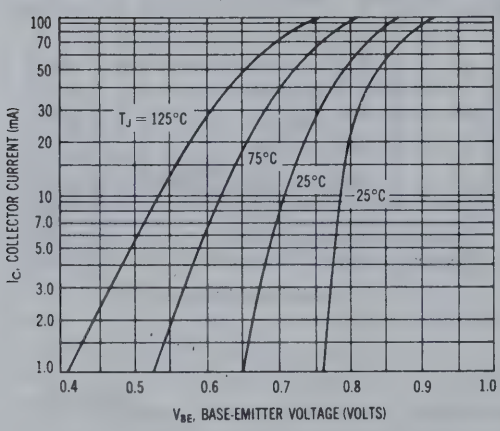
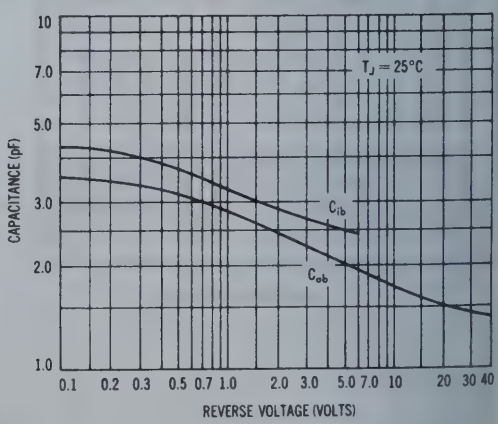


FIGURE 10 — CAPACITANCES



MPS6567 (SILICON)



CASE 29(2)
TO-92

NPN silicon annular transistor designed for 4.5 MHz sound IF applications in TV receivers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	310 2.81	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	^oC/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_E = 0)	BV_{CEO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)	I_{CBO}	—	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5 Vdc)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5 Vdc)	$V_{BE(on)}$	—	0.8	Vdc
DYNAMIC CHARACTERISTICS				
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{re}	—	0.7	pF
Output Resistance (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 4.5 MHz)	R_{oep}	100	—	kohms

COMMON-EMITTER y PARAMETERS

$f = 4.5$ MHz, $T_A = 25°C$

FIGURE 1 — INPUT ADMITTANCE

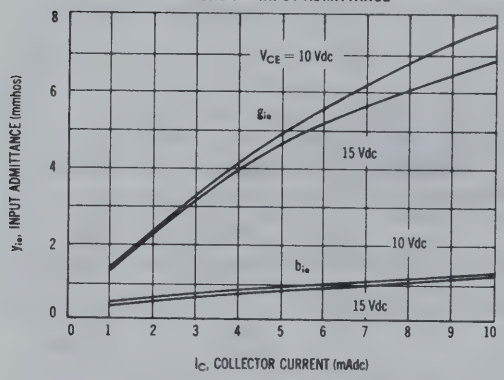


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

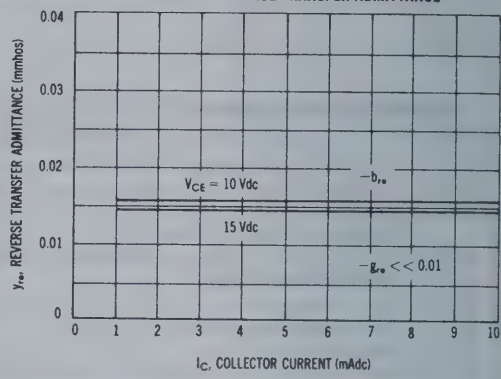


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

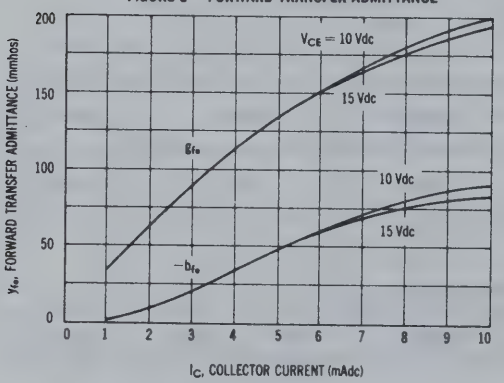


FIGURE 4 — OUTPUT ADMITTANCE

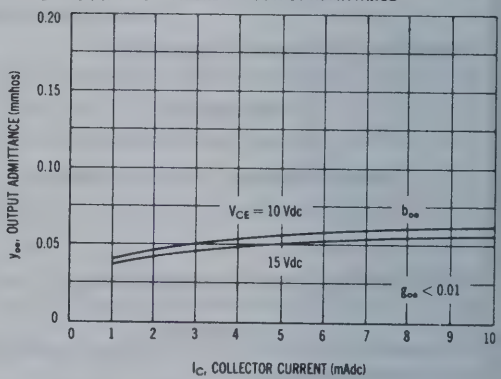


FIGURE 5 — CAPACITANCES

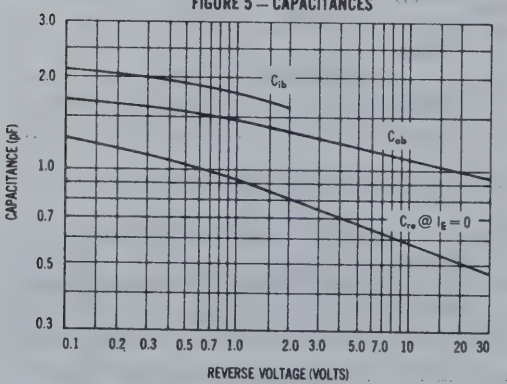
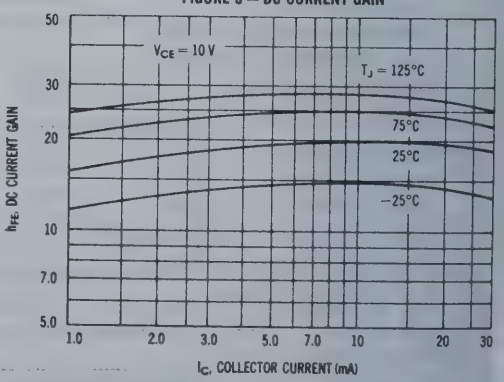


FIGURE 6 — DC CURRENT GAIN



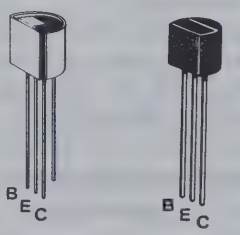
MPS6568 (SILICON)
MPS6568A

NPN SILICON ANNULAR TRANSISTORS

. . . designed for VHF-RF amplifier applications in TV receivers.

- Guaranteed Noise Figure — NF = 3.3 dB (Max) at 200 MHz
- Guaranteed AGC Characteristics
- Complete y-Parameter Curves at 200 MHz
- Guaranteed Power Gain — G_{pe} = 20 dB (Min) at 200 MHz

NPN SILICON VHF RF AMPLIFIER TRANSISTORS



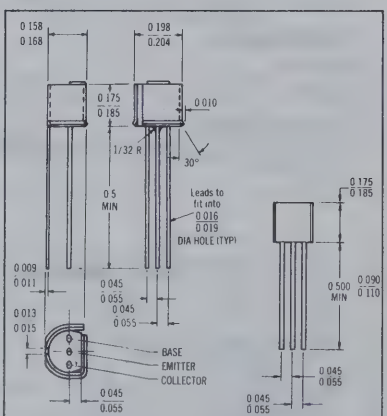
TO-92 WITH SHIELD MPS6568 | TO-92 MPS6568A

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.137	°C/mW
Thermal Resistance, Case to Ambient	θ_{CA}	0.220	°C/mW



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 mAdc)	h_{FE}	20	200	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	0.1	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	-	0.96	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	375	800	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded, with shield) MPS6568 (without shield) MPS6568A	C_{cb}	0.25 -	0.5 0.65	pF
Noise Figure (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz, Figure 9)	NF	-	3.3	dB
FUNCTIONAL TEST				
Power Gain (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz, Figure 9)	G_{pe}	20	27	dB
Forward AGC Voltage (Gain Reduction = 30 dB, R_S = 50 ohms, f = 200 MHz, Figure 9)	V_{AGC}	4.0	5.0	Vdc

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 200 MHz, See Figure 9

FIGURE 1 — POWER GAIN

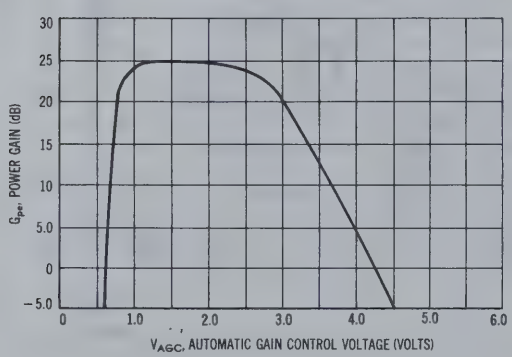
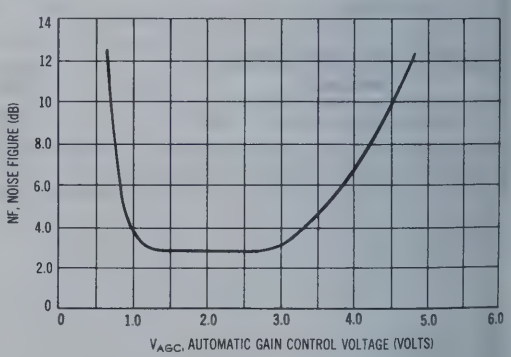


FIGURE 2 — NOISE FIGURE



COMMON-EMITTER y PARAMETERS

V_{CE} = 12 Vdc, T_A = 25°C, f = 200 MHz

FIGURE 3 — INPUT ADMITTANCE

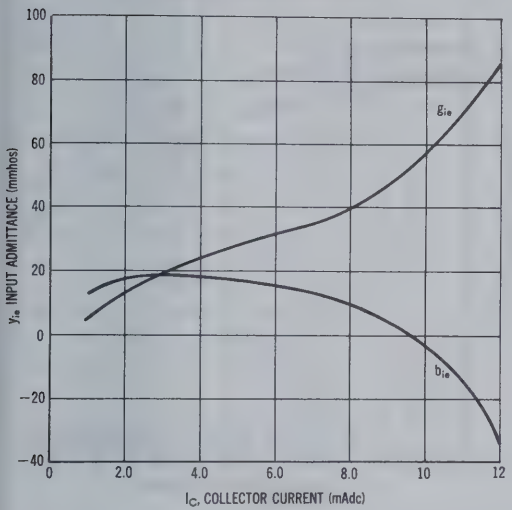


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

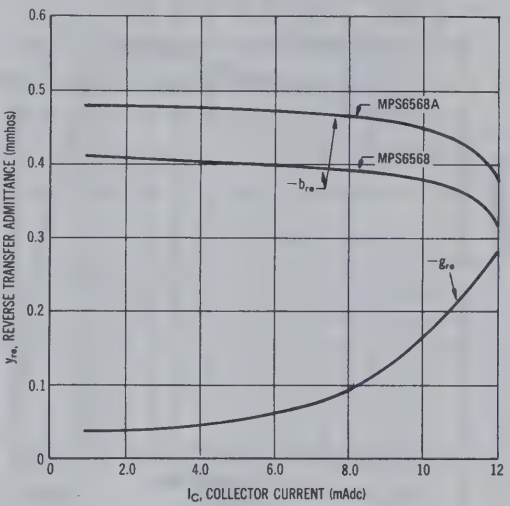


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

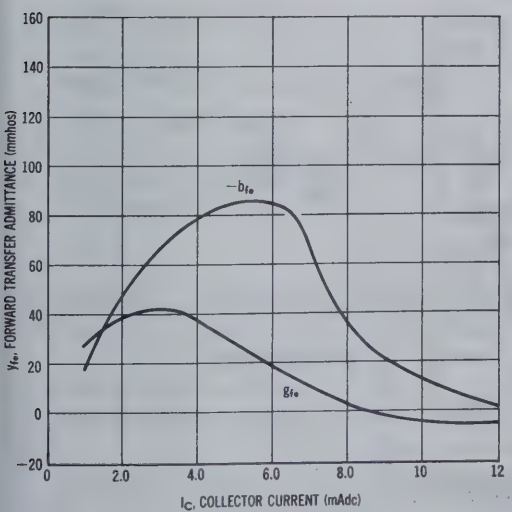


FIGURE 6 — OUTPUT ADMITTANCE

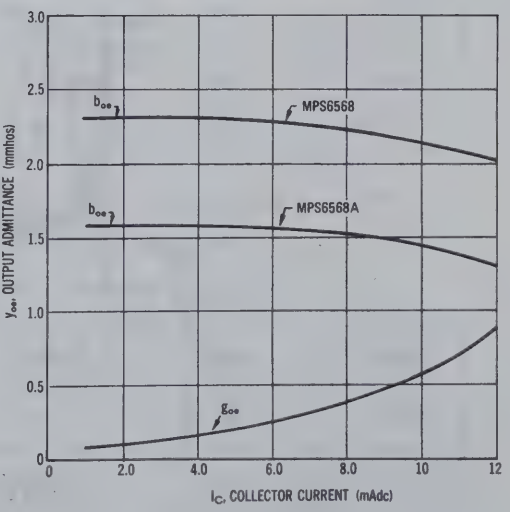


FIGURE 7 — DC CURRENT GAIN

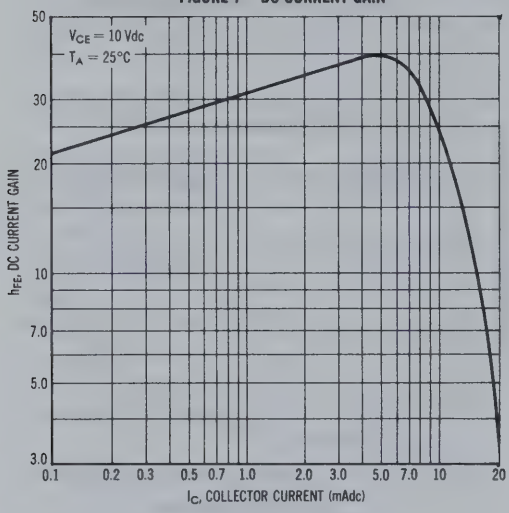


FIGURE 8 — COLLECTOR-BASE CAPACITANCE

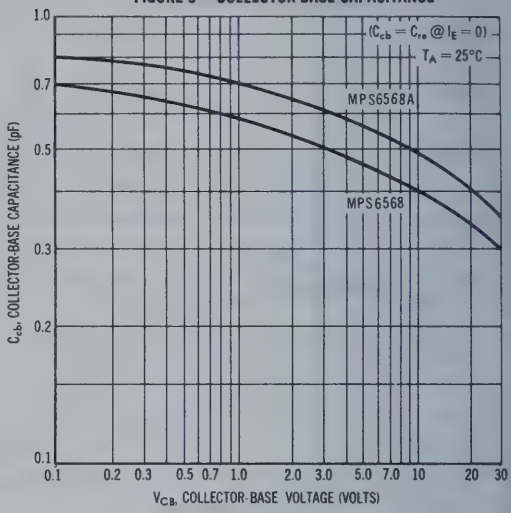
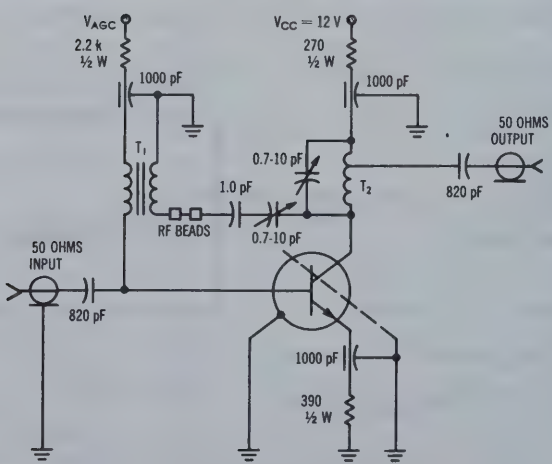


FIGURE 9 — 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)



T_1 = FERRITE CORE INDIANA GEN. CORP. F-684
T_2 = 6 TURNS #16 BUSS WIRE, ID = ¼", L = ¾".

MPS6569 (SILICON)
MPS6570



CASE 29A

NPN silicon annular transistors designed for VHF-RF and video IF stages in TV receivers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.137	°C/mW
Thermal Resistance, Case to Ambient	θ_{CA}	0.220	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)		BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	20	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	-	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4 mAdc, V_{CE} = 5 Vdc)		h_{FE}	20	200	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$	0.1	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5 mAdc)		$V_{BE(sat)}$	-	0.96	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS6568 MPS6569, MPS6570	f_T	375 300	800 800	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz, emitter guarded, with shield)		C_{cb}	0.25	0.5	pF
Noise Figure (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz, Figure 9) (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 10)	 MPS6568 MPS6569, MPS6570	NF	 - -	 3.3 6.0	dB
FUNCTIONAL TEST					
Power Gain (V_{AGC} = 1.4 Vdc, R_S = 50 ohms, f = 200 MHz, Figure 9) (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 10)	 MPS6568 MPS6569, MPS6570	G_{pe}	 20 22.5	 27 28.5	dB
Forward AGC Voltage (Gain Reduction = 30 dB, R_S = 50 ohms, f = 200 MHz, Figure 9) (Gain Reduction = 30 dB, R_S = 50 ohms, f = 45 MHz, Figure 10)	 MPS6568 MPS6569 MPS6570	V_{AGC}	 4.0 4.4 5.2	 5.0 5.4 6.2	Vdc

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 OHMS, SEE FIGURES 9 AND 10

—— f = 45 MHz — — f = 200 MHz

FIGURE 1 — POWER GAIN

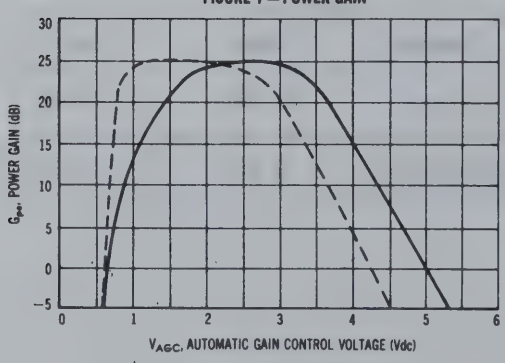
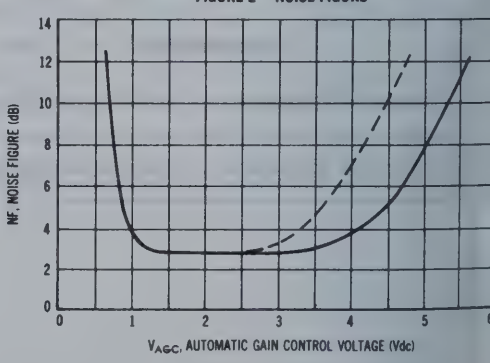


FIGURE 2 — NOISE FIGURE



COMMON-EMITTER y PARAMETERS

V_{CE} = 12 Vdc, T_A = 25°C

— f = 45 MHz — — f = 200 MHz

FIGURE 3 — INPUT ADMITTANCE

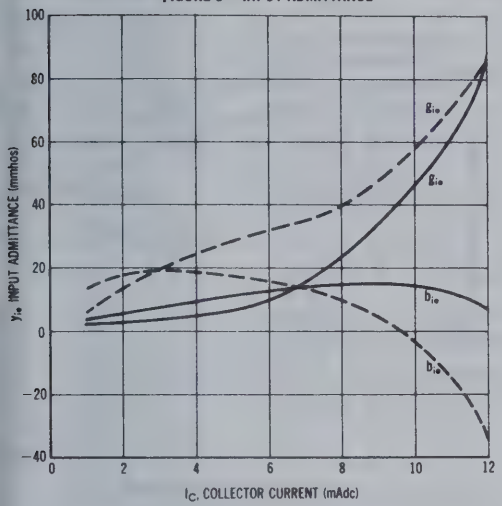


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

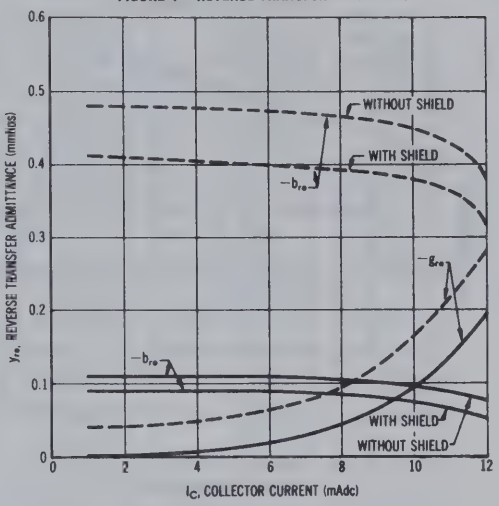


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

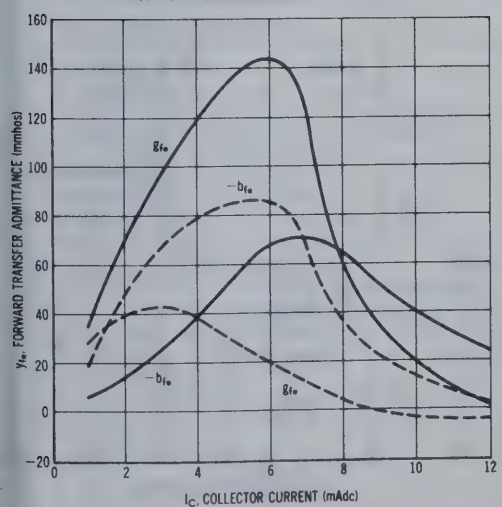


FIGURE 6 — OUTPUT ADMITTANCE

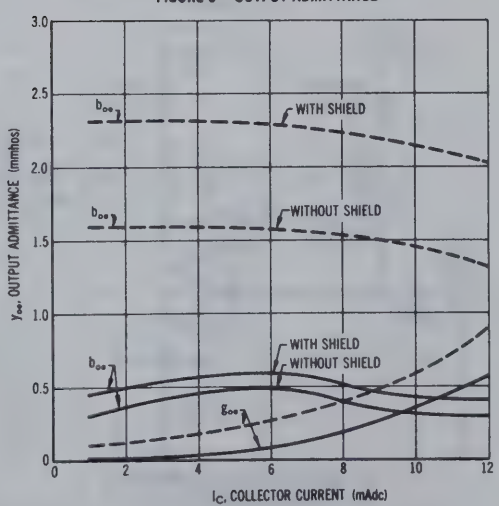


FIGURE 7 — DC CURRENT GAIN

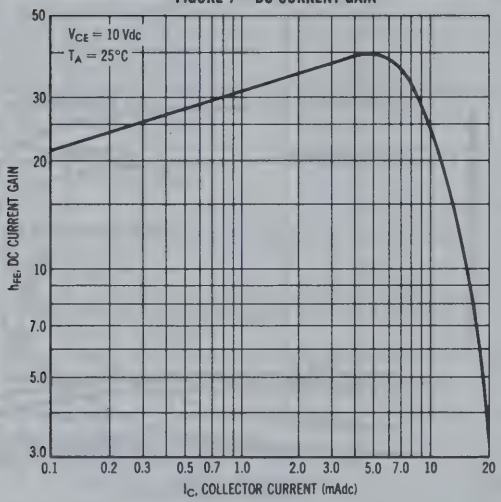


FIGURE 8 — COLLECTOR-BASE CAPACITANCE

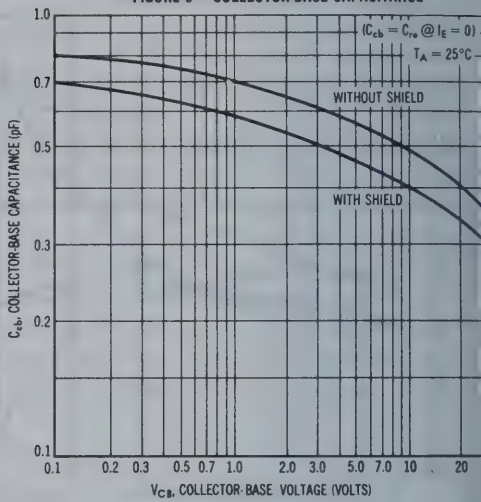
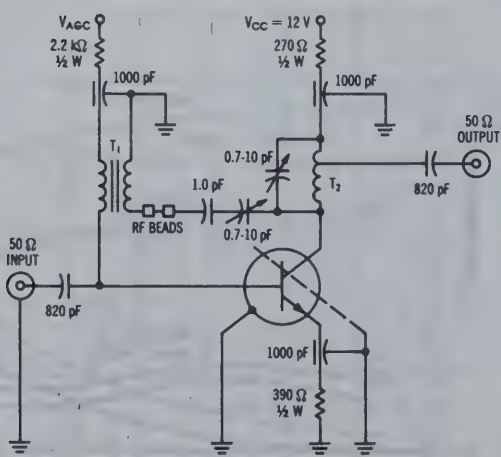
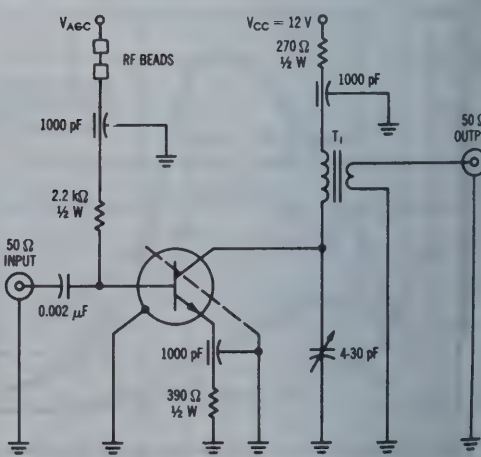


FIGURE 9 — 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)



T_1 = FERRITE CORE INDIANA GEN. CORP. F-684
T_2 = 6 TURNS #16 BUSS WIRE, ID = ¼", L = ¾".

FIGURE 10 — 45 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)



T_1 = TOROID 4:1 RATIO, 8T-PRI 2T-SEC } #22 WIRE

MPS6571 (SILICON)



CASE 29(1)
TO-92

NPN silicon annular amplifier transistor designed for audio pre-amplifier applications in audio amplifiers.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $I_B = 0$)	BV_{CEO}	20	-	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)	BV_{CBO}	25	-	-	Vdc
Collector Cutoff Current ($V_{CB} = 20$ Vdc, $I_E = 0$)	I_{CBO}	-	-	50	nAdc
Emitter Cutoff Current ($V_{EB(off)} = 3.0$ Vdc, $I_C = 0$)	I_{EBO}	-	-	50	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc)	h_{FE}	250	-	1000	-
Collector-Emitter Saturation Voltage ($I_C = 10$ mAdc, $I_B = 1.0$ mAdc)	$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter On, Voltage ($I_C = 10$ mAdc, $V_{CE} = 5.0$ Vdc)	$V_{BE(on)}$	-	-	0.8	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 500$ μAdc, $V_{CE} = 5.0$ Vdc, f = 20 MHz)	f_T	50	175	-	MHz
Output Capacitance ($V_{CB} = 5.0$ Vdc, $I_E = 0$, f = 100 kHz)	C_{ob}	-	-	4.5	pF
Noise Figure ($I_C = 100$ μAdc, $V_{CE} = 5.0$ Vdc, $R_S = 10$ kohms, f = 100 Hz)	NF	-	1.2	-	dB

FIGURE 1 — DC CURRENT GAIN

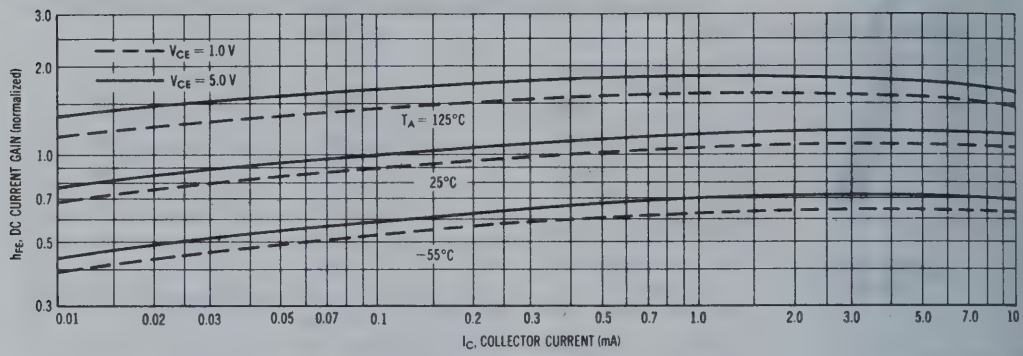


FIGURE 2 — CURRENT GAIN

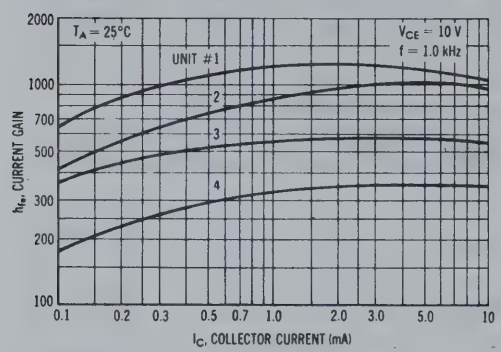
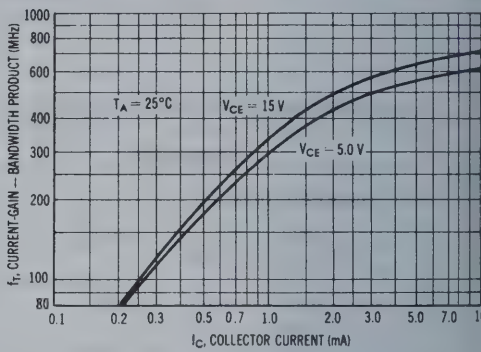


FIGURE 3 — CURRENT GAIN — BANDWIDTH PRODUCT



NOISE FIGURE

V_{CE} = 5.0 Vdc, T_A = 25°C

FIGURE 4 — FREQUENCY EFFECTS

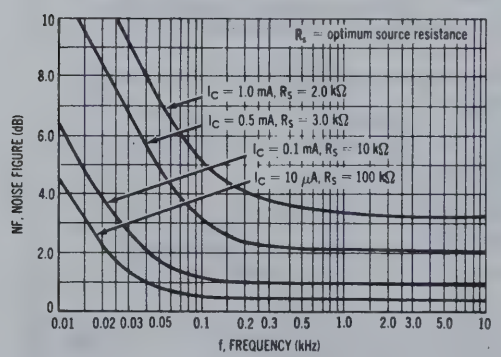
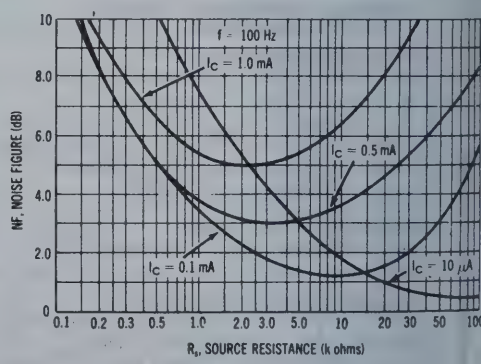


FIGURE 5 — SOURCE RESISTANCE EFFECTS



MPS-A05 (SILICON)
MPS-A06

NPN SILICON ANNULAR AUDIO TRANSISTORS

. . . designed for use as medium-power drivers and low-power outputs.

- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 60 Vdc (Min) @I_C = 1.0 mAdc — MPS-A05
  = 80 Vdc (Min) @I_C = 1.0 mAdc — MPS-A06
- Excellent Current-Gain Linearity — 1.0 mAdc to 200 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @I_C = 100 mAdc
- Complements to MPS-A55 and MPS-A56

NPN SILICON AUDIO TRANSISTORS



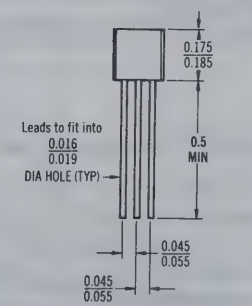
MAXIMUM RATINGS

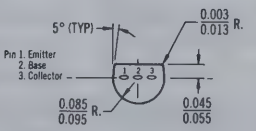
Rating	Symbol	MPS-A05	MPS-A06	Unit
Collector–Emitter Voltage	V_{CEO}	60	80	Vdc
Collector–Base Voltage	V_{CB}	60	80	Vdc
Emitter–Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.54		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	800 7.27		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.137	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA}**	0.220	°C/mW

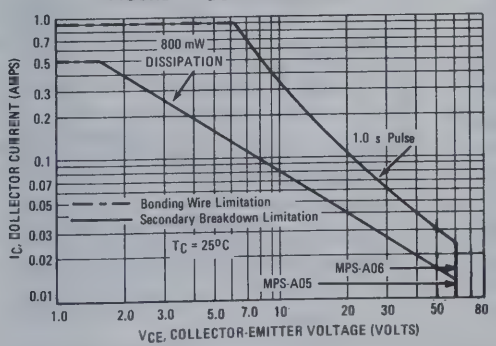
**θ_{JA} is measured with the device soldered into a typical printed circuit board.





CASE 29 (1)
TO-92

FIGURE 1 — DC SAFE OPERATING AREA



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless othewise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector–Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0) MPS–A05	BV_{CEO}	60	–	–	Vdc
MPS–A06		80	–	–	
Emitter–Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) MPS–A05	I_{CBO}	–	–	100	nAdc
(V_{CB} = 80 Vdc, I_E = 0) MPS–A06		–	–	100	
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	50	125	–	–
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		50	150	–	
(I_C = 350 mAdc, V_{CE} = 1.0 Vdc)		–	90	–	
Collector–Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	–	0.08	0.25	Vdc
Base–Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	–	0.75	–	Vdc
Base–Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	–	0.7	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current–Gain – Bandwidth Product (I_C = 100 mAdc, V_{CE} = 1.0 Vdc, f = 100 MHz)	f_T	50	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	6.0	–	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	15	–	pF

FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

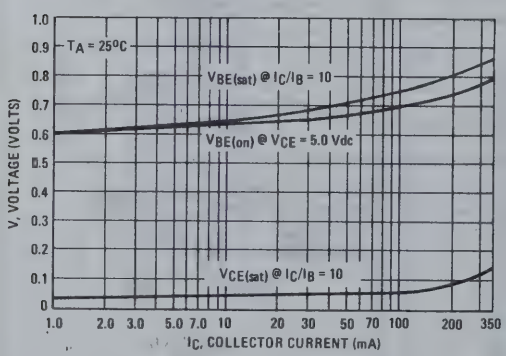
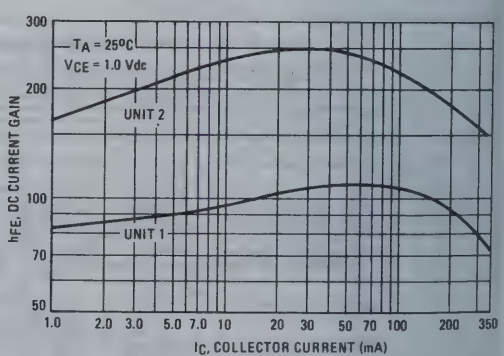


FIGURE 3 – DC CURRENT GAIN



MPS-A09 (SILICON)



NPN silicon annular amplifier transistors designed for pre-amplifier applications in audio amplifiers.

CASE 29(1)
(TO-92)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Collector Current - Continuous Peak	I_C	50 100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	50	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	50	-	-	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	-	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	100	-	600	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	-	0.9	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	-	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 0.5 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	f_T	30	80	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	-	5.0	pF
Noise Figure (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc, R_S = 6.8 k ohms, f = 1.0 kHz)	NF	-	1.4	-	dB

FIGURE 1 – DC CURRENT GAIN

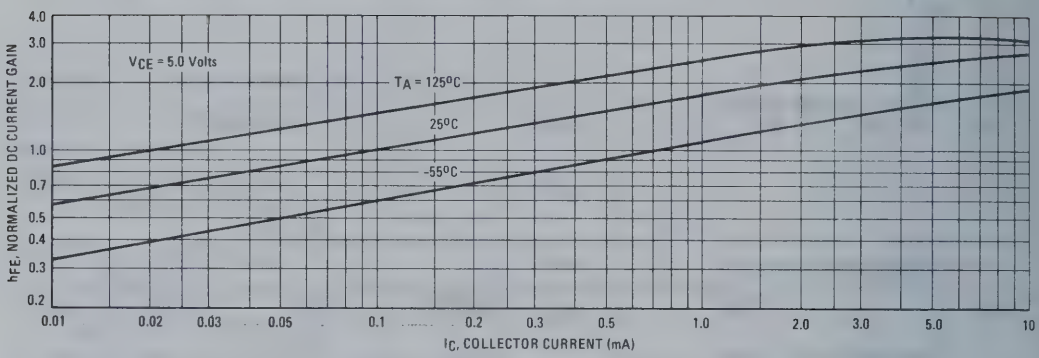


FIGURE 2 – COLLECTOR SATURATION REGION

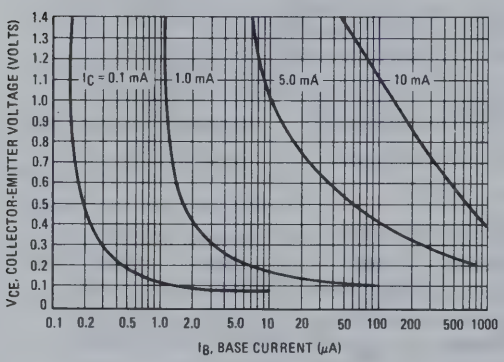
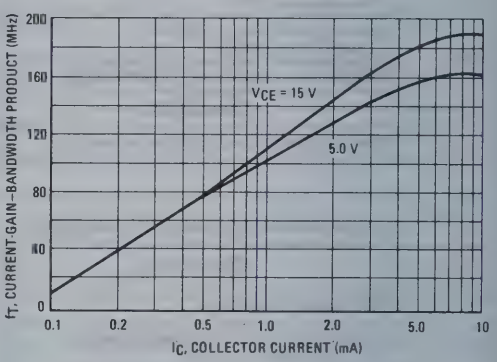


FIGURE 3 – CURRENT GAIN–BANDWIDTH PRODUCT



NOISE FIGURE

(V_{CE} = 5.0 Vdc, T_A = 25°C)

FIGURE 4 – FREQUENCY EFFECTS

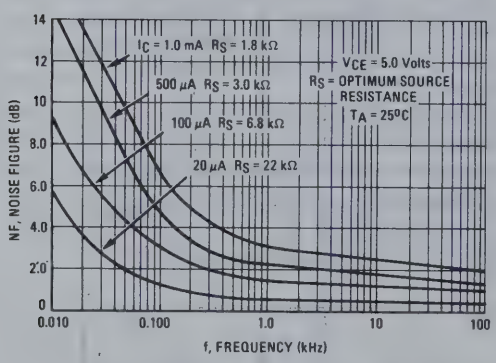
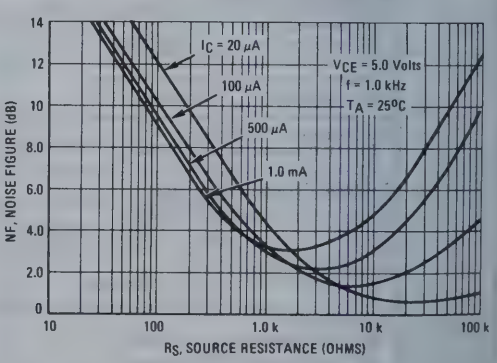


FIGURE 5 - SOURCE RESISTANCE EFFECT



MPS-A10 (SILICON)
MPS-K10, MPS-K11
MPS-K12

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose use in audio, radio, and television applications.

- MPS-K10, MPS-K11, MPS-K12 are 3, 5 and 9 Transistor Kits Available in Varied h_{FE} Ranges — See Table 1
- High Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Low Output Capacitance — C_{ob} = 4.0 pF (Max) @ V_{CB} = 10 Vdc
- One-Piece, Injection-Molded Unibloc Package

NPN SILICON AMPLIFIER TRANSISTORS

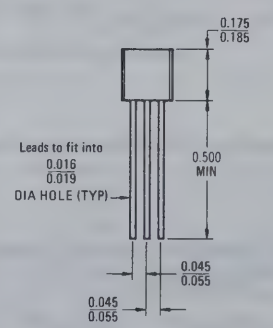


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.367	°C/mW

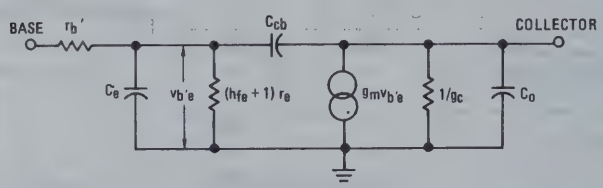


CASE 29 (1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	400	-
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	4.0	pF

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-A10 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

r_b' – See Figure 8

$r_e = 26\ mV/I_E$

$C_e = \dfrac{1}{2\pi f_t r_e}$

$C_{cb} = C_{ob} - 0.2$ pF (See Figure 6)

$g_m = 1/r_e$

$g_c = (h_{fe}+1)\,h_{ob}$ (See Figures 2 & 7)

$C_o = 0.2$ pF

Low frequency h parameters may be found from:

$h_{ie} = r_b' + (h_{fe}+1)\,r_e$

h_{fe} = See Figure 2

h_{re} = Negligible

$h_{oe} = (h_{fe}+1)\,h_{ob}$

FIGURE 2 – SMALL SIGNAL CURRENT GAIN

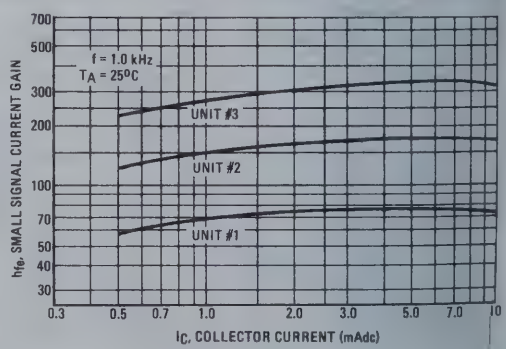


FIGURE 3 – NORMALIZED DC CURRENT GAIN

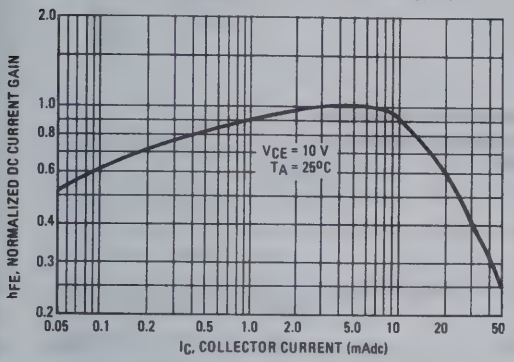


FIGURE 4 – "SATURATION" AND "ON" VOLTAGES

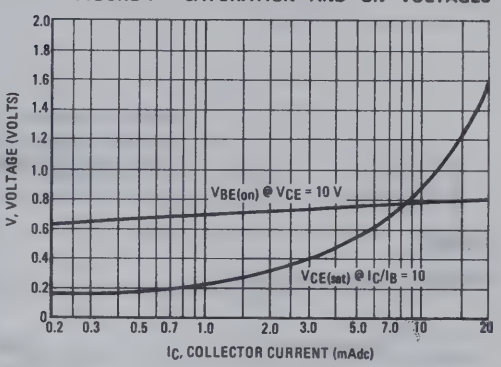


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

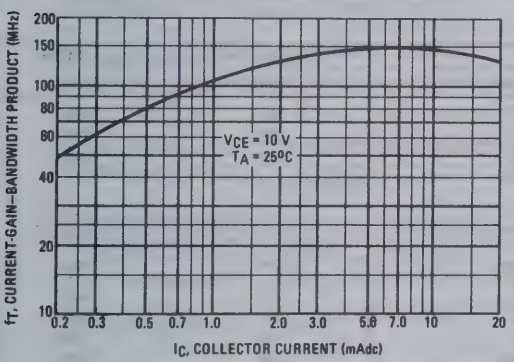


FIGURE 6 – CAPACITANCES

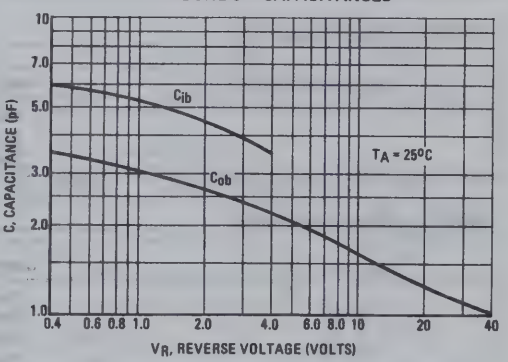


FIGURE 7 – OUTPUT ADMITTANCE

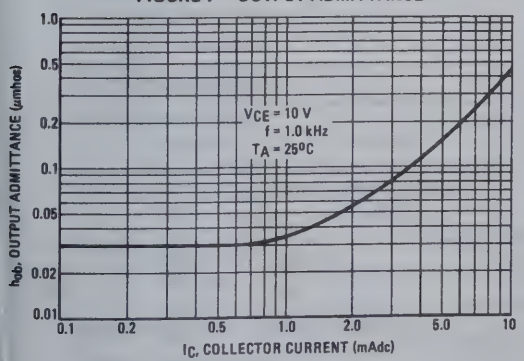
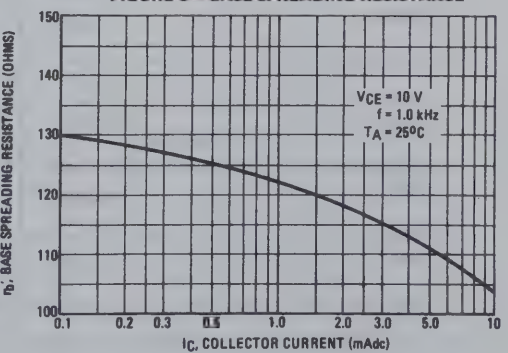


FIGURE 8 – BASE SPREADING RESISTANCE



MPS-K10, MPS-K11 and MPS-K12 are three, five and nine transistor kits consisting of MPS-A10's with various h_{FE} selections.

Table 1

MPS-K10 — Three Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
1	Red	40	400
1	White	80	400
1	Blue	120	300

MPS-K11 — Five Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
3	Red	40	400
1	Green	100	200
1	Yellow	150	300

MPS-K12 — Nine Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
4	Red	40	400
2	White	80	400
2	Green	100	200
1	Yellow	150	300

MPS-A12 (SILICON)



CASE 29(1)
(TO-92)

NPN silicon darlington amplifier transistors designed for pre-amplifier input applications requiring input impedance of several megohms.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	20	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C =100 μAdc, I_B = 0)	BV_{CES}	20	-	-	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	-	-	100	nAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	-	-	100	nAdc
Emitter Cutoff Current (V_{EB} = 10 Vdc, I_C = 0)	I_{EBO}	-	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20,000	-	-	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.01 mAdc)	$V_{CE(sat)}$	-	-	1.0	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	-	-	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	8.0	-	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	-	35	-	-

FIGURE 1 – NORMALIZED DC CURRENT GAIN

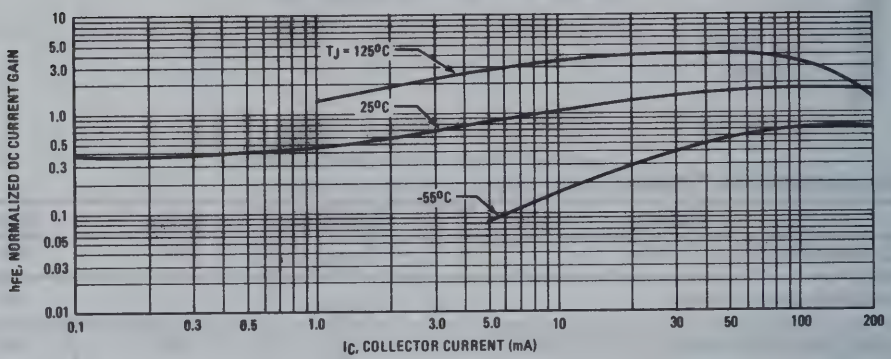


FIGURE 2 – COLLECTOR-EMITTER SATURATION VOLTAGE versus COLLECTOR CURRENT

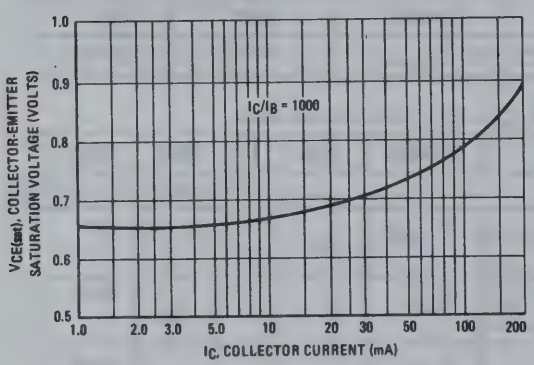


FIGURE 3 – BASE EMITTER "ON" VOLTAGE versus COLLECTOR CURRENT

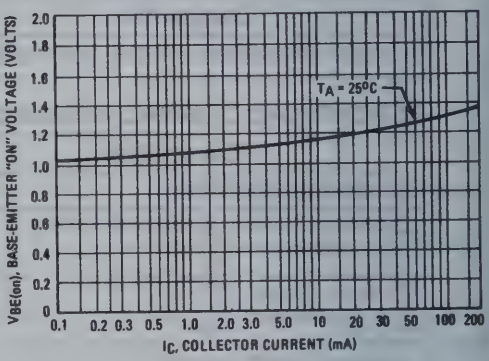
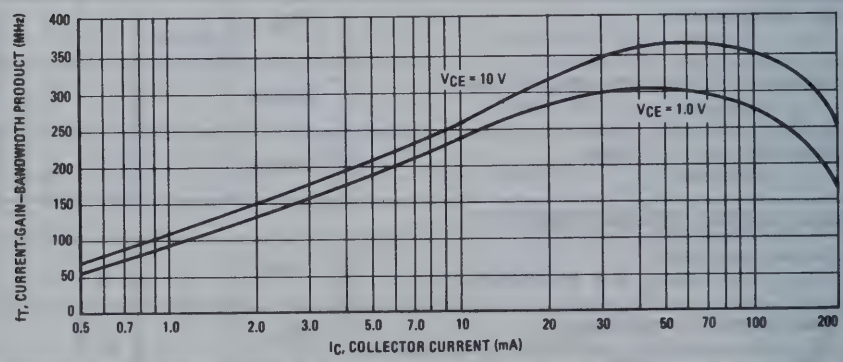


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT versus COLLECTOR CURRENT



MPS-A13 (SILICON)
MPS-A14

NPN SILICON DARLINGTON AMPLIFIER TRANSISTORS

. . . designed for pre-amplifier input applications requiring high input impedance.

- High DC Current Gain –
  h_{FE} = 5,000 (Min) @ I_C = 10 mAdc (MPS-A13)
  10,000 (Min) @ I_C = 10 mAdc (MPS-A14)
- Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 30 Vdc (Min) @ I_C = 10 mAdc
- Low Noise Figure –
  NF = 2.0 dB (Typ) @ I_C = 1.0 mAdc

NPN SILICON DARLINGTON TRANSISTORS

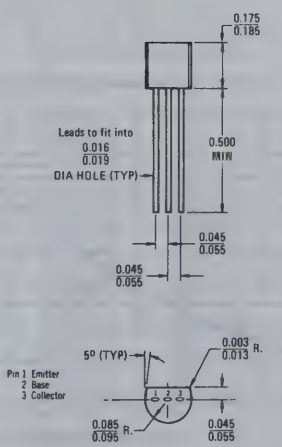


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current – Continuous	I_C	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.54	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.220	°C/mW



CASE 29 (1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C =100μAdc, I_B = 0)		BV_{CES}	30	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPS-A13		5000	–	–	
	MPS-A14		10,000	–	–	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MPS-A13		10,000	–	–	
	MPS-A14		20,000	–	–	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	–	0.8	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	1.25	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	125	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	5.0	–	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 100 k ohms, f = 1.0 kHz)		NF	–	2.0	–	dB

FIGURE 1 – NORMALIZED DC CURRENT GAIN

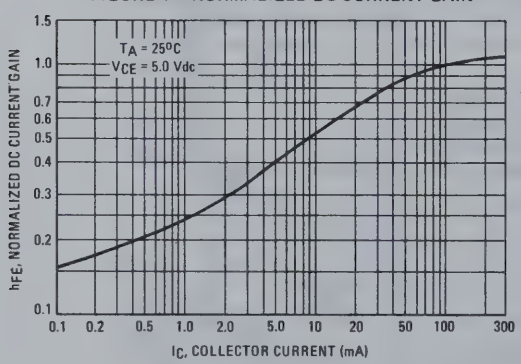


FIGURE 2 – BASE-EMITTER "ON" VOLTAGE

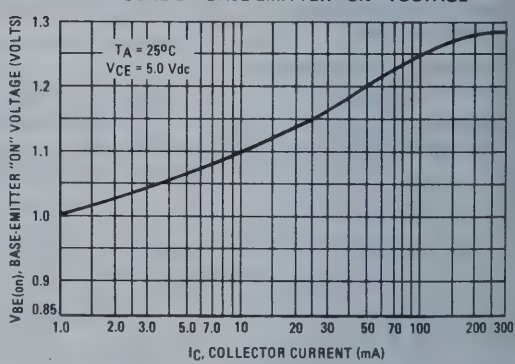


FIGURE 3 – TRANSCONDUCTANCE versus FREQUENCY

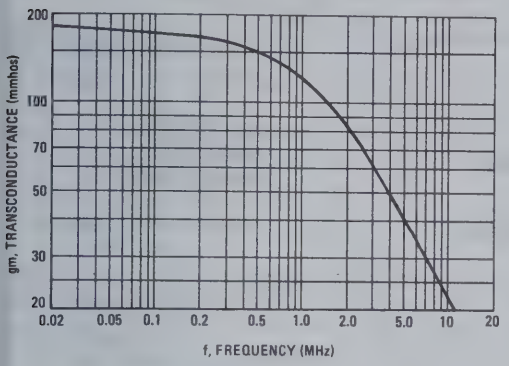


FIGURE 4 – NOISE FIGURE versus CURRENT

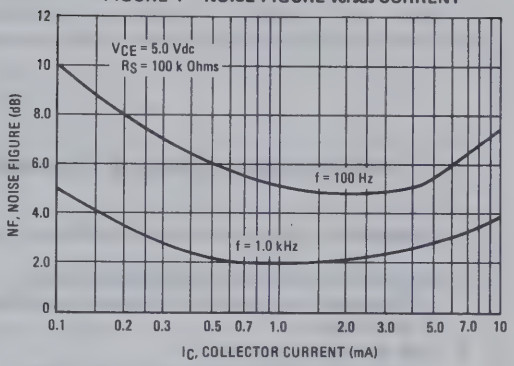


FIGURE 5 – NOISE FIGURE versus FREQUENCY

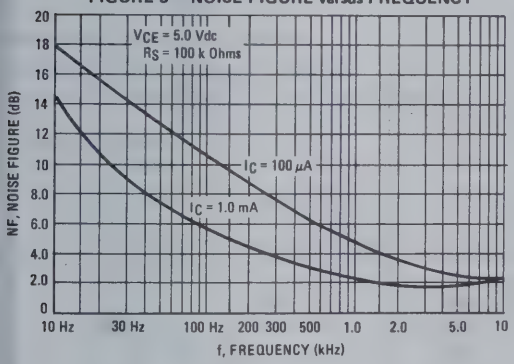
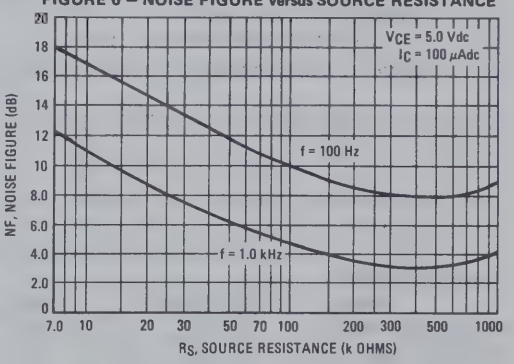


FIGURE 6 – NOISE FIGURE versus SOURCE RESISTANCE



MPS-A20 (SILICON)
MPS-K20, MPS-K21, MPS-K22

NPN SILICON ANNULAR TRANSISTORS

. . . designed for use in audio, radio, and television applications.

- MPS-K20, MPS-K21, MPS-K22 are 3, 5 and 9 Transistor Kits Available in Varied h_{FE} Ranges — See Table 1
- High Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 10 mAdc
- Low Output Capacitance — C_{ob} = 4.0 pF (Max) @ V_{CB} = 10 Vdc
- One-Piece, Injection-Molded Unibloc Package

NPN SILICON AMPLIFIER TRANSISTORS

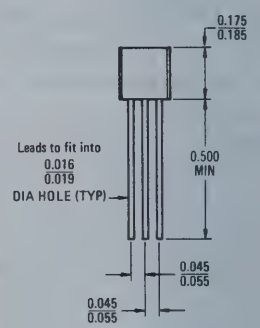


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.367	°C/mW

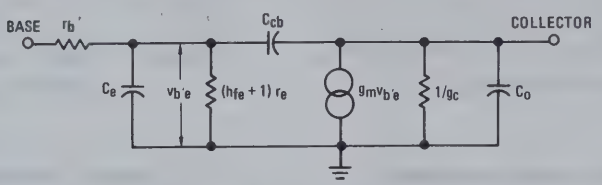


CASE 29 (1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	400	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	4.0	pF

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-A20 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

r_b' – See Figure 8

$r_e = 26\ mV/I_E$

$C_e = \dfrac{1}{2\pi f_t r_e}$

$C_{cb} = C_{ob} - 0.2$ pF (See Figure 6)

$g_m = 1/r_e$

$g_c = (h_{fe} + 1)\, h_{ob}$ (See Figures 2 & 7)

$C_o = 0.2$ pF

Low frequency h parameters may be found from:

$h_{ie} = r_b' + (h_{fe} + 1)\, r_e$

h_{fe} = See Figure 2

h_{re} = Negligible

$h_{oe} = (h_{fe} + 1)\, h_{ob}$

FIGURE 2 – SMALL SIGNAL CURRENT GAIN

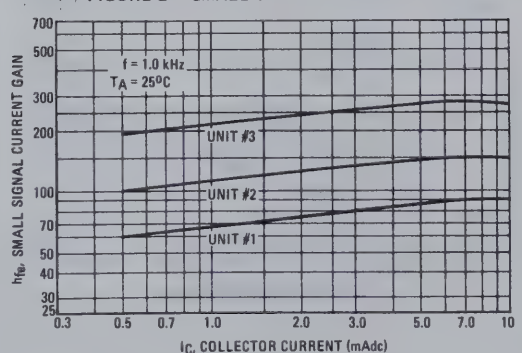


FIGURE 3 – NORMALIZED DC CURRENT GAIN

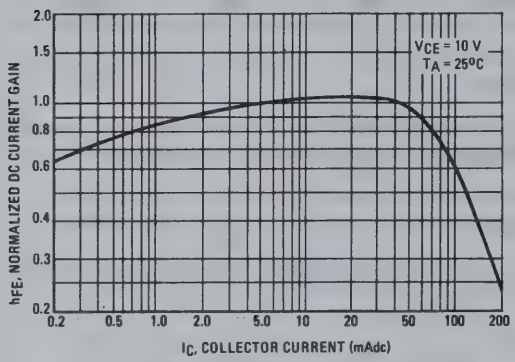


FIGURE 4 – "SATURATION" AND "ON" VOLTAGES

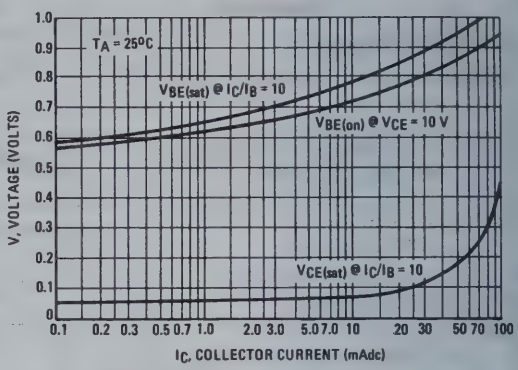


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

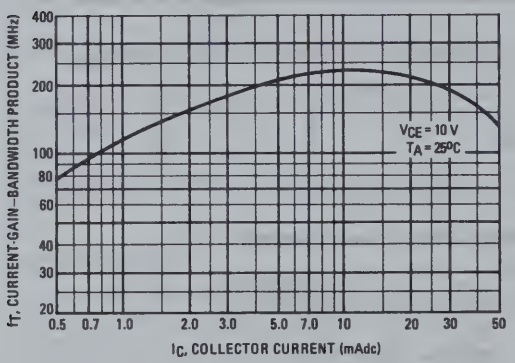


FIGURE 6 – CAPACITANCES

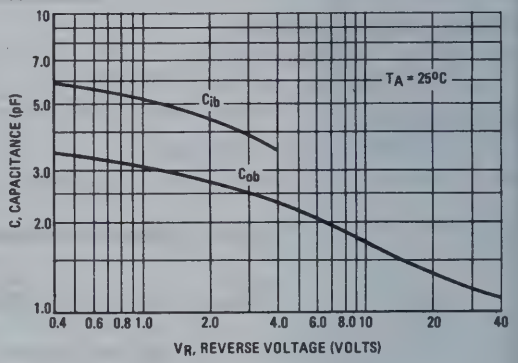


FIGURE 7 – OUTPUT ADMITTANCE

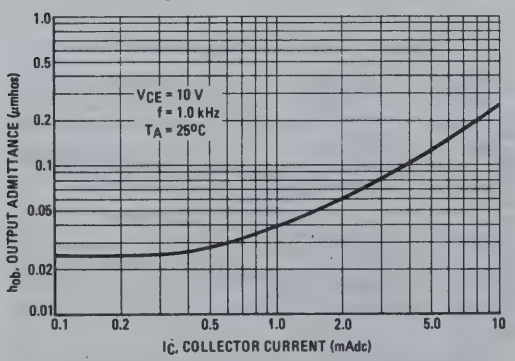
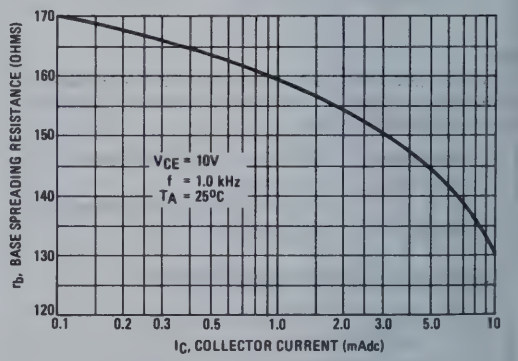


FIGURE 8 – BASE SPREADING RESISTANCE



MPS-K20, MPS-K21 and MPS-K22 are three, five and nine transistor kits consisting of MPS-A20's with various h_{FE} selections.

Table 1

MPS-K20 — Three Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
1	Red	40	400
1	White	80	400
1	Blue	120	300

MPS-K21 — Five Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
3	Red	40	400
1	Green	100	200
1	Yellow	150	300

MPS-K22 — Nine Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc	
		Min	Max
4	Red	40	400
2	White	80	400
2	Green	100	200
1	Yellow	150	300

MPS-A55 (SILICON)
MPS-A56

PNP SILICON ANNULAR AUDIO TRANSISTORS

. . . designed for use as medium-power drivers and low-power outputs.

- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 60 Vdc (Min) @ I_C = 1.0 mAdc — MPS-A55
  80 Vdc (Min) @ I_C = 1.0 mAdc — MPS-A56
- Excellent Current-Gain Linearity — 1.0 mAdc to 200 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 100 mAdc
- Complements to MPS-A05 and MPS-A06

PNP SILICON AUDIO TRANSISTORS



MAXIMUM RATINGS

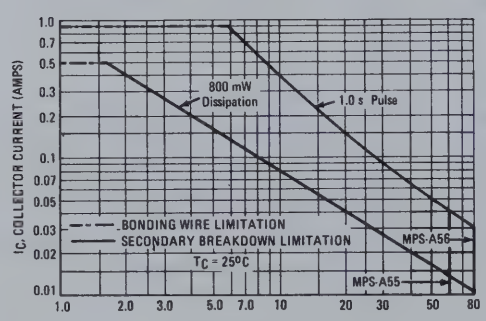
Rating	Symbol	MPS-A55	MPS-A56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.54		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	800 7.27		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

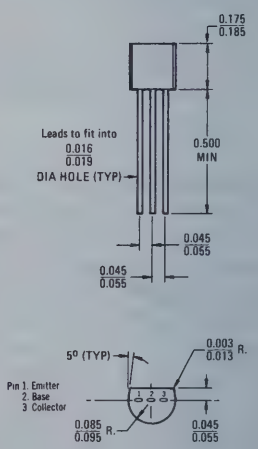
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.137	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA}**	0.220	°C/mW

**θ_{JA} is measured with the device soldered into a typical printed circuit board.

FIGURE 1 — DC SAFE OPERATING AREA





CASE 29 (1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPS-A55	BV_{CEO}	60	–	–	Vdc
	MPS-A56		80	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				nAdc
(V_{CB} = 60 Vdc, I_E = 0)	MPS-A55		–	–	100	
(V_{CB} = 80 Vdc, I_E = 0)	MPS-A56		–	–	100	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			50	150	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			50	125	–	
(I_C = 350 mAdc, V_{CE} = 1.0 Vdc)			–	80	–	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	–	0.09	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{BE(sat)}$	–	0.78	–	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	–	0.73	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 100 mAdc, V_{CE} = 1.0 Vdc, f = 100 MHz)		f_T	50	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	6.5	–	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	20	–	pF

FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

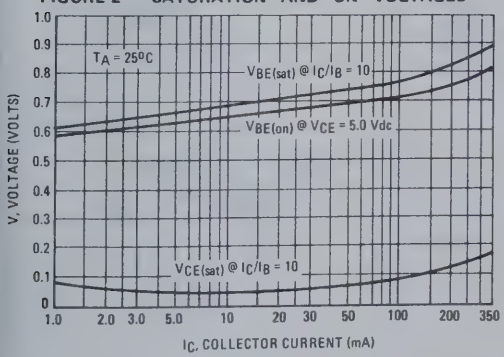
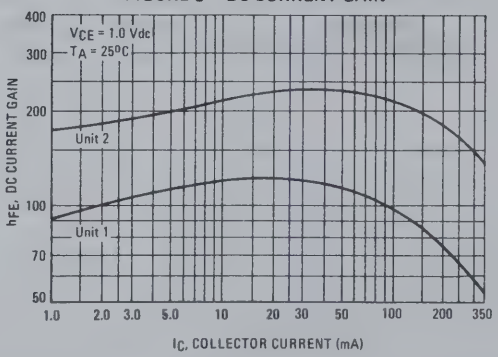


FIGURE 3 – DC CURRENT GAIN



MPS-A65 (SILICON)
MPS-A66

PNP SILICON DARLINGTON AMPLIFIER TRANSISTORS

. . . designed for pre-amplifier input applications requiring high input impedance.

- High DC Current Gain —
  h_{FE} = 50,000 (Min) @ I_C = 10 mAdc (MPS-A65)
  75,000 (Min) @ I_C = 10 mAdc (MPS-A66)
- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 30 Vdc (Min) @ I_C = 10 mAdc
- Low Noise Figure —
  NF = 2.0 dB (Typ) @ I_C = 1.0 mAdc

PNP SILICON DARLINGTON TRANSISTORS

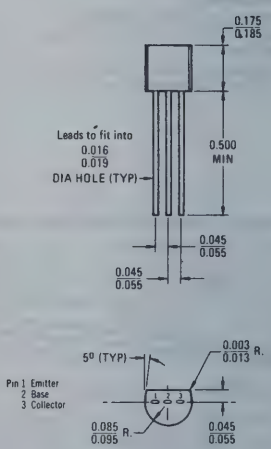


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	8.0	Vdc
Collector Current — Continuous	I_C	300	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.54	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.220	°C/mW



CASE 29 (1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C =100 μAdc, I_B = 0)		BV_{CES}	30	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	–	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 8.0 Vdc, I_C = 0)		I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	MPS-A65		50,000	–	–	
	MPS-A66		75,000	–	–	
(I_C = 100 mAdc, V_{CE} = 5.0 Vdc)	MPS-A65		20,000	–	–	
	MPS-A66		40,000	–	–	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	–	0.9	1.5	Vdc
Base-Emitter On Voltage (I_C = 100 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	1.45	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	100	175	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	2.5	–	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, R_S = 100 k ohms, f = 1.0 kHz)		NF	–	2.0	–	dB

FIGURE 1 – NORMALIZED DC CURRENT GAIN

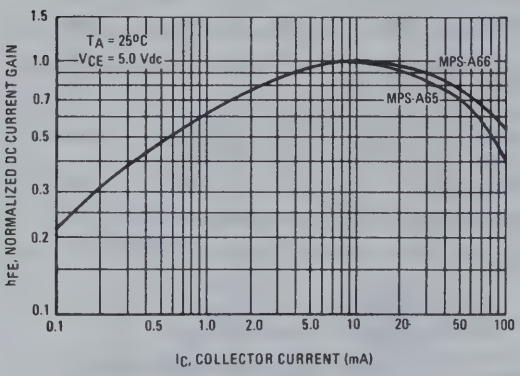


FIGURE 2 – BASE-EMITTER "ON" VOLTAGE

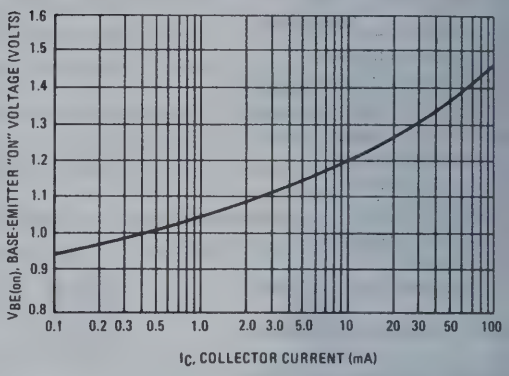


FIGURE 3 – TRANSCONDUCTANCE versus FREQUENCY

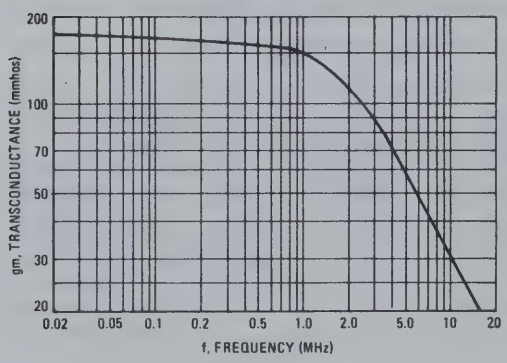


FIGURE 4 – NOISE FIGURE versus CURRENT

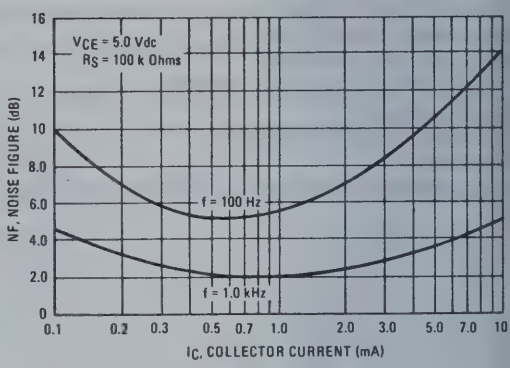


FIGURE 5 – NOISE FIGURE versus FREQUENCY

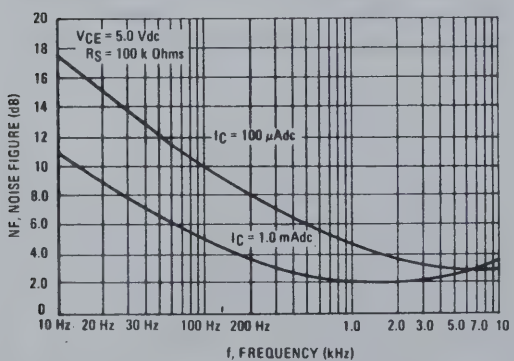
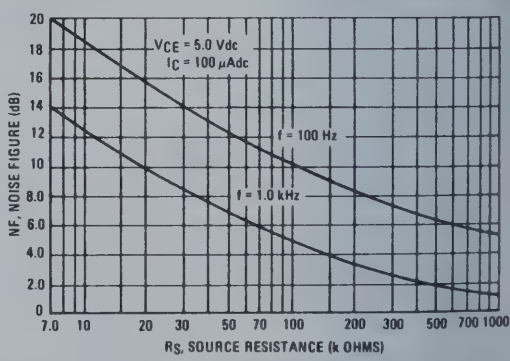


FIGURE 6 – NOISE FIGURE versus SOURCE RESISTANCE



MPS-A70 (SILICON)
MPS-K70, MPS-K71
MPS-K72

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general purpose use in audio, radio, and television applications.

- MPS-K70, MPS-K71, MPS-K72 are 3, 5 and 9 Transistor Kits Available in Varied h_{FE} Ranges — See Table 1
- High Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 10 mAdc
- Low Output Capacitance — C_{ob} = 4.0 pF (Max) @ V_{CB} = 10 Vdc
- One-Piece, Injection-Molded Unibloc Package

PNP SILICON AMPLIFIER TRANSISTORS

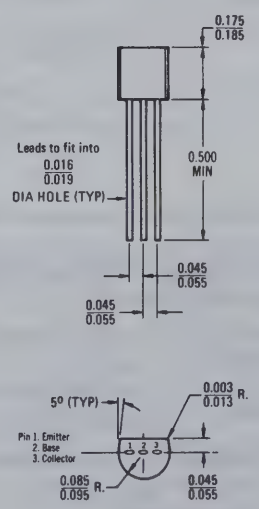


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.367	°C/mW

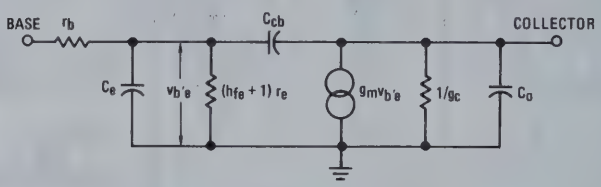


CASE 29 (1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	40	400	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	125	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	4.0	pF

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-A70 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

r_b' – See Figure 8

$r_e = 26\ mV/I_E$

$C_e = \dfrac{1}{2\pi f_t r_e}$

$C_{cb} = C_{ob} - 0.2\ pF$ (See Figure 6)

$g_m = 1/r_e$

$g_c = (h_{fe} + 1)\, h_{ob}$ (See Figures 2 & 7)

$C_o = 0.2\ pF$

Low frequency h parameters may be found from:

$h_{ie} = r_b' + (h_{fe} + 1)\, r_e$

h_{fe} = See Figure 2

h_{re} = Negligible

$h_{oe} = (h_{fe} + 1)\, h_{ob}$

FIGURE 2 – SMALL SIGNAL CURRENT GAIN

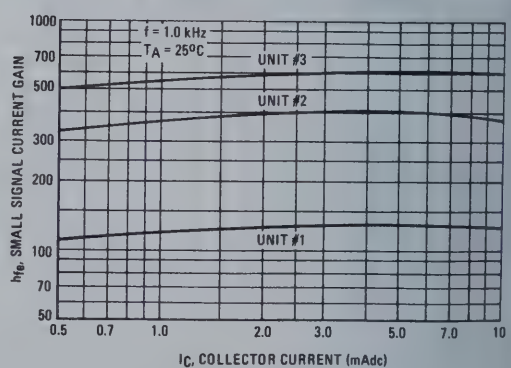


FIGURE 3 – NORMALIZED DC CURRENT GAIN

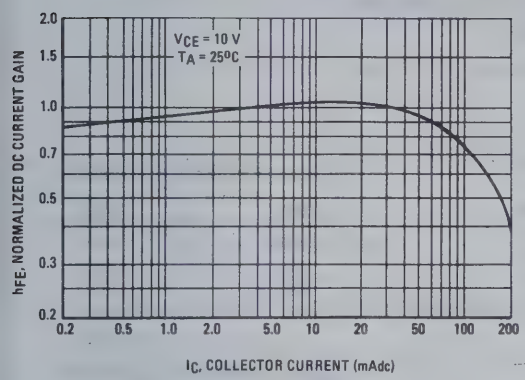


FIGURE 4 – "SATURATION" AND "ON" VOLTAGES

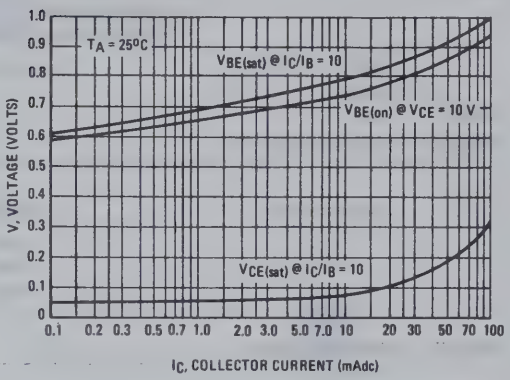


FIGURE 5 – CURRENT-GAIN–BANDWIDTH PRODUCT

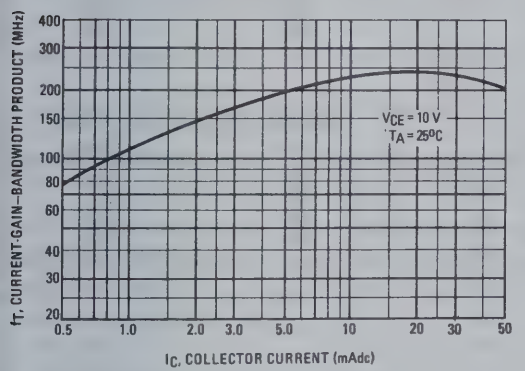


FIGURE 6 – CAPACITANCES

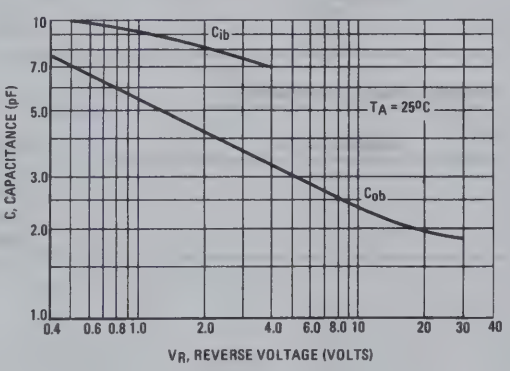


FIGURE 7 – OUTPUT ADMITTANCE

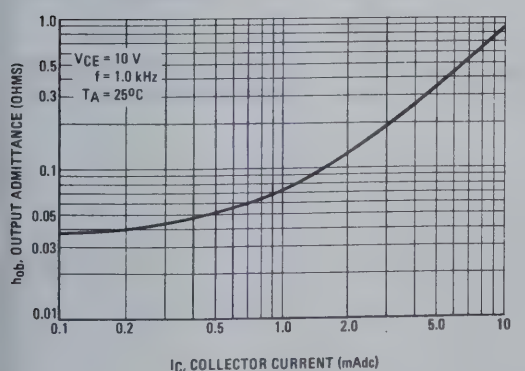
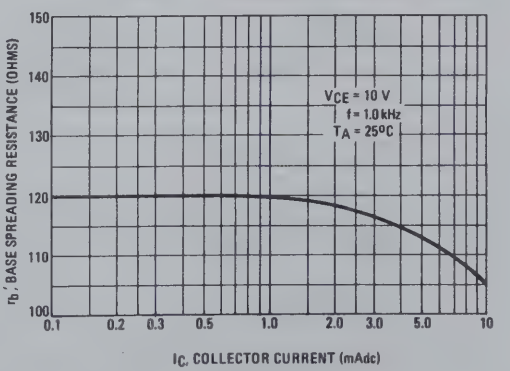


FIGURE 8 – BASE SPREADING RESISTANCE



MPS-K70, MPS-K71and MPS-K72 are three, five and nine transistor kits consisting of MPS-A70's with various h_{FE} selections.

Table 1

MPS-K70 — Three Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc Min	Max
1	Red	40	400
1	White	80	400
1	Blue	120	300

MPS-K71 — Five Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc Min	Max
3	Red	40	400
1	Green	100	200
1	Yellow	150	300

MPS-K72 — Nine Transistor Kit

Quantity Per Kit	Color Code	h_{FE} @ I_C = 5.0 mAdc, V_{CE} = 10 Vdc Min	Max
4	Red	40	400
2	White	80	400
2	Green	100	200
1	Yellow	150	300

MPS-H02 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for a common-emitter VHF-RF amplifier stage in TV receivers.

- Low Collector-Base Capacitance — C_{cb} = 0.5 pF (Max)
- Guaranteed Noise Figure — NF = 3.3 dB (Max) @ f = 200 MHz
- Guaranteed AGC Characteristics
- Complete y-Parameter Curves from 50 MHz to 300 MHz
- Guaranteed Power Gain — G_{pe} = 20 dB (Min) @ f = 200 MHz

NPN SILICON VHF TRANSISTOR

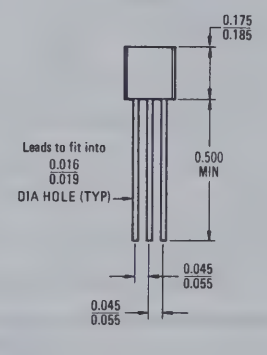


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.54	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.137	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.220	°C/mW



CASE 29 (2)
TO-92

MPS-H02 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	200	–
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	375	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.5	pF
Noise Figure (Figure 9) (V_{AGC} = 1.4 Vdc, R_S = 50 Ohms, f = 200 MHz)	NF	–	3.3	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 9) (V_{AGC} = 1.4 Vdc, R_S = 50 Ohms, f = 200 MHz)	G_{pe}	20	–	dB
Forward AGC Voltage (Figure 9) (Gain Reduction = 30 dB, R_S = 50 Ohms, f = 200 MHz)	V_{AGC}	4.0	5.0	Vdc

AGC CHARACTERISTICS

(V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 200 MHz, See Figure 9)

FIGURE 1 – POWER GAIN

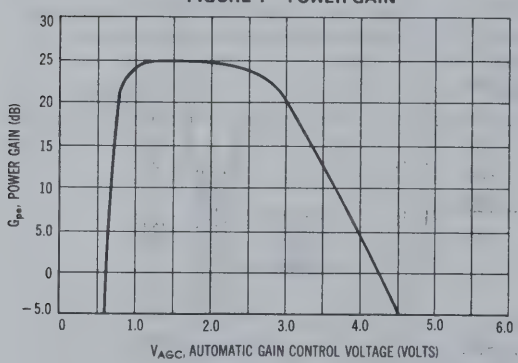
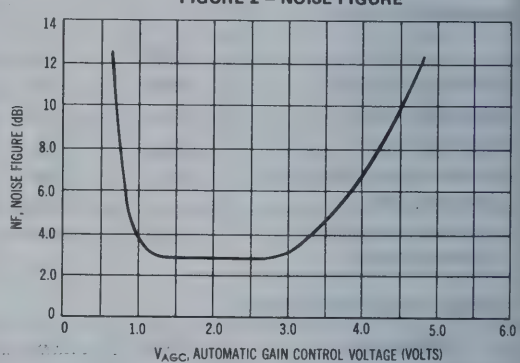


FIGURE 2 – NOISE FIGURE



COMMON-EMITTER y PARAMETERS

(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

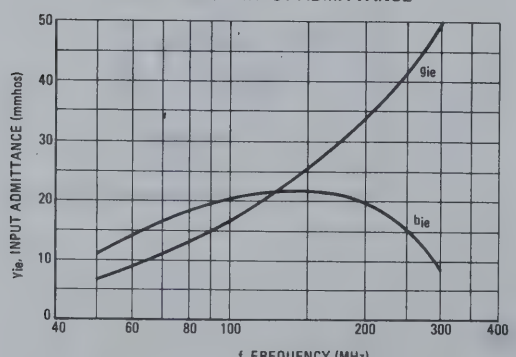
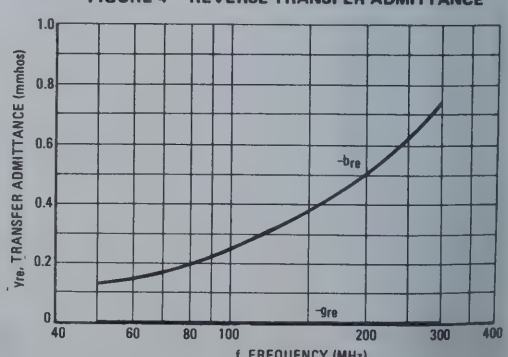


FIGURE 4 – REVERSE TRANSFER ADMITTANCE



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 5 – FORWARD TRANSFER ADMITTANCE

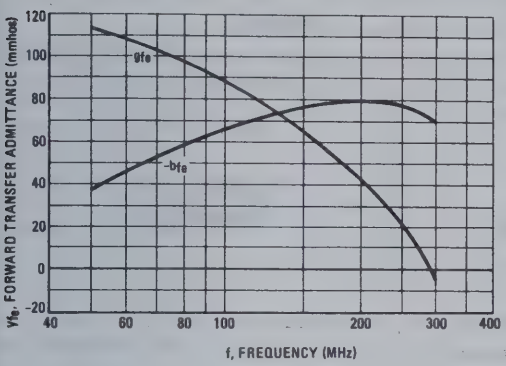


FIGURE 6 – OUTPUT ADMITTANCE

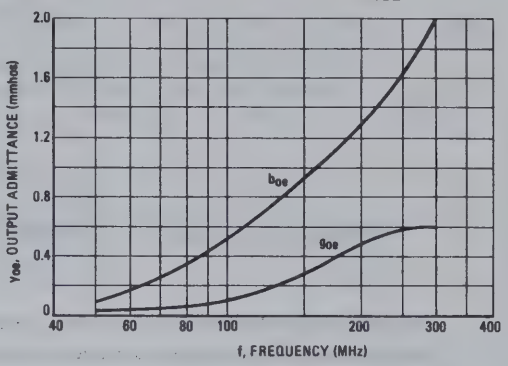


FIGURE 7 – DC CURRENT GAIN

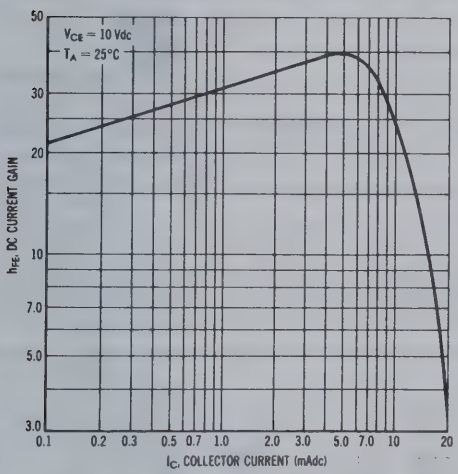


FIGURE 8 – COLLECTOR-BASE CAPACITANCE

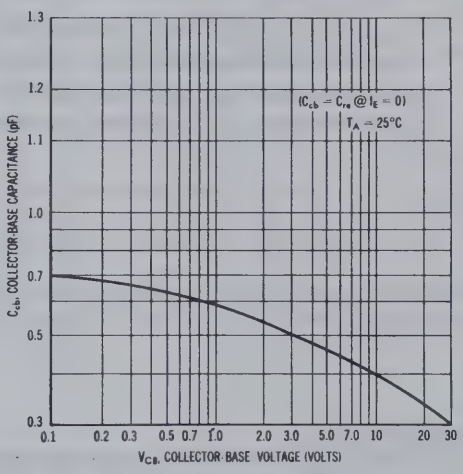
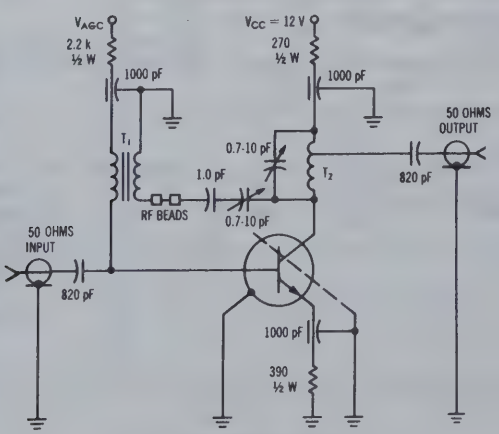


FIGURE 9 – 200 MHz FUNCTIONAL TEST CIRCUIT (NEUTRALIZED)



T_1 = FERRITE CORE INDIANA GEN. CORP. F-684
T_2 = 6 TURNS #16 BUSS WIRE, ID = ⅛", L = ¾"

MPS-H04 (SILICON)
MPS-H05

NPN SILICON ANNULAR TRANSISTORS

. . . MPS-H04 is designed for RF amplifier applications in AM receivers.

. . . MPS-H05 is designed for mixer, oscillator, autodyne converter, and IF amplifier applications in AM receivers.

- High Breakdown Voltage — BV_{CEO} = 80 Vdc (Min)
- Low Collector-Base Capacitance — C_{cb} = 1.0 pF (Typ)
- Low Output Admittance — h_{oe} = 5.0 μmhos (Max)
- Low Noise Figure — NF = 2.0 dB (Max) — MPS-H04

NPN SILICON TRANSISTORS

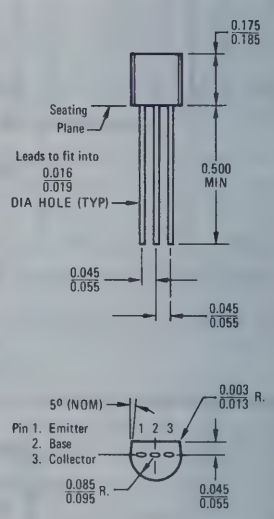


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	θ_{JA}	0.367	°C/mW

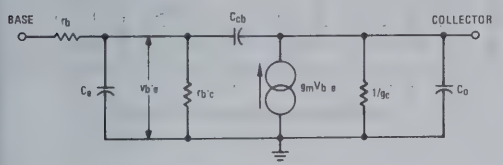


CASE 29(1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	80	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	80	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.5 mAdc, V_{CE} = 10 Vdc)	MPS-H04 MPS-H05	h_{FE}	 30 30	 70 70	 120 150	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.12	0.25	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	80	180	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)		C_{cb}	–	1.0	1.6	pF
Output Admittance (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	–	2.0	5.0	μmhos
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 MHz) MPS-H04		NF	–	1.7	2.0	dB

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-H04 and MPS-H05 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

$r_{b'} \approx 15$ Ohms

$r_e = 26\ mV/I_E$

$C_e = \dfrac{1}{2\pi f_t r_e}$

C_{cb}, See Figure 5

$g_m = 1/r_e$

$g_c = (h_{fe} + 1)\, h_{ob}$ (See Figures 3 and 6)

$C_o = 0.2$ pF

$r_{b'c} = (h_{fe} + 1)\, r_e$

Low frequency h parameters may be found from:

$h_{ie} = r_{b'} + r_{b'c}$

$h_{fe} \approx 1.1\, h_{FE}$ (See Figure 2)

h_{re} = Negligible

$h_{oe} = (h_{fe} + 1)\, h_{ob}$

y Parameters may be determined from the following calculations:

$$y_{11} = \frac{1 + j\omega\,(C_e + C_{cb})\, r_{b'c}}{(r_{b'} + r_{b'c}) + j\omega\,(C_e + C_{cb})\, r_{b'} r_{b'c}}$$

$$y_{12} = \frac{j\omega\, C_{cb}}{j\omega\,(C_{cb} + C_e)\, r_{b'} + \dfrac{r_{b'} + r_{b'c}}{r_{b'c}}}$$

$$y_{21} = g_m \left(\frac{1}{\left(1 + \dfrac{r_{b'}}{r_{b'c}}\right) + j\omega\,(C_e + C_{cb})\, r_{b'}} \right) - \frac{j\omega\, C_{cb}}{\left(1 + \dfrac{r_{b'}}{r_{b'c}}\right) + j\omega\,(C_e + C_{cb})\, r_{b'}}$$

$$y_{22} = g_c + jwCo - g_m r_{b'} y_{12} + \frac{\left(\dfrac{r_{b'} + r_{b'c}}{r_{b'} r_{b'c}} + j\omega\, C_e\right)\left(j\omega\, C_{cb}\right)}{\left(\dfrac{r_{b'} + r_{b'c}}{r_{b'} r_{b'c}} + j\omega\,(C_e + C_{cb})\right)}$$

ELECTRICAL CHARACTERISTICS (V_{CE} = 10 V, T_A = 25°C unless otherwise noted)

FIGURE 2 – NORMALIZED DC CURRENT GAIN

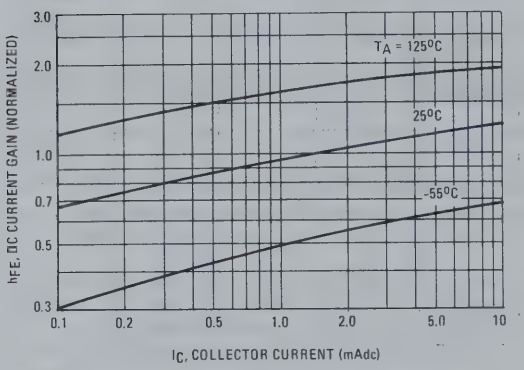


FIGURE 3 – "ON" VOLTAGES

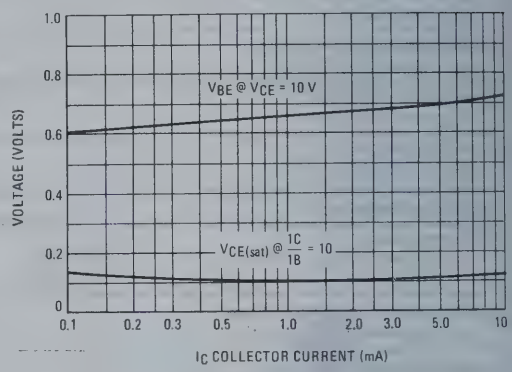


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

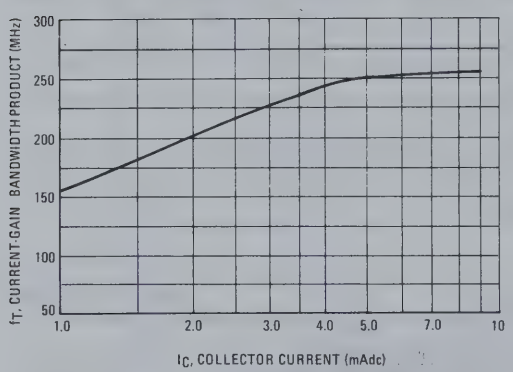


FIGURE 5 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE

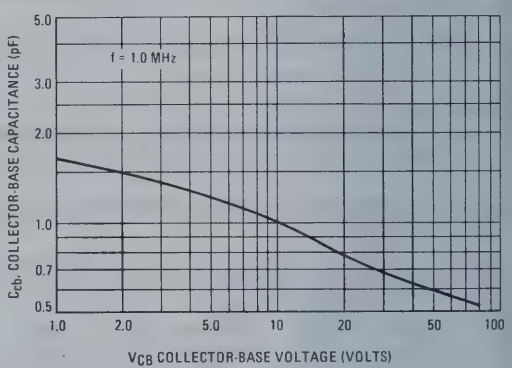


FIGURE 6 – OUTPUT ADMITTANCE

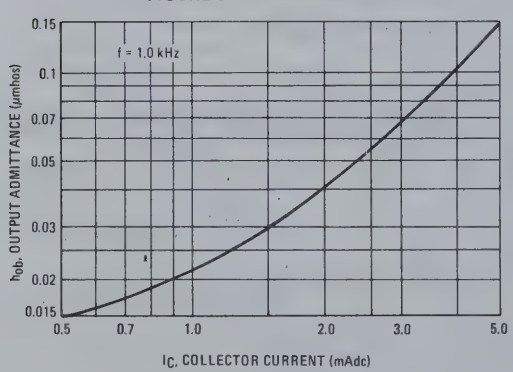
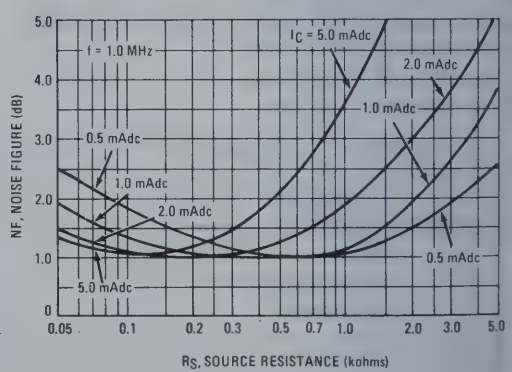
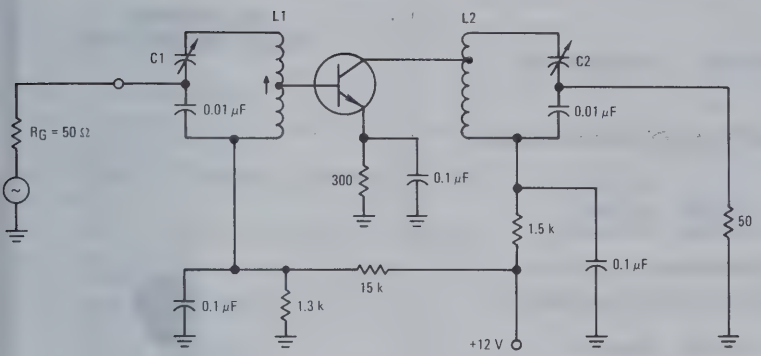


FIGURE 7 – NOISE FIGURE



AM RADIO DESIGN INFORMATION

FIGURE 8 – 1.0 MHz AMPLIFIER TEST CIRCUIT



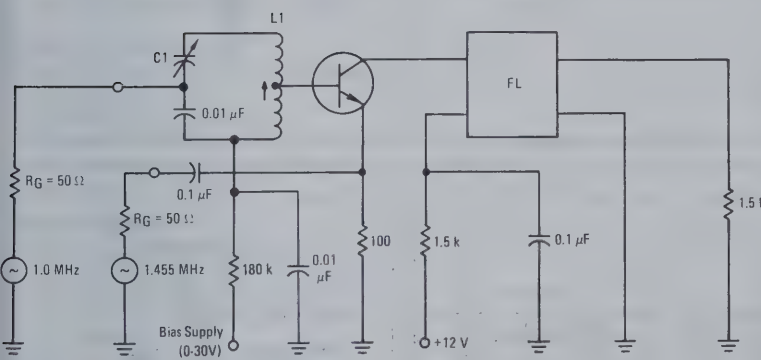
L1 90 turns of 7 x 41 Litz wire on 1/4" form, tapped 4 turns from ground end. Turns ratio of coil ≈ 22, unloaded Q, $Q_u \approx 130$ Loaded Q, $Q_L \approx 60$

L2 90 turns of 7 x 41 Litz wire on 1/4" form, tapped 21 turns from high end. Turns ratio of coil ≈ 1.3, unloaded Q, $Q_u \approx 130$, Loaded Q, $Q_L \approx 60$

C1 25-280 pF Variable

C2 100-400 pF Variable

FIGURE 9 – 1.0 MHz MIXER TEST CIRCUIT



L1 90 turns of 7 x 41 Litz wire on 1/4" form; tapped 4 turns from ground end. Turns ratio of coil ≈ 22, unloaded Q, $Q_u \approx 130$, Loaded Q, $Q_L \approx 60$.

C1 25-280 pF Variable

FL 455 kHz Filter

FIGURE 10 – AMPLIFIER POWER GAIN

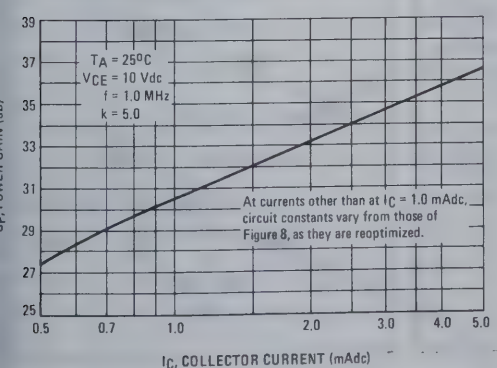
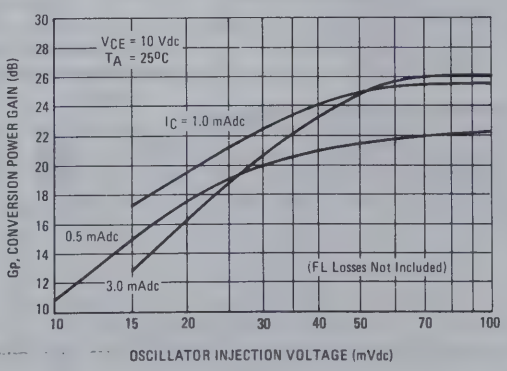


FIGURE 11 – CONVERSION POWER GAIN



MPS-H07 (SILICON)
MPS-H08

NPN SILICON ANNULAR TRANSISTORS

. . . designed for common-base FM/VHF RF amplifier applications.

- Guaranteed Noise Figure —
  NF = 3.2 dB (Max) @ f = 100 MHz MPS-H07
  = 3.5 dB (Max) @ f = 200 MHz MPS-H08
- Guaranteed Forward AGC Characteristics
- Complete y-Parameter Curves at Both 100 MHz and 200 MHz
- Guaranteed Power Gain —
  G_{pb} = 18 dB (Min) @ f = 100 MHz MPS-H07
  = 14 dB (Min) @ f = 200 MHz MPS-H08
- Low Feedback Capacitance Allowing Stable Unneutralized Operation

NPN SILICON FM/VHF TRANSISTORS

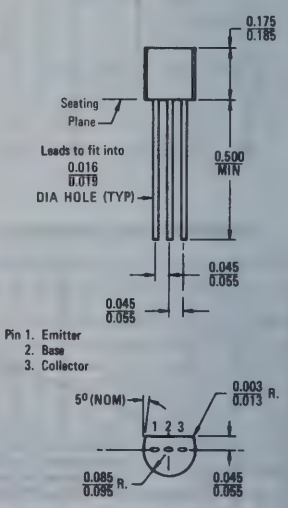


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.55	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.220	°C/mW



CASE 29(1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	30	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)		h_{FE}	20	–	–
Base-Emitter On Voltage (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS-H07	f_T	400	–	MHz
	MPS-H08		500	–	
Collector-Emitter Capacitance (V_{CE} = 10 Vdc, I_B = 0, f = 1.0 MHz, base guarded)		C_{ce} (C_{rb})	–	0.3	pF
Noise Figure (Figure 9) (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 100 MHz)	MPS-H07	NF	–	3.2	dB
(I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 200 MHz)	MPS-H08		–	3.5	
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 9) (I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms f = 100 MHz)	MPS-H07	G_{pb}	18	–	dB
(I_C = 3.0 mAdc, V_{CB} = 10 Vdc, R_S = 50 Ohms, f = 200 MHz)	MPS-H08		14	–	
Forward AGC Current (Figure 9) (Gain Reduction = 30 dB, R_S = 50 Ohms f = 100 MHz)	MPS-H07	I_{AGC}	5.0	8.0	mAdc
(Gain Reduction = 30 dB, R_S = 50 Ohms, f = 200 MHz)	MPS-H08		5.0	8.0	

AGC CHARACTERISTICS

V_{CC} = 10 Vdc, R_S = 50 Ohms, See Figure 9

—— f = 100 MHz ––– f = 200 MHz

FIGURE 1 – POWER GAIN

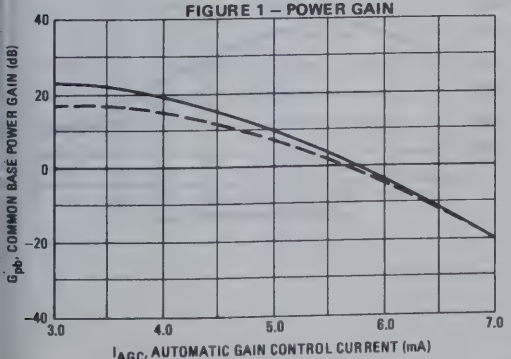
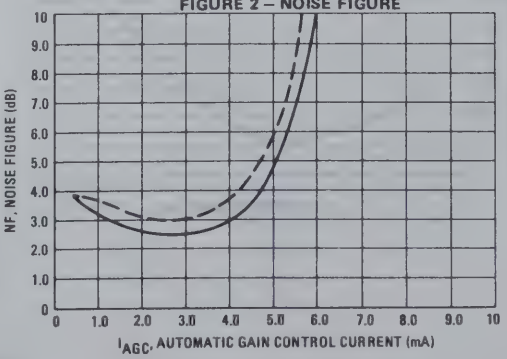


FIGURE 2 – NOISE FIGURE



COMMON-BASE y PARAMETERS

V_{CB} = 10 Vdc, T_A = 25°C

—— f = 100 MHz ——— f = 200 MHz

FIGURE 3 – INPUT ADMITTANCE

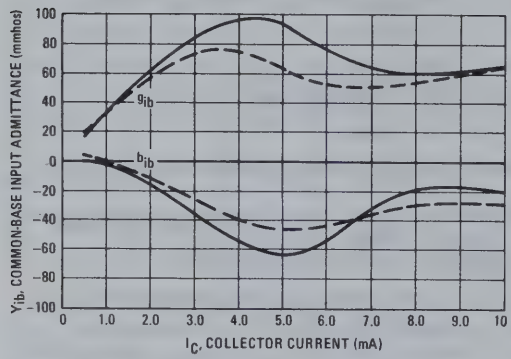


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

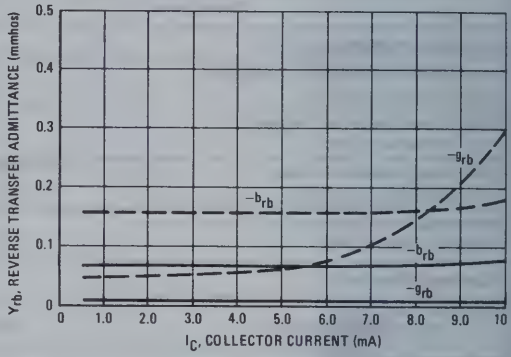


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

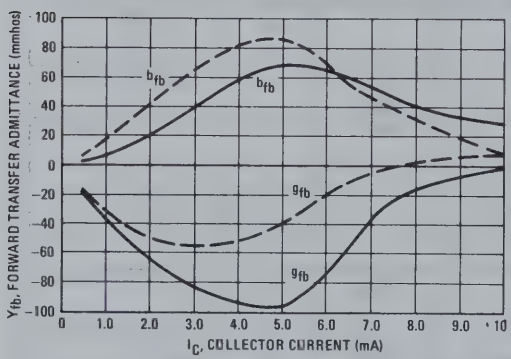


FIGURE 6 – OUTPUT ADMITTANCE

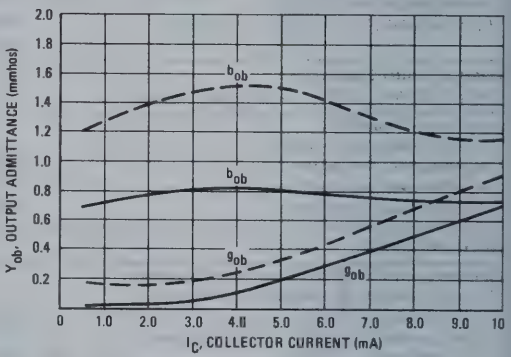


FIGURE 7 – COLLECTOR-BASE TIME CONSTANT

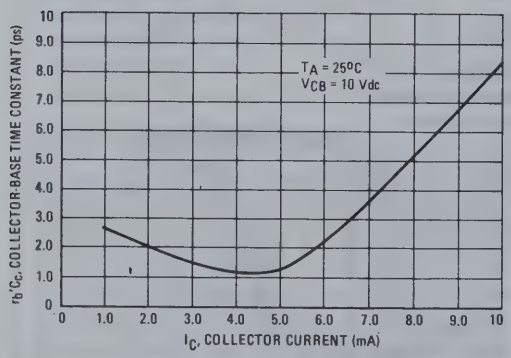


FIGURE 8 – CURRENT-GAIN BANDWIDTH PRODUCT

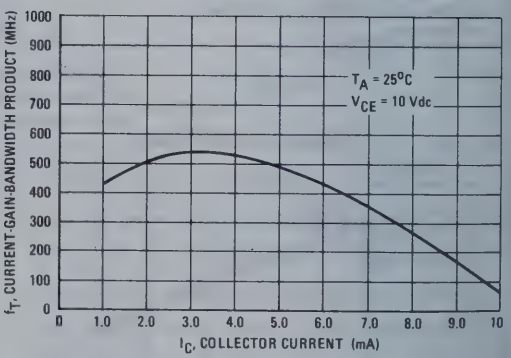
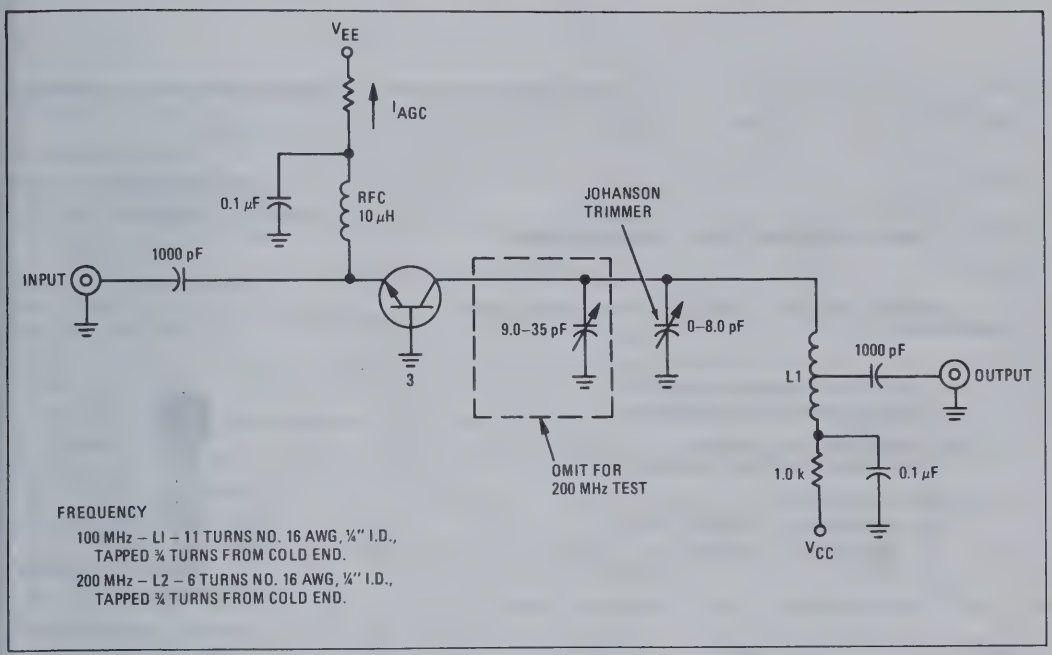


FIGURE 9 – 100-MHz AND 200-MHz COMMON-BASE AMPLIFIER



MPS-H10 (SILICON)
MPS-H11

NPN SILICON EPITAXIAL TRANSISTORS

. . . designed for use in VHF/UHF common base oscillator applications.

- High Current-Gain—Bandwidth Product —
  f_T = 650 MHz (Min) @ I_C = 4.0 mAdc
- Low Collector-Base Time Constant —
  $r_b'C_c$ = 9.0 ps (Max) @ I_C = 4.0 mAdc
- Feedback Capacitance —
  C_{rb} = 0.35—0.65 pF — MPS-H10
  0.6—0.9 pF — MPS-H11

NPN SILICON VHF/UHF TRANSISTORS

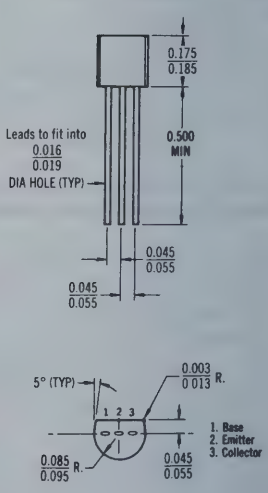


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



CASE 29 (2)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	25	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	60	–	–
Collector-Emitter Saturation Voltage (I_C = 4.0 mAdc, I_B = 0.4 mAdc)	$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	–	0.95	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	650	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.7	pF
Common-Base Feedback Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz) MPS-H10 MPS-H11	C_{rb}	 0.35 0.6	 0.65 0.9	pF
Collector-Base Time Constant (I_C = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	9.0	ps

COMMON-BASE y PARAMETERS versus FREQUENCY
(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{ib}, INPUT ADMITTANCE

FIGURE 1 – RECTANGULAR FORM

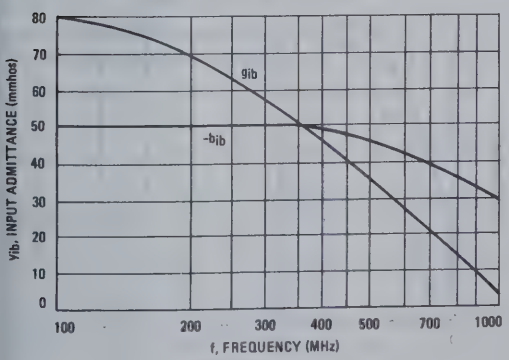
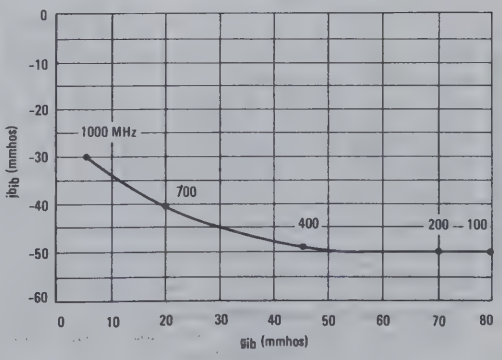


FIGURE 2 – POLAR FORM



COMMON-BASE y PARAMETERS versus FREQUENCY

(V_{CB} = 10 Vdc, I_C = 4.0 mAdc, T_A = 25°C)

y_{fb}, FORWARD TRANSFER ADMITTANCE

FIGURE 3 – RECTANGULAR FORM

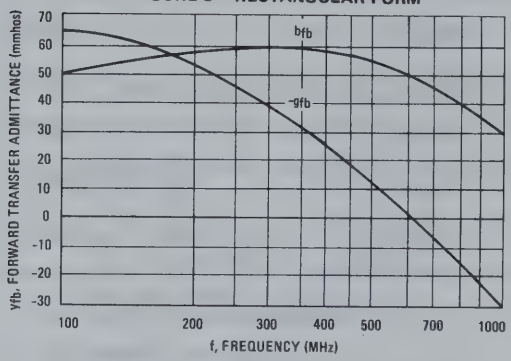
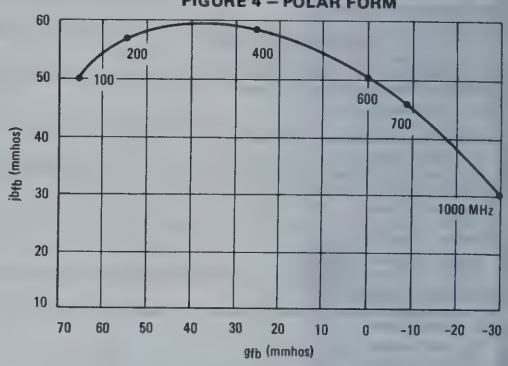


FIGURE 4 – POLAR FORM



y_{rb}, REVERSE TRANSFER ADMITTANCE

FIGURE 5 – RECTANGULAR FORM

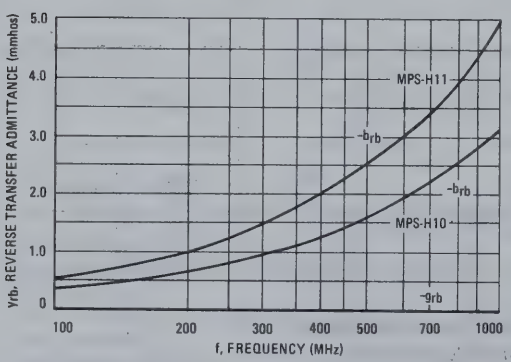
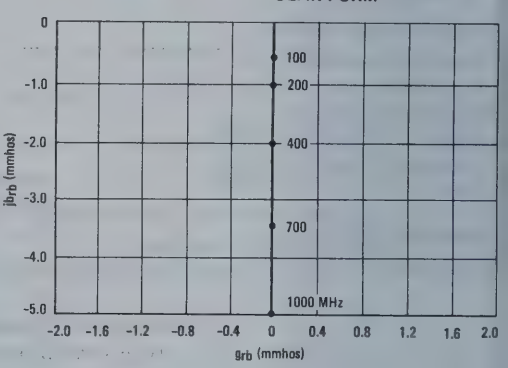


FIGURE 6 – POLAR FORM



y_{ob}, OUTPUT ADMITTANCE

FIGURE 7 – RECTANGULAR FORM

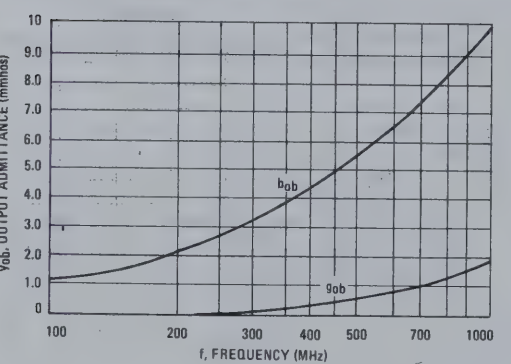
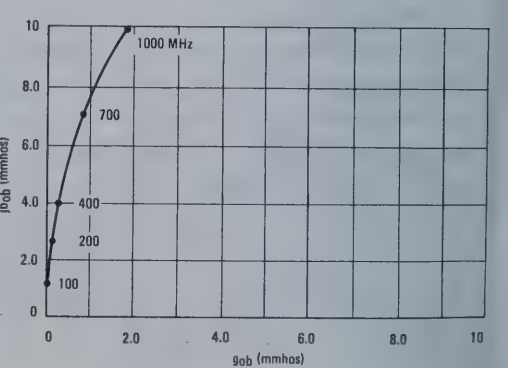


FIGURE 8 – POLAR FORM



MPS-H20 (SILICON)

NPN SILICON EPITAXIAL TRANSISTORS

. . . designed for VHF mixer applications in TV receivers.

- Excellent Conversion Gain – 23 dB (Typ)
- Low Collector-Base Capacitance – C_{cb} = 0.65 pF (Max)
- High Current-Gain–Bandwidth Product – f_T = 400 MHz (Min)
- Complete y-Parameter Curves from 50 to 300 MHz
- One-Piece, Injection Molded Unibloc Package

NPN SILICON VHF TRANSISTOR

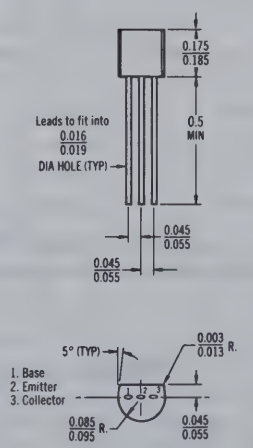


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



CASE 29 (2)
TO-92

MPS-H20 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	–	–	–
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	620	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.5	0.65	pF
Collector-Base Time Constant (I_E = 4.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	10	–	ps
Conversion Gain (213 to 45 MHz) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, Oscillator Injection = 200 mVdc, See Figures 1, 2 and 9)	–	18	23	–	dB

CONVERSION GAIN CHARACTERISTICS
(TEST CIRCUIT FIGURE 9)

FIGURE 1 – VARIATION WITH COLLECTOR CURRENT

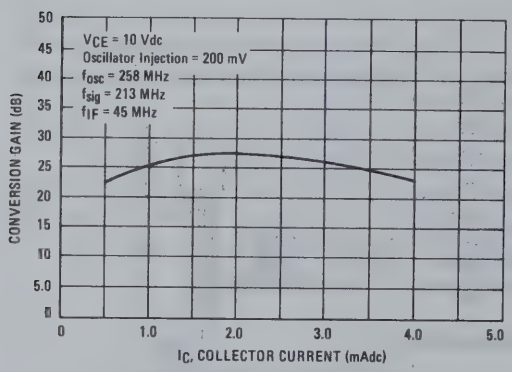
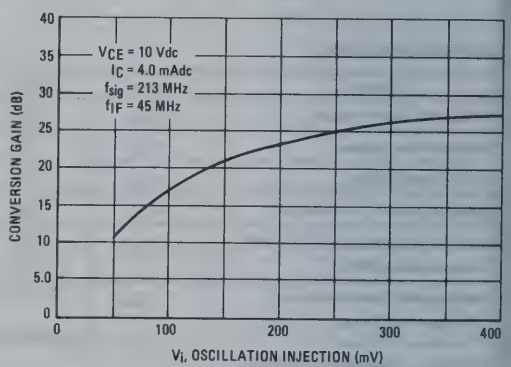


FIGURE 2 – VARIATION WITH INJECTION LEVEL



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

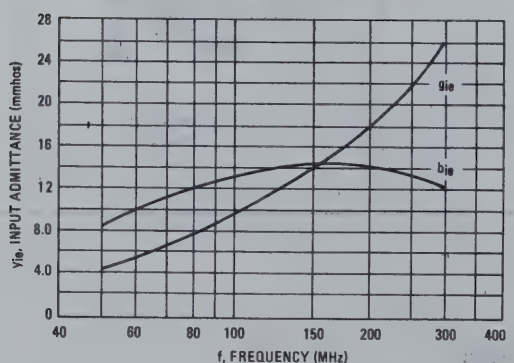
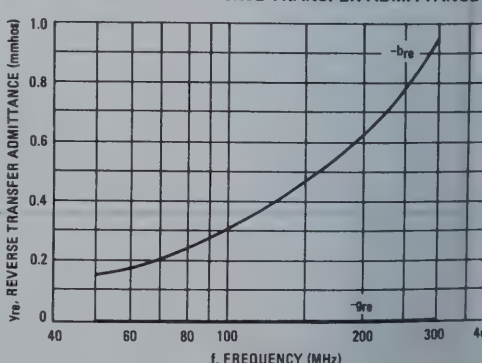


FIGURE 4 – REVERSE TRANSFER ADMITTANCE



COMMON-EMITTER y PARAMETERS
(I_C = 4.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 5 – FORWARD TRANSFER ADMITTANCE

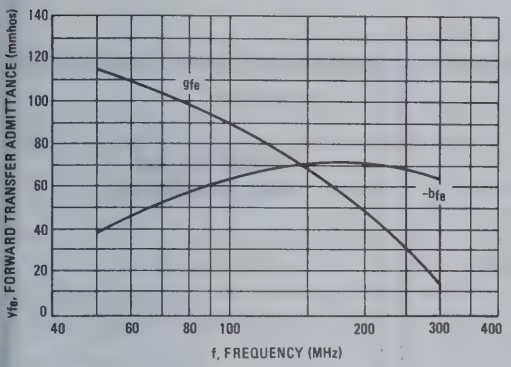


FIGURE 6 – OUTPUT ADMITTANCE

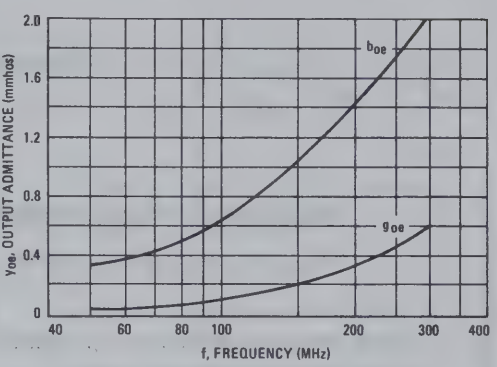


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

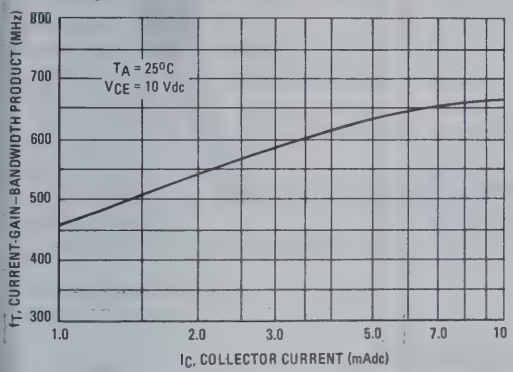


FIGURE 8 – CAPACITANCES

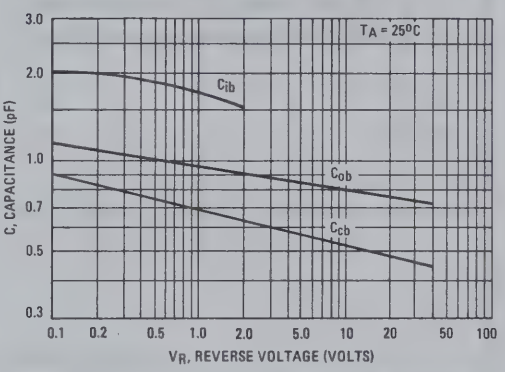
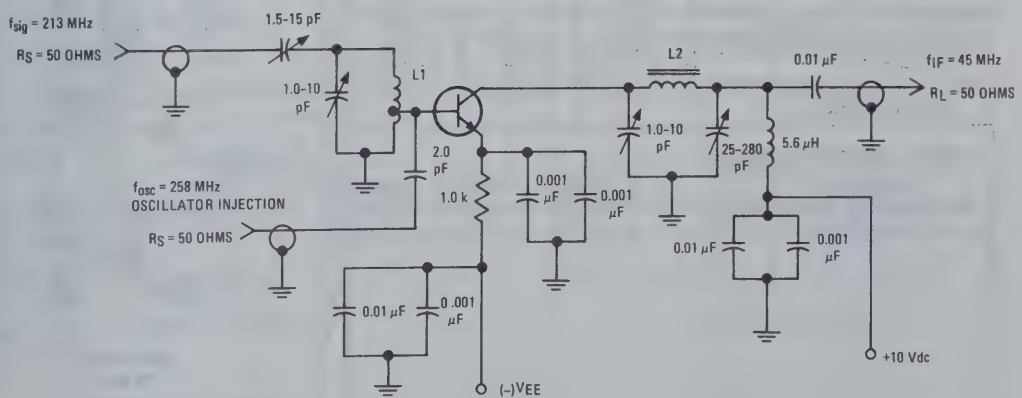


FIGURE 9 – MIXER TEST CIRCUIT



L1 = 3 TURNS #18 ENAMELED WIRE, 1/4" I.D., AIR WOUND, WINDING LENGTH 1/2"; BASE TAPPED 1 TURN FROM GROUND.

L2 = 10 TURNS #26 INSULATED WIRE, WOUND ON 1/4" I.D. COIL FORM, ARNOLD PART NO. A1-10 IRON POWDER CORE.

MPS-H24 (SILICON)

NPN SILICON EPITAXIAL TRANSISTOR

. . . designed for VHF mixer applications in TV receivers.

- Excellent Conversion Gain – 24 dB (Typ)
- Low Collector-Base Capacitance – C_{cb} = 0.36 pF (Max)
- High Current-Gain–Bandwidth Product – f_T = 400 MHz (Min)
- Input y-Parameter Curves at 60 and 213 MHz
- Output and Transfer y-Parameters at 45 MHz

NPN SILICON VHF TRANSISTOR

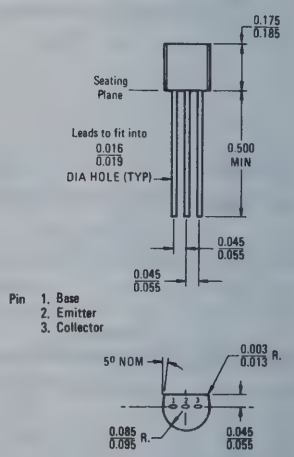


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.55	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	220	°C/W



CASE 29 (2)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 8.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 8.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	620	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.25	0.36	pF
Conversion Gain (Figures 1, 2 and 7)	–				dB
(213 MHz to 45 MHz)					
(I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms)		19	24	–	
(60 MHz to 45 MHz)					
(I_C = 8.0 mAdc, V_{CC} = 20 Vdc, Oscillator Injection = 150 mVrms)		24	29	–	

CONVERSION GAIN CHARACTERISTICS

(TEST CIRCUIT FIGURE 7)

(V_{CC} = 20 Vdc, R_S = R_L = 50 Ohms, f_{if} = 44 MHz, B.W. = 6.0 MHz)

FIGURE 1 – CONVERSION GAIN versus COLLECTOR CURRENT

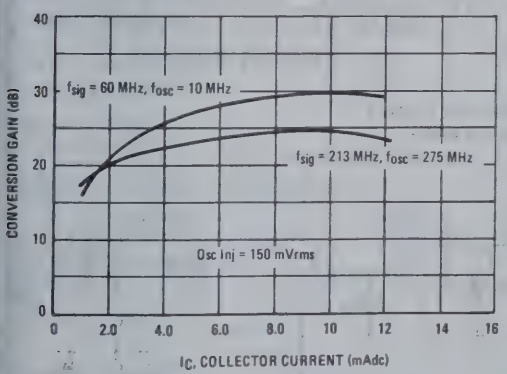
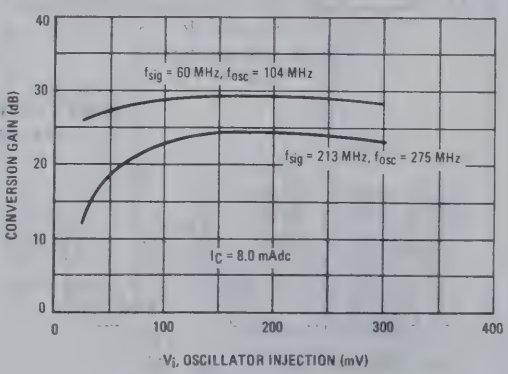


FIGURE 2 – CONVERSION GAIN versus INJECTION LEVEL



COMMON-EMITTER y PARAMETERS
(V_{CE} = 15 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

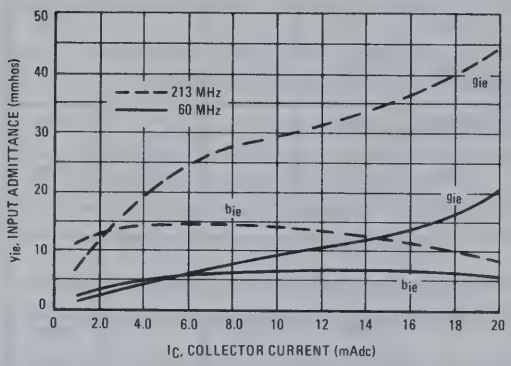


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

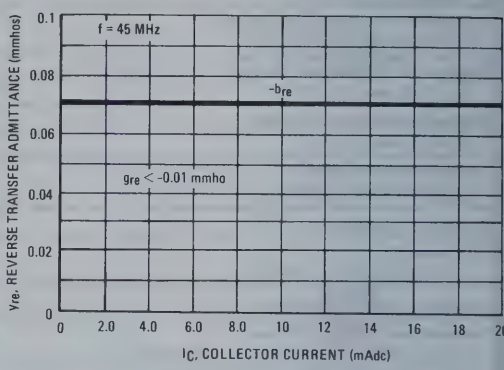


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

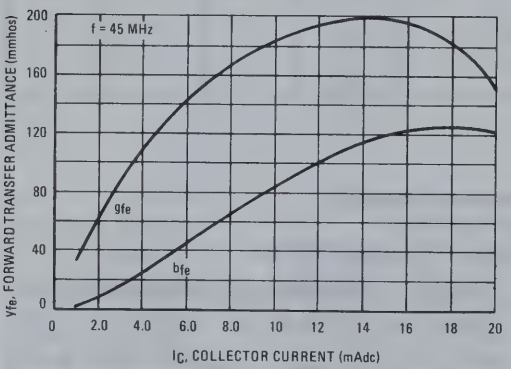


FIGURE 6 – OUTPUT ADMITTANCE

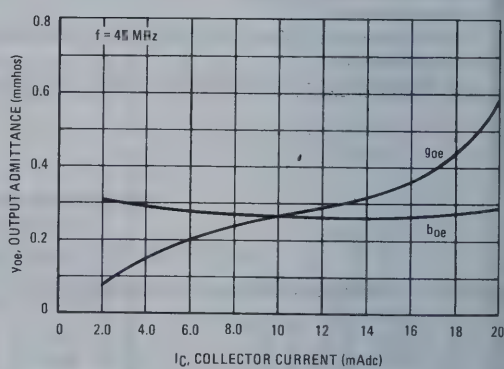
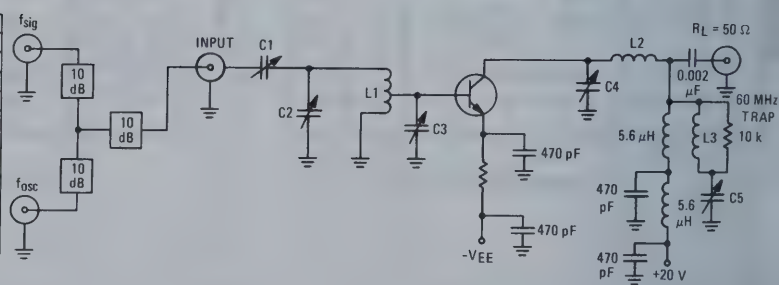


FIGURE 7 – VHF MIXER TEST CIRCUIT
(f_{if} = 44 MHz, B.W. = 6.0 MHz)

f_{sig}	60 MHz	213 MHz
f_{osc}	105 MHz	258 MHz
C1	1.5-20 pF	1.5-20 pF
C2	8.0-60 pF	6.0-12 pF
C3	8.0-60 pF	1.5-20 pF
C4	3.0-35 pF	–
C5	1.5-20 pF	–
L1	5 Turns #26 Air, Tap 1 Turn	3 Turns #16 Air, Tap ½ Turn
L2	10 Turns #26 Air	10 Turns #26 Arnold A1-10 Core
L3	Ohmite Z235	–



MPS-H30 (SILICON)
MPS-H31

NPN SILICON ANNULAR TRANSISTORS

. . . designed for first and second video IF stages in TV receivers.

- Guaranteed Noise Figure –
  NF = 6.0 dB (Max) at 45 MHz
- Guaranteed AGC Characteristics
- Complete y-Parameter Curves at 45 MHz
- Guaranteed Power Gain –
  G_{pe} = 22.5 dB (Min) (Unneutralized) at 45 MHz

NPN SILICON IF AMPLIFIER TRANSISTORS

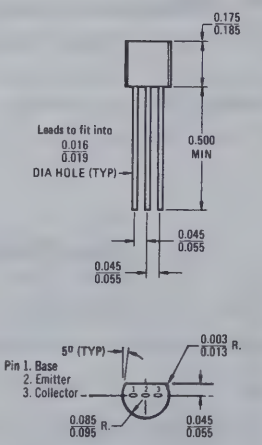


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



CASE 29 (2)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	-	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	50	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	200	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	0.1	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	-	0.96	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	800	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz, emitter guarded)	C_{cb}	-	0.65	pF
Noise Figure (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 9)	NF	-	6.0	dB
FUNCTIONAL TESTS				
Power Gain (V_{AGC} = 2.75 Vdc, R_S = 50 ohms, f = 45 MHz, Figure 9)	G_{pe}	22.5	31	dB
Forward AGC Voltage (Gain Reduction = 30 dB, R_S = 50 ohms, f = 45 MHz, Figure 9) MPS-H30 MPS-H31	V_{AGC}	4.4 5.2	5.4 6.2	Vdc

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 45 MHz, See Figure 9

FIGURE 1 — POWER GAIN

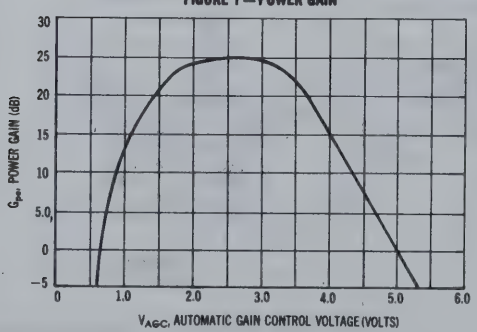
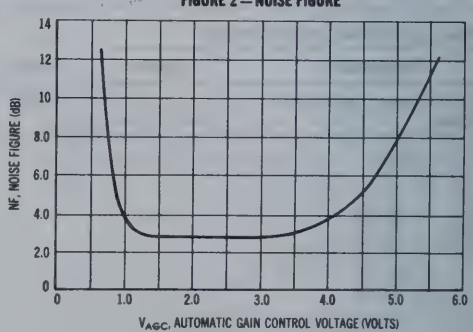


FIGURE 2 — NOISE FIGURE



COMMON-EMITTER y PARAMETERS

V_{CE} = 12 Vdc, T_A = 25°C, f = 45 MHz

FIGURE 3 — INPUT ADMITTANCE

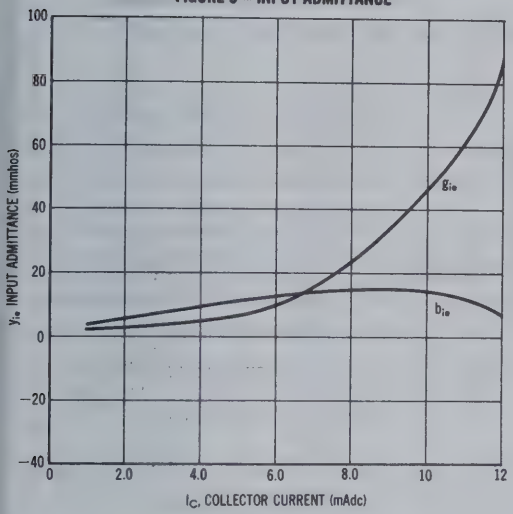


FIGURE 4 — REVERSE TRANSFER ADMITTANCE

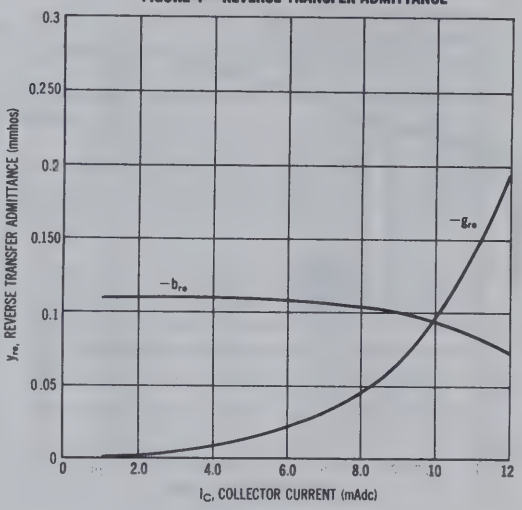


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

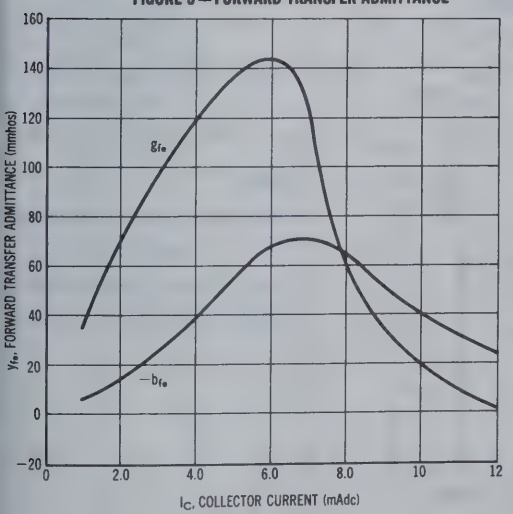


FIGURE 6 — OUTPUT ADMITTANCE

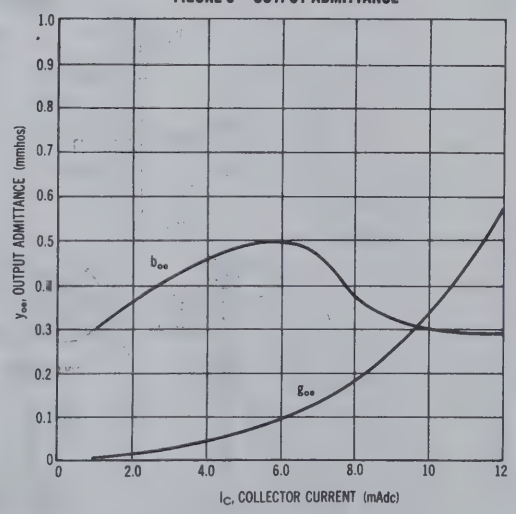


FIGURE 7 — DC CURRENT GAIN

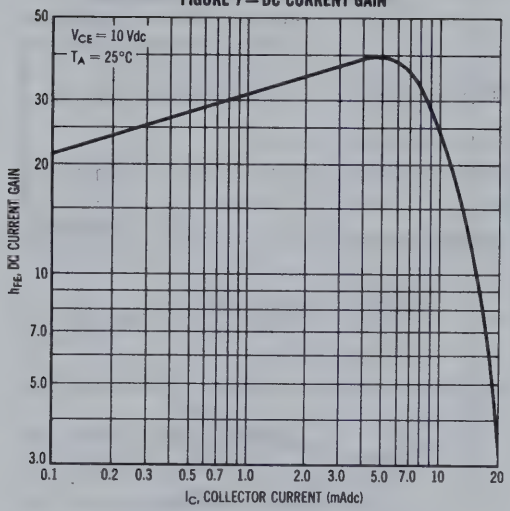


FIGURE 8 — COLLECTOR-BASE CAPACITANCE

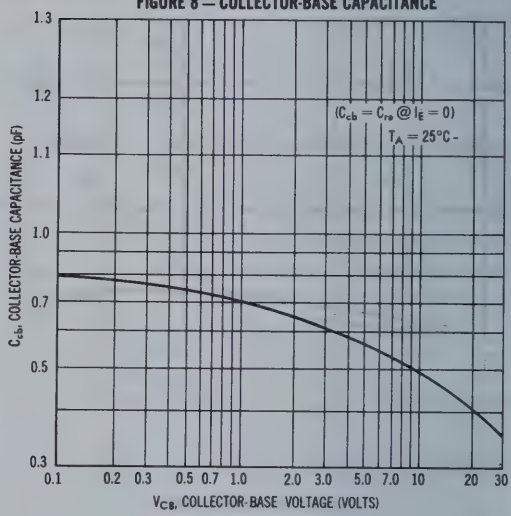
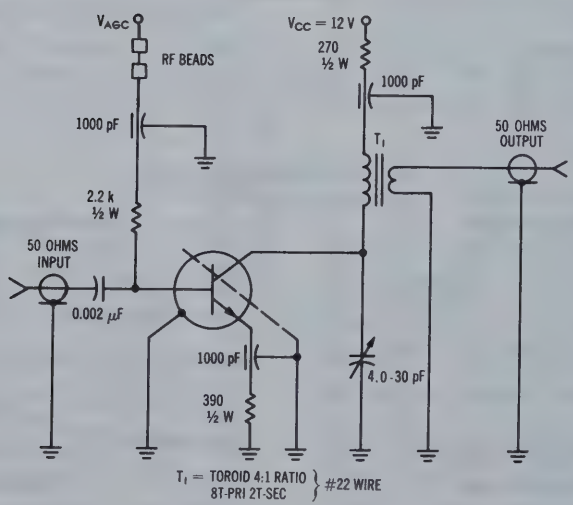


FIGURE 9 — 45 MHz FUNCTIONAL TEST CIRCUIT
(UNNEUTRALIZED)



MPS-H32 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for first and second video IF stages in TV receivers.

- Low Collector-Base Capacitance – C_{cb} = 0.22 pF (Max)
- Maximum Unilateralized Power Gain – G_{um} = 44 dB (Typ)
- Low Noise Figure – NF = 3.3 dB (Typ) @ f = 45 MHz
- Forward AGC Characteristics
- Complete y-Parameter Curves at 45 MHz
- Guaranteed Power Gain – G_{pe} = 22.5 dB (Min) (Unneutralized) @ f = 45 MHz

NPN SILICON VHF TRANSISTOR

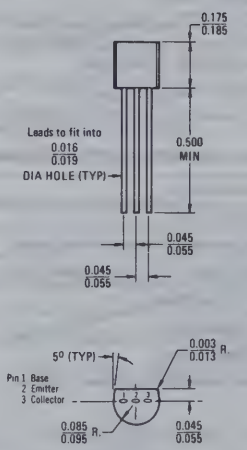


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.54	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.137	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.220	°C/mW



CASE 29 (2)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 4.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	27	35	200	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	–	1.5	3.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	0.9	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	440	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz) (Emitter Guarded)	C_{cb}	–	0.2	0.22	pF
Noise Figure (Figure 10) ($I_E \approx$ 4.0 mAdc, $V_{CE} \approx$ 9.3 Vdc, V_{AGC} = 2.75 Vdc, R_S = 50 Ohms, f = 45 MHz)	NF	–	3.3	–	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 10) ($I_E \approx$ 4.0 mAdc, $V_{CE} \approx$ 9.3 Vdc, V_{AGC} = 2.75 Vdc, R_S = 50 Ohms, f = 45 MHz)	G_{pe}	22.5	25	–	dB
Forward AGC Voltage (Figure 10) (Gain Reduction = 30 dB, R_S = 50 Ohms, f = 45 MHz)	V_{AGC}	–	5.5	–	Vdc

SUMMARY-COMMON EMITTER y PARAMETERS (V_{CE} = 10 Vdc, I_C = 4.0 mAdc, f = 45 MHz)

Input Conductance	g_{ie}	–	6.0	–	mmhos
Input Capacitance	C_{ie}	–	33	–	pF
Forward Transfer Admittance Magnitude	$\lvert y_{fe} \rvert$	–	110	–	mmhos
Forward Transfer Admittance Phase Angle	$\angle y_{fe}$	–	-22	–	Degrees
Feedback Capacitance	C_{re}	–	0.2	–	pF
Output Conductance	g_{oe}	–	20	–	μmhos
Output Capacitance	C_{oe}	–	1.4	–	pF
Maximum Unilateralized Power Gain $G_{um} = \frac{\lvert y_{fe} \rvert^2}{4\, g_{ie}\, g_{oe}}$	G_{um}	–	44	–	dB

AGC CHARACTERISTICS

V_{CC} = 12 Vdc, R_S = 50 Ohms, f = 45 MHz, See Figure 10

FIGURE 1 – POWER GAIN

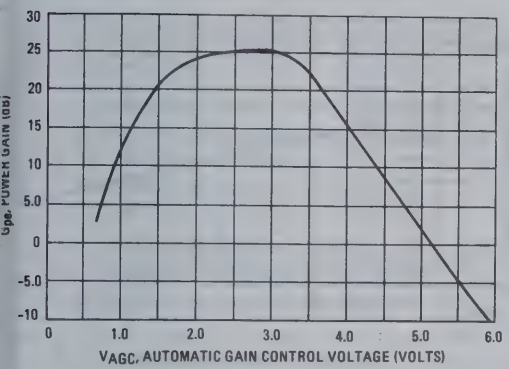
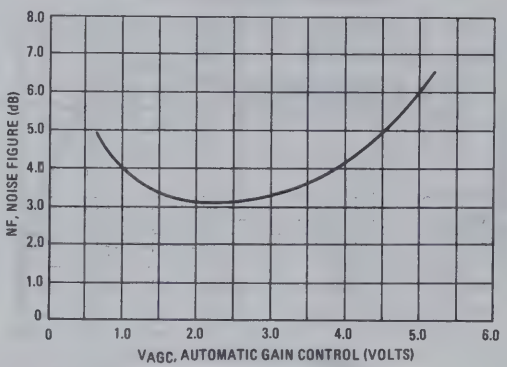


FIGURE 2 – NOISE FIGURE



COMMON-EMITTER y PARAMETERS

V_{CE} = 10 Vdc, f = 45 MHz, T_A = 25°C

FIGURE 3 – INPUT ADMITTANCE

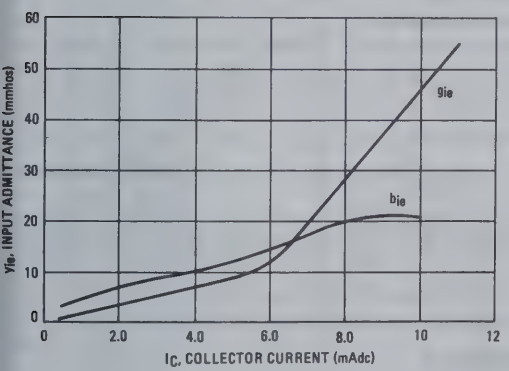


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

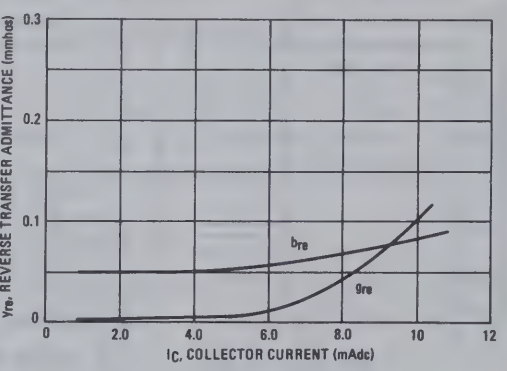


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

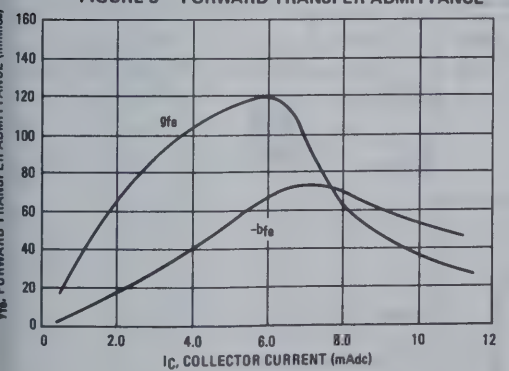


FIGURE 6 – OUTPUT ADMITTANCE

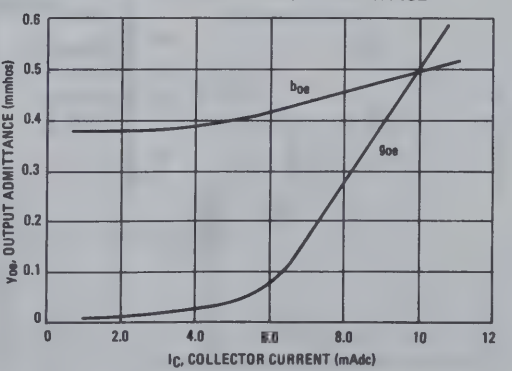


FIGURE 7 – DC CURRENT GAIN

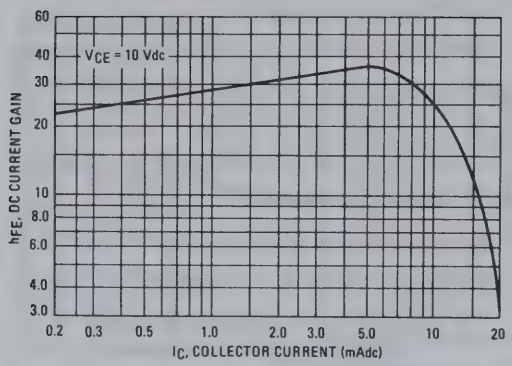


FIGURE 8 – COLLECTOR-BASE CAPACITANCE

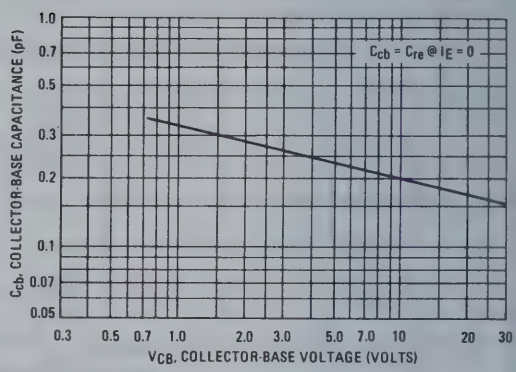


FIGURE 9 – CURRENT-GAIN–BANDWIDTH PRODUCT

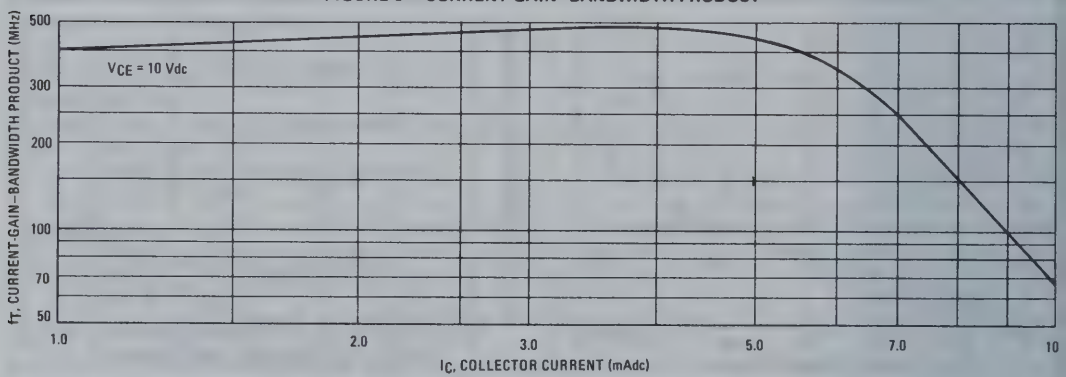
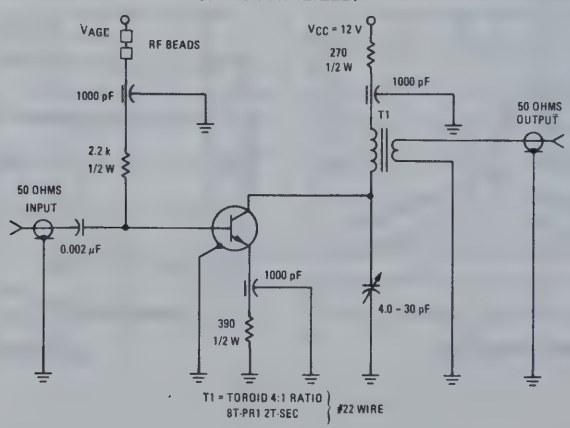


FIGURE 10 – 45 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)



MPS-H34 (SILICON)

NPN SILICON EPITAXIAL TRANSISTOR

. . . designed for third-stage video IF applications in television receivers.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 45 Vdc (Min)
- High Collector-Base Breakdown Voltage — BV_{CBO} = 45 Vdc (Min)
- Low Collector-Base Capacitance — C_{cb} = 0.32 pF (Max) @ V_{CB} = 10 Vdc
- Complete y-Parameter Curves @ 45 MHz

NPN SILICON IF TRANSISTOR

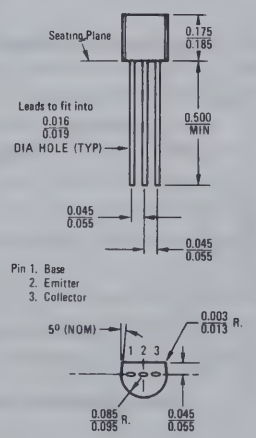


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 4.55	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Rating	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	220	°C/W



CASE 29 (2)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	45	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	45	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 7.0 mAdc, V_{CE} = 15 Vdc) (I_C = 20 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	40 15	– –	– –	–
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
Base-Emitter On Voltage (I_C = 7.0 mAdc, V_{CE} = 15 Vdc)	$V_{BE(on)}$	–	–	0.95	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 15 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	500	720	–	MHz
Current-Gain – Bandwidth Ratio (I_C = 15 mAdc to I_C = 20 mAdc, V_{CE} = 15 Vdc)	$\frac{f_{T15}}{f_{T20}}$	–	–	1.6	–
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.25	0.32	pF

FIGURE 1 – CURRENT-GAIN – BANDWIDTH PRODUCT

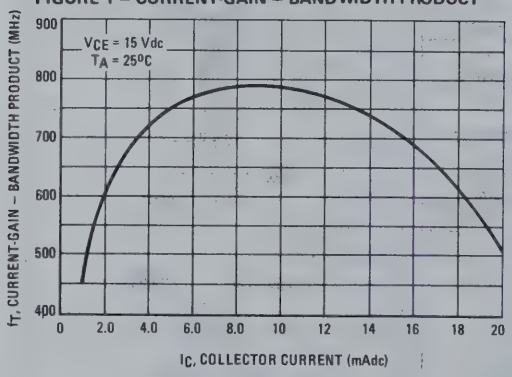
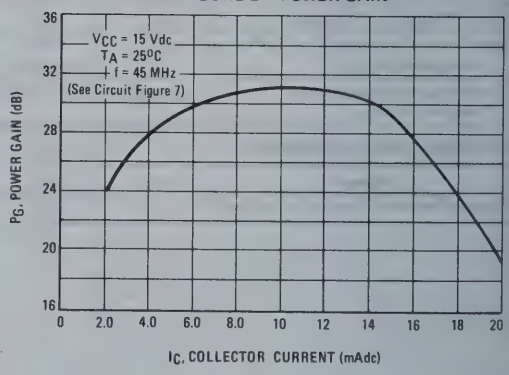


FIGURE 2 – POWER GAIN



COMMON-EMITTER y PARAMETERS

(f = 45 MHz, V_{CE} = 15 Vdc, T_A = 25°C)

FIGURE 3 – INPUT ADMITTANCE

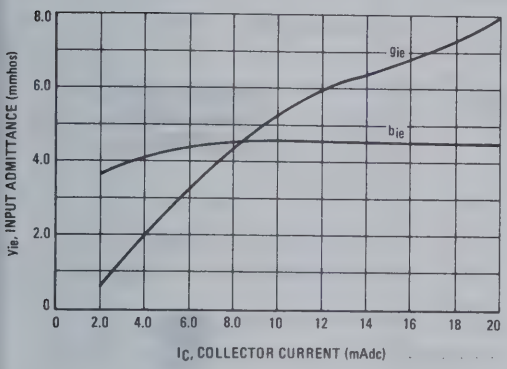


FIGURE 4 – REVERSE TRANSFER ADMITTANCE

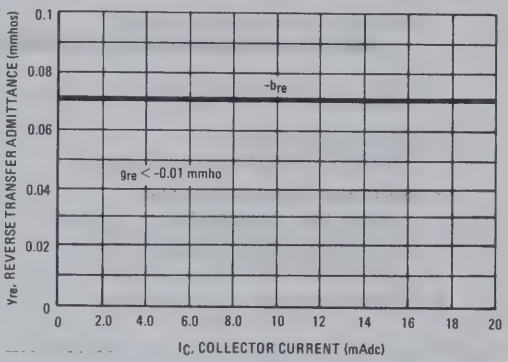


FIGURE 5 – FORWARD TRANSFER ADMITTANCE

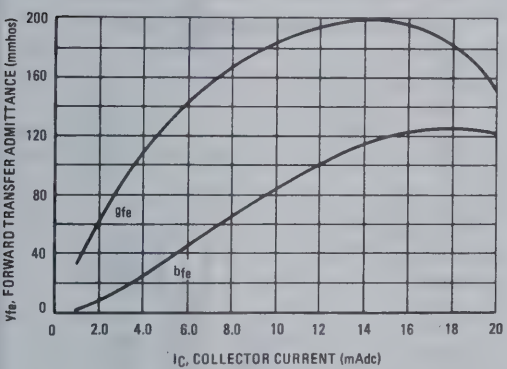


FIGURE 6 – OUTPUT ADMITTANCE

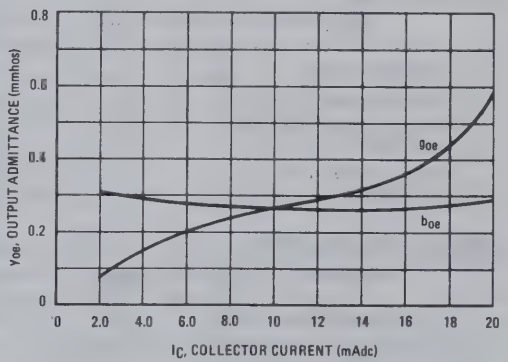
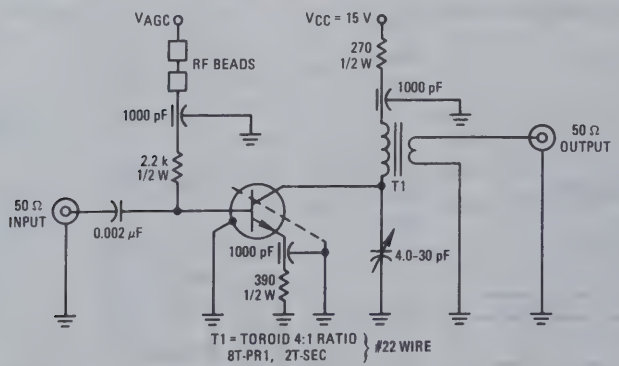


FIGURE 7 – 45 MHz FUNCTIONAL TEST CIRCUIT (UNNEUTRALIZED)



MPS-H37 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for 4.5 MHz sound IF applications in TV receivers.

- High Breakdown Voltage — BV_{CEO} = 40 V (Min) @ I_C = 1.0 mAdc
- High Output Resistance @ 4.5 MHz — R_{oep} = 100 k Ohms (Min) @ I_C = 2.0 mAdc
- Low Reverse Feedback Capacitance — C_{re} = 0.7 pF (Max) @ V_{CB} = 10 Vdc
- Complete y-Parameter Curves @ 4.5 MHz

NPN SILICON IF AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

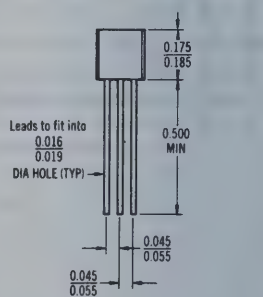
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	BV_{CEO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 35 Vdc, I_E = 0)	I_{CBO}	—	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter On Voltage (I_C = 5.0 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	—	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	—	MHz
Common-Emitter Reverse Transfer Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{re}	—	0.7	pF
Output Resistance (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 4.5 MHz)	R_{oep}	100	—	k ohms



CASE 29 (2)
TO-92

COMMON-EMITTER y PARAMETERS

f = 4.5 MHz, T_A = 25°C

FIGURE 1 — INPUT ADMITTANCE

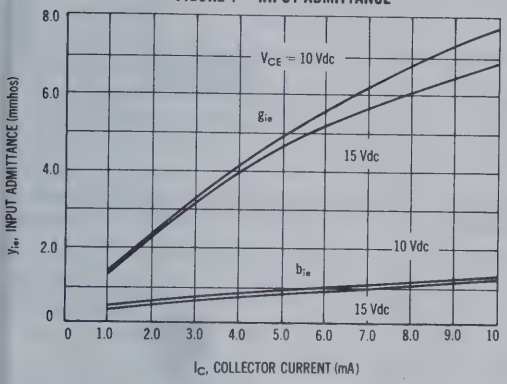


FIGURE 2 — REVERSE TRANSFER ADMITTANCE

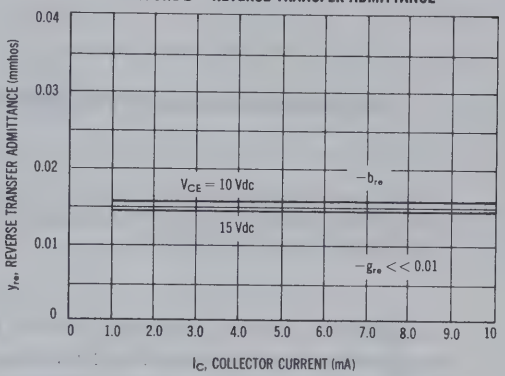


FIGURE 3 — FORWARD TRANSFER ADMITTANCE

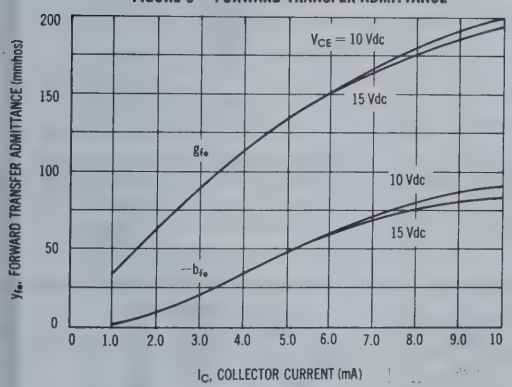


FIGURE 4 — OUTPUT ADMITTANCE

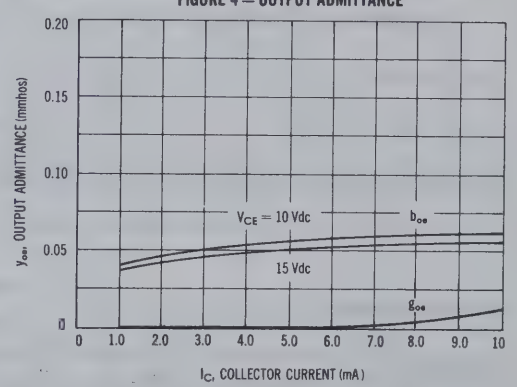


FIGURE 5 — CAPACITANCES

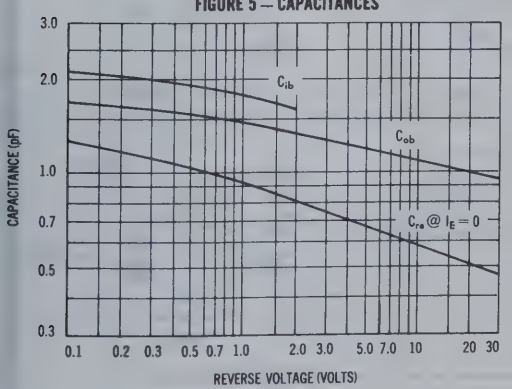
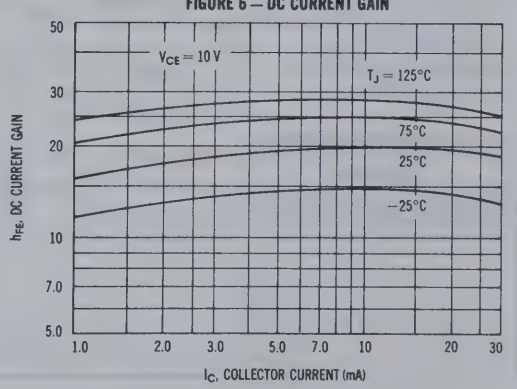


FIGURE 6 — DC CURRENT GAIN



MPS-H54 (SILICON)
MPS-H55

PNP SILICON ANNULAR TRANSISTORS

. . . MPS-H54 is designed for RF amplifier applications in AM receivers.
. . . MPS-H55 is designed for mixer, oscillator, autodyne converter, and IF amplifier applications in AM receivers.

- High Breakdown Voltage — BV_{CEO} = 80 Vdc (Min)
- Low Collector-Base Capacitance — C_{cb} = 1.0 pF (Typ)
- Low Output Admittance — h_{oe} = 10 μmhos (Max)
- Low Noise Figure — NF = 2.0 dB (Max) — MPS-H54
- Complement to NPN MPS-H04, MPS-H05

PNP SILICON TRANSISTORS

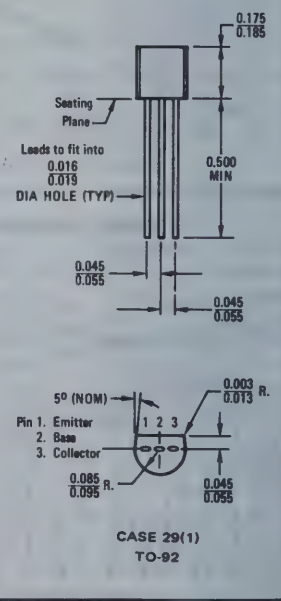


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.73	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	θ_{JA}	0.367	°C/mW

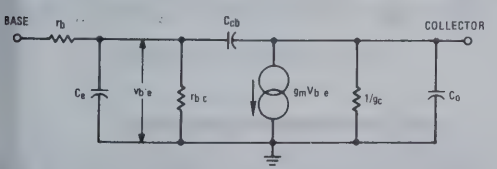


CASE 29(1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	80	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	80	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.5 mAdc, V_{CE} = 10 Vdc) MPS-H54 MPS-H55	h_{FE}	30 30	70 70	120 150	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.16	0.25	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	80	185	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, f = 1.0 MHz)	C_{cb}	-	1.0	1.6	pF
Output Admittance (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	–	6.0	10	μmhos
Noise Figure (I_C = 1.5 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 1.0 MHz) MPS-H54	NF	–	1.5	2.0	dB

FIGURE 1 – SIMPLIFIED AC EQUIVALENT CIRCUIT (Common Emitter)



Note:

Data for MPS-H04 and MPS-H05 is presented in terms of the equivalent circuit shown in Figure 1. Values for its components may be found or calculated as follows:

$r_{b'} \approx 15$ Ohms

$r_e = 26\ mV/I_E$

$C_e = \dfrac{1}{2\pi f_t r_e}$

C_{cb}, See Figure 5

$g_m = 1/r_e$

$g_c = (h_{fe} + 1)\, h_{ob}$ (See Figures 3 and 6)

$C_o = 0.2$ pF

$r_{b'c} = (h_{fe} + 1)\, r_e$

Low frequency h parameters may be found from:

$h_{ie} = r_{b'} + r_{b'c}$

$h_{fe} \approx 1.1\, h_{FE}$ (See Figure 2)

h_{re} = Negligible

$h_{oe} = (h_{fe} + 1)\, h_{ob}$

y Parameters may be determined from the following calculations:

$$y_{11} = \frac{1 + j\omega\,(C_e + C_{cb})\, r_{b'c}}{(r_{b'} + r_{b'c}) + j\omega\,(C_e + C_{cb})\, r_{b'}\, r_{b'c}}$$

$$y_{12} = \frac{j\omega\, C_{cb}}{j\omega\,(C_{cb} + C_e)\, r_{b'} + \dfrac{r_{b'} + r_{b'c}}{r_{b'c}}}$$

$$y_{21} = g_m \left(\frac{1}{\left(1 + \dfrac{r_{b'}}{r_{b'c}}\right) + j\omega\,(C_e + C_{cb})\, r_{b'}} \right) - \frac{j\omega\, C_{cb}}{\left(1 + \dfrac{r_{b'}}{r_{b'c}}\right) + j\omega\,(C_e + C_{cb})\, r_{b'}}$$

$$y_{22} = g_c + j\omega C_o - g_m\, r_{b'}\, y_{12} + \frac{\left(\dfrac{r_{b'} + r_{b'c}}{r_{b'}\, r_{b'c}} + j\omega\, C_e\right)\left(j\omega\, C_{cb}\right)}{\left(\dfrac{r_{b'} + r_{b'c}}{r_{b'}\, r_{b'c}} + j\omega\,(C_e + C_{cb})\right)}$$

ELECTRICAL CHARACTERISTICS (V_{CE} = 10 V, T_A = 25°C unless otherwise noted)

FIGURE 2 – NORMALIZED DC CURRENT GAIN

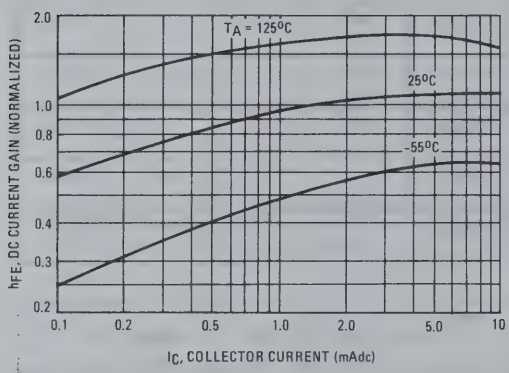


FIGURE 3 – "ON" VOLTAGES

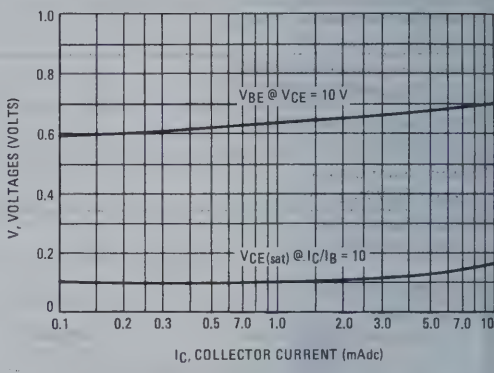


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

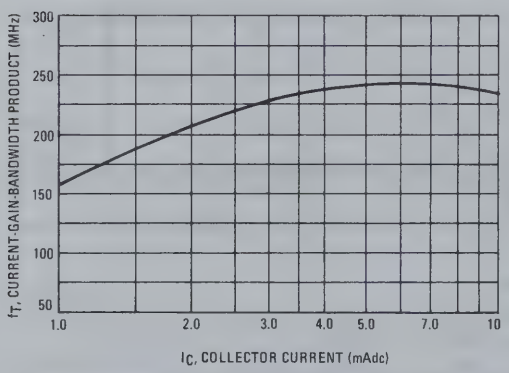


FIGURE 5 – COLLECTOR-BASE CAPACITANCE

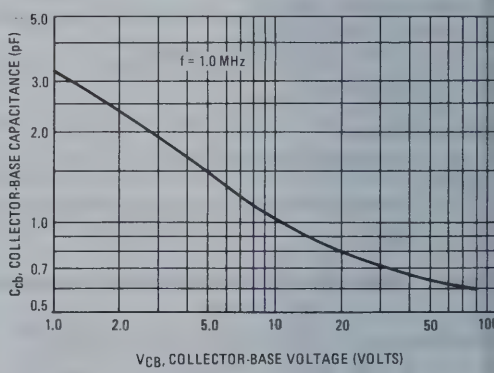


FIGURE 6 – OUTPUT ADMITTANCE

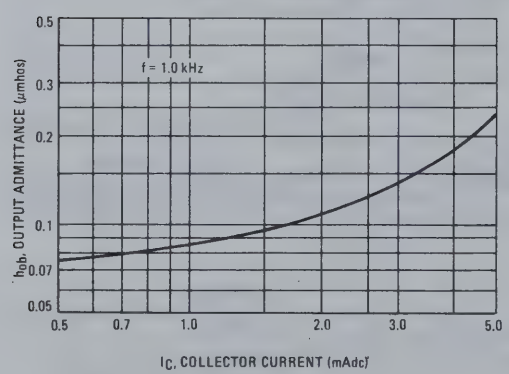
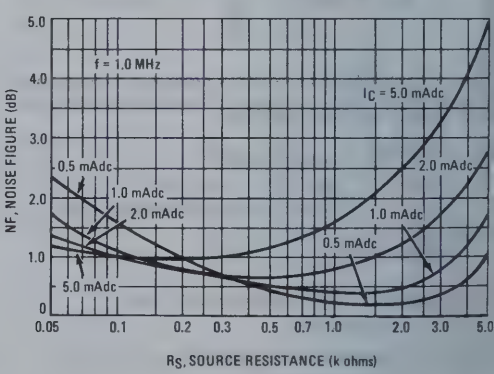


FIGURE 7 – NOISE FIGURE



AM RADIO DESIGN INFORMATION

FIGURE 8 – 1.0 MHz AMPLIFIER TEST CIRCUIT

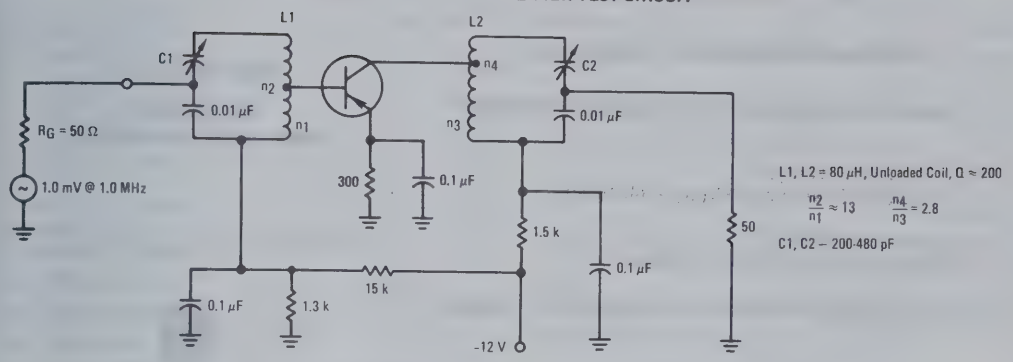


FIGURE 9 – 1.0 MHz MIXER TEST CIRCUIT

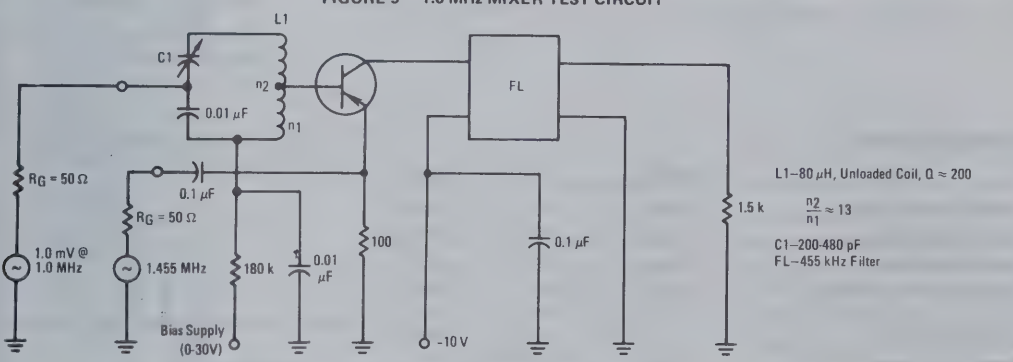


FIGURE 10 – AMPLIFIER POWER GAIN

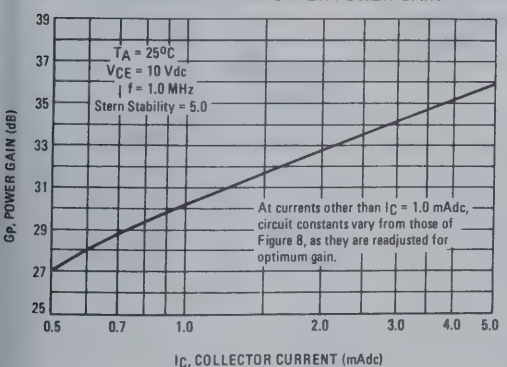
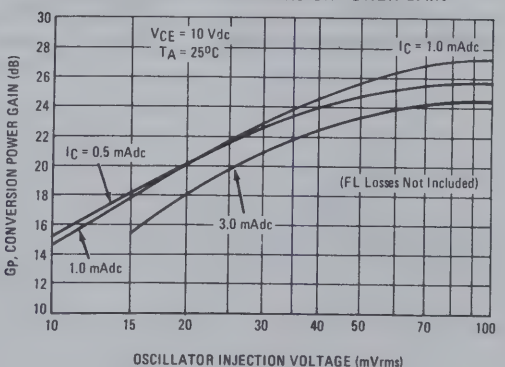


FIGURE 11 – CONVERSION POWER GAIN



MPS-L01 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier applications.

- High Breakdown Voltages —
  BV_{CEO} = 120 Vdc (Min), BV_{CBO} = 140 Vdc (Min)
- Low Saturation Voltage
  $V_{CE(sat)}$ = 0.30 V (max) @ I_C = 50 mA
- One-Piece, Injection-Molded Unibloc Package for High Reliability

HIGH VOLTAGE

NPN SILICON AMPLIFIER TRANSISTOR

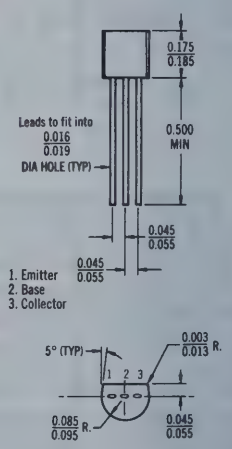


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	120	Vdc
Collector-Base Voltage	V_{CB}	140	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



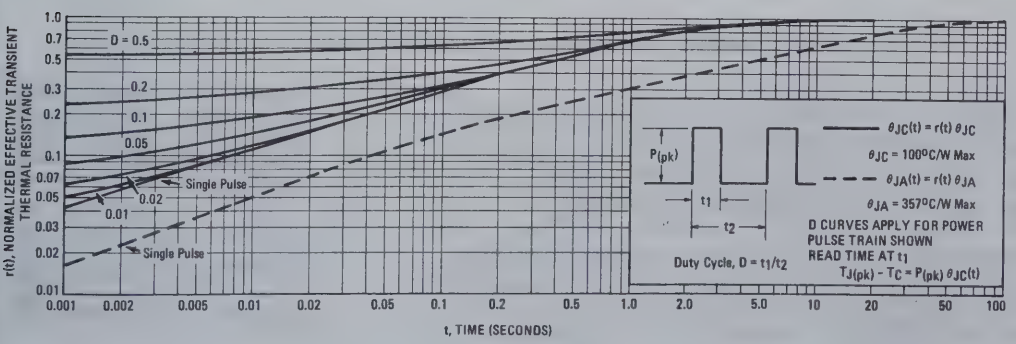
CASE 29 (1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}*	120	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	140	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	I_{CBO}	–	1.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}*	50	300	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	– –	0.20 0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	– –	1.2 1.4	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	60	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	–	–

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – THERMAL RESPONSE



h PARAMETERS
(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 2 – CURRENT GAIN

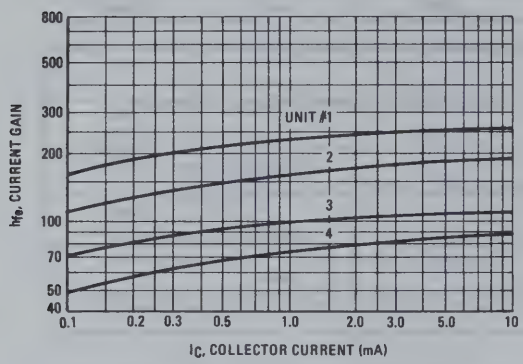


FIGURE 3 – OUTPUT ADMITTANCE

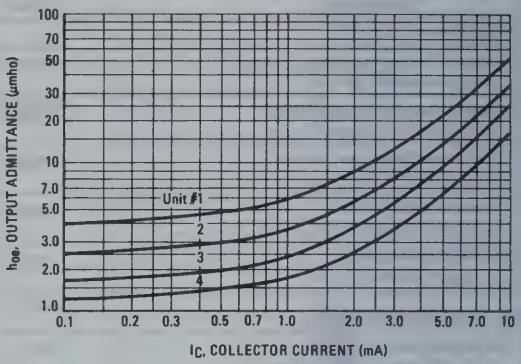


FIGURE 4 – INPUT IMPEDANCE

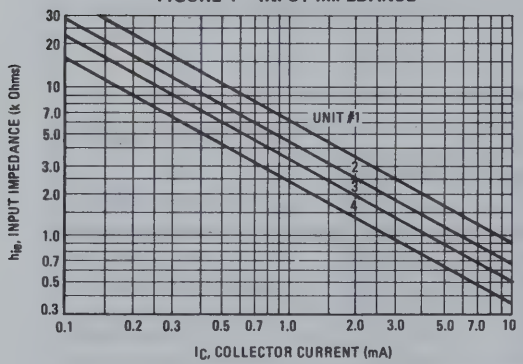


FIGURE 5 – VOLTAGE FEEDBACK RATIO

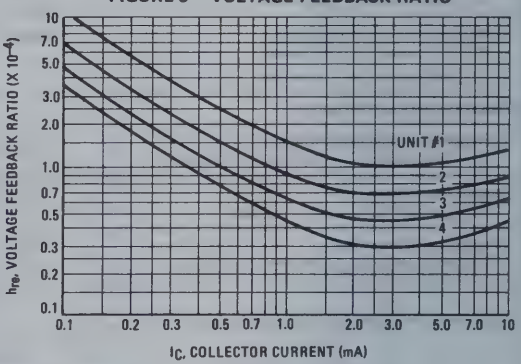
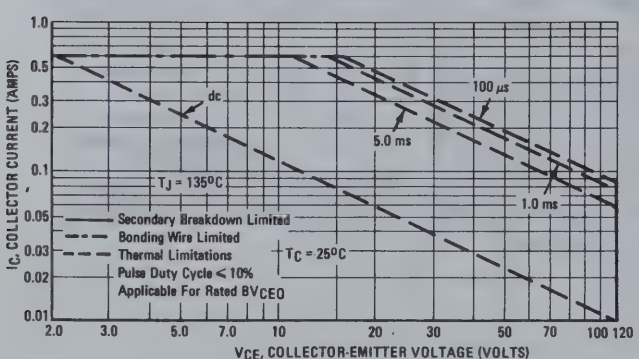


FIGURE 6 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 6 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)}$ < 135°C. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 7 – DC CURRENT GAIN

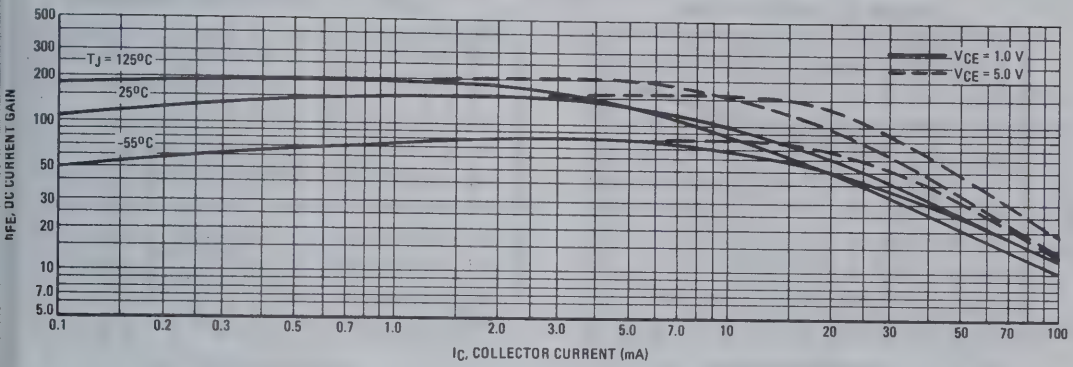


FIGURE 8 – COLLECTOR SATURATION REGION

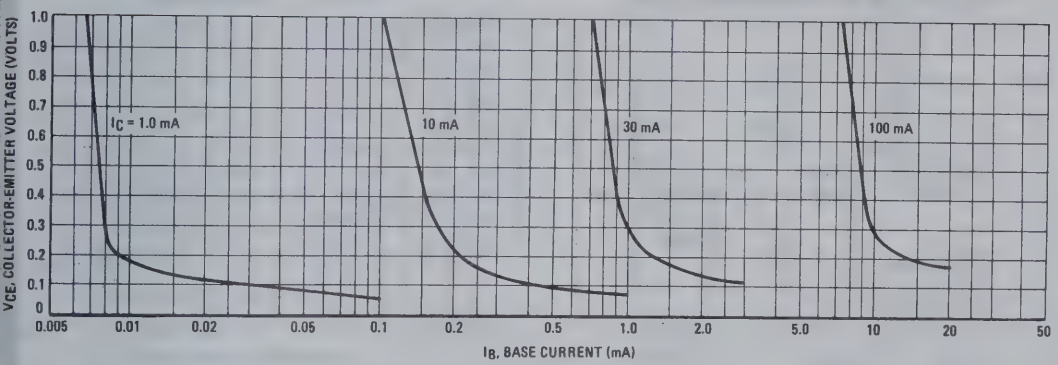


FIGURE 9 – COLLECTOR CUT-OFF REGION

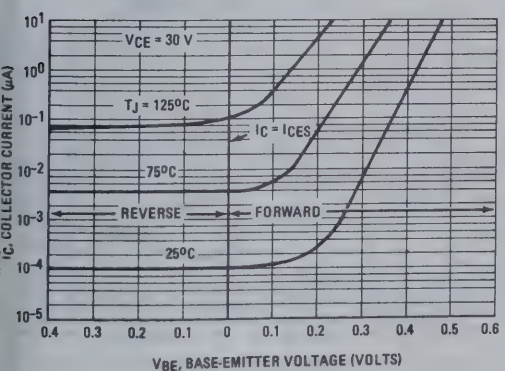


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

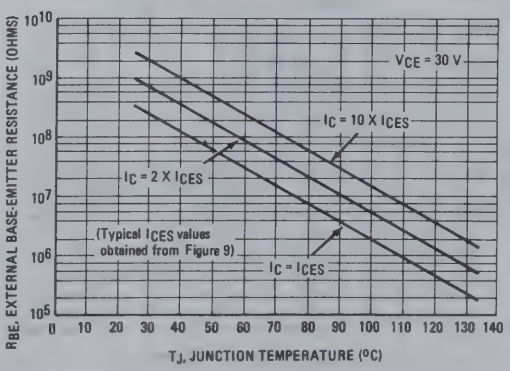


FIGURE 11 – "ON" VOLTAGES

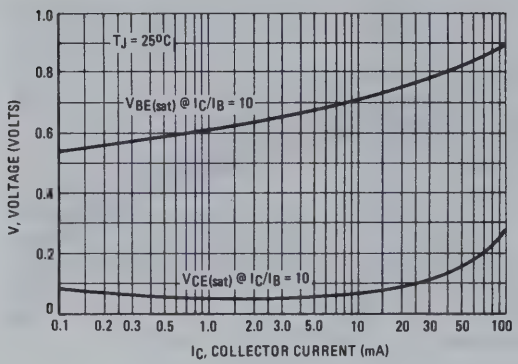


FIGURE 12 – TEMPERATURE COEFFICIENTS

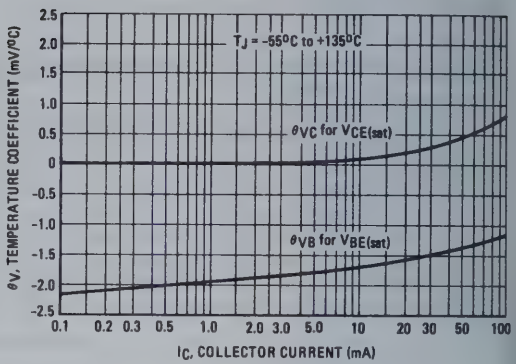


FIGURE 13 – SWITCHING TIME TEST CIRCUIT

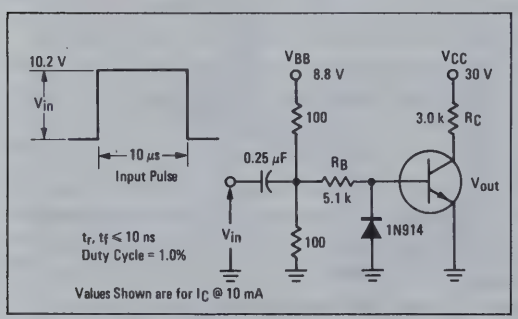


FIGURE 14 – CAPACITANCES

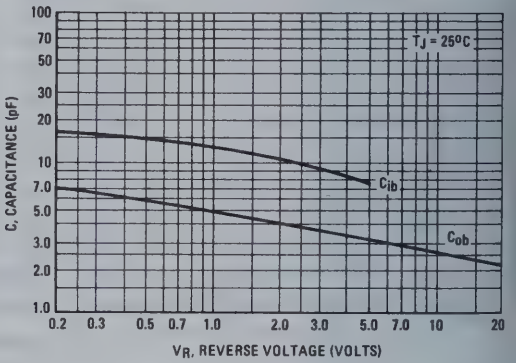


FIGURE 15 – TURN-ON TIME

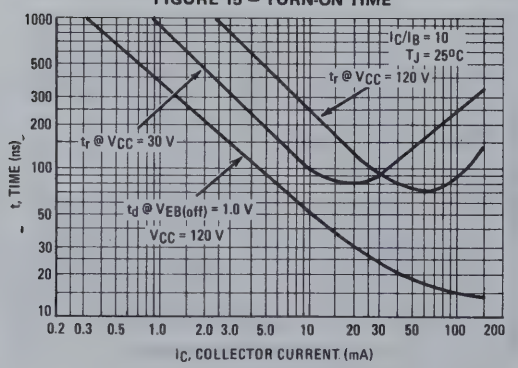
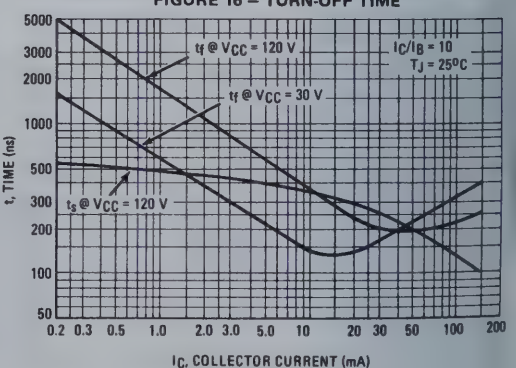


FIGURE 16 – TURN-OFF TIME



MPS-L07 (SILICON)
MPS-L08

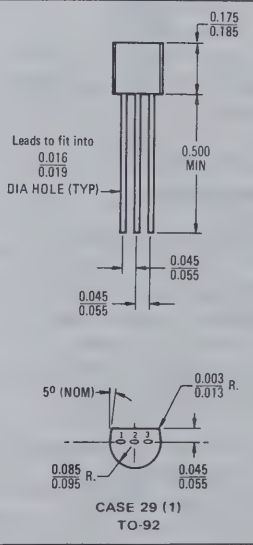
PNP SILICON ANNULAR TRANSISTORS

. . . designed for high-speed saturated switching applications.

- Fast Switching Time –
  $t_{on} + t_{off}$ = 50 ns (Typ) @ I_C = 10 mAdc
- Low Storage Time –
  τ_s = 15 ns (Max) @ I_C = 10 mAdc (MPS-L07)
  = 20 ns (Max) @ I_C = 10 mAdc (MPS-L08)
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.07 Vdc (Typ) @ I_C = 10 mAdc
- High Current-Gain–Bandwidth Product –
  f_T = 500 MHz (Min) @ 10 mA (MPS-L07)
  = 700 MHz (Min) @ 10 mA (MPS-L08)

PNP SILICON SWITCHING TRANSISTORS





CASE 29 (1)
TO-92

MAXIMUM RATINGS

Rating	Symbol	MPS-L07	MPS-L08	Unit
Collector-Emitter Voltage	V_{CEO}	6.0	12	Vdc
Collector-Base Voltage	V_{CB}	6.0	12	Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current – Continuous	I_C	80		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

FIGURE 1 – TURN-ON AND TURN-OFF TEST CIRCUIT

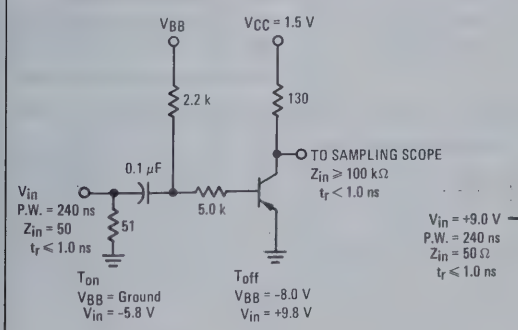
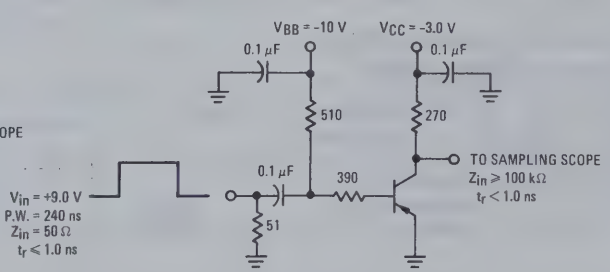


FIGURE 2 – CHARGE STORAGE TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$				Vdc
(I_C = 3.0 mAdc, I_B = 0)	MPS-L07		6.0	–	–	
	MPS-L08		12	–	–	
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 100 μAdc, V_{BE} = 0)	MPS-L07		6.0	–	–	
	MPS-L08		12	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 100 μAdc, I_E = 0)	MPS-L07		6.0	–	–	
	MPS-L08		12	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}	4.5	–	–	Vdc
(I_E = 100 μAdc, I_C = 0)						
Collector Cutoff Current		I_{CES}				nAdc
(V_{CE} = 3.0 Vdc, V_{BE} = 0)	MPS-L07		–	1.0	10	
(V_{CE} = 6.0 Vdc, V_{BE} = 0)	MPS-L08		–	1.0	10	
(V_{CE} = 3.0 Vdc, V_{BE} = 0, T_A = 65°C)	MPS-L07		–	–	5.0	μAdc
(V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = 65°C)	MPS-L08		–	–	5.0	
Base Current		I_B				nAdc
(V_{CE} = 3.0 Vdc, V_{BE} = 0)	MPS-L07		–	–	10	
(V_{CE} = 6.0 Vdc, V_{BE} = 0)	MPS-L08		–	–	10	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)			15	40	–	
(I_C = 10 mAdc, V_{CE} = 3.0 Vdc)			30	50	120	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)			30	35	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.07	0.15	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	0.2	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			0.73	0.79	0.88	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	0.89	1.5	
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	MPS-L07		500	1000	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	MPS-L08		700	1200	–	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	–	1.9	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	–	3.6	5.0	pF
SWITCHING CHARACTERISTICS						
Turn-On Time (I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) (Figure 1)		t_{on}	–	15	20	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) (Figure 1)		t_{off}	–	35	40	ns
[1]Charge Storage Time (Figure 2)		t_s				ns
(I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	MPS-L07		–	–	15	
	MPS-L08		–	–	20	

MPS-L51 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose, high-voltage amplifier applications.

- High Breakdown Voltages –
  BV_{CEO} = 100 Vdc (Min), BV_{CBO} = 100 Vdc (Min)
- Low Saturation Voltage
  $V_{CE(sat)}$ = 0.30 V (max) @ I_C = 50 mA
- One-Piece, Injection-Molded Unibloc Package for High Reliability

HIGH VOLTAGE

PNP SILICON AMPLIFIER TRANSISTOR

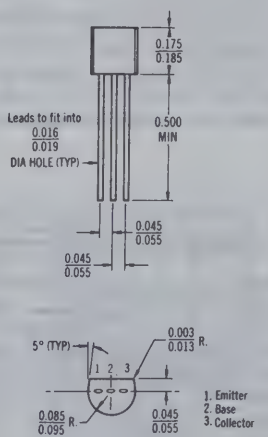


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	100	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current - Continuous	I_C	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW



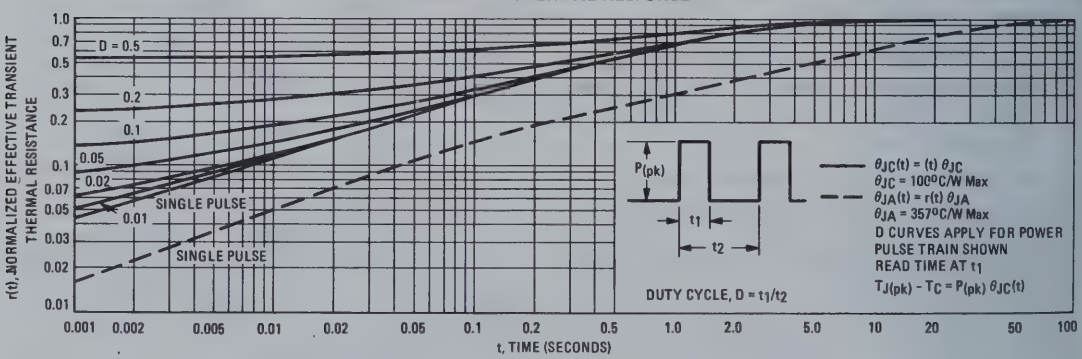
CASE 29 (1)
TO-92

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}*	100	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	100	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	1.0	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}*	40	250	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	–	0.25 0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	1.2 1.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	60	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	–	–

*Pulse Test: Pulse Test = 300 μs. Duty Cycle = 2.0%

FIGURE 1 – THERMAL RESPONSE



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 2 – CURRENT GAIN

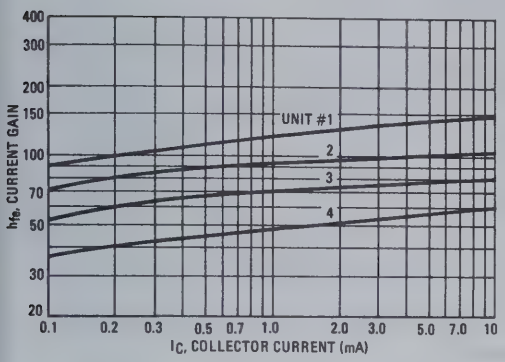


FIGURE 3 – OUTPUT ADMITTANCE

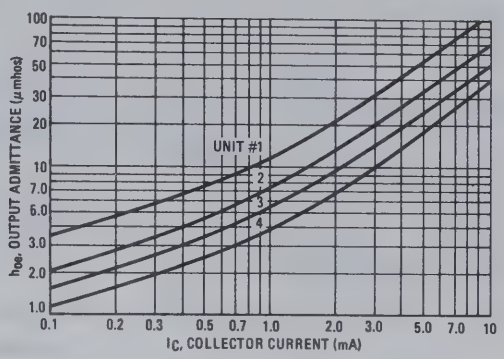


FIGURE 4 – INPUT IMPEDANCE

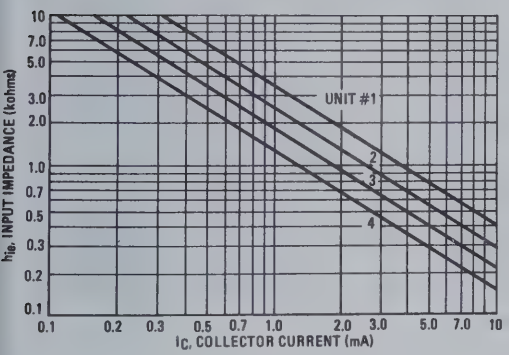


FIGURE 5 – VOLTAGE FEEDBACK RATIO

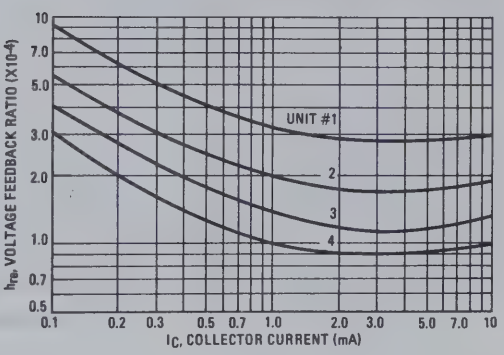
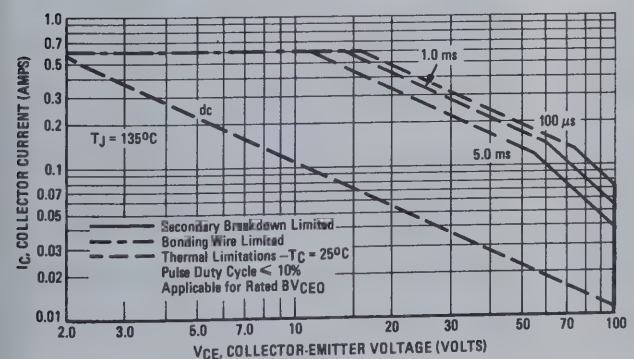


FIGURE 6 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 6 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 135°C$. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 7 – DC CURRENT GAIN

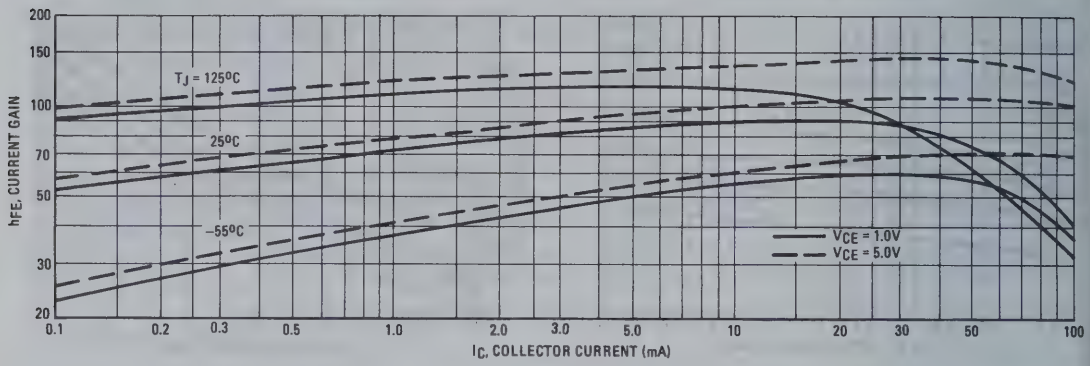


FIGURE 8 – COLLECTOR SATURATION REGION

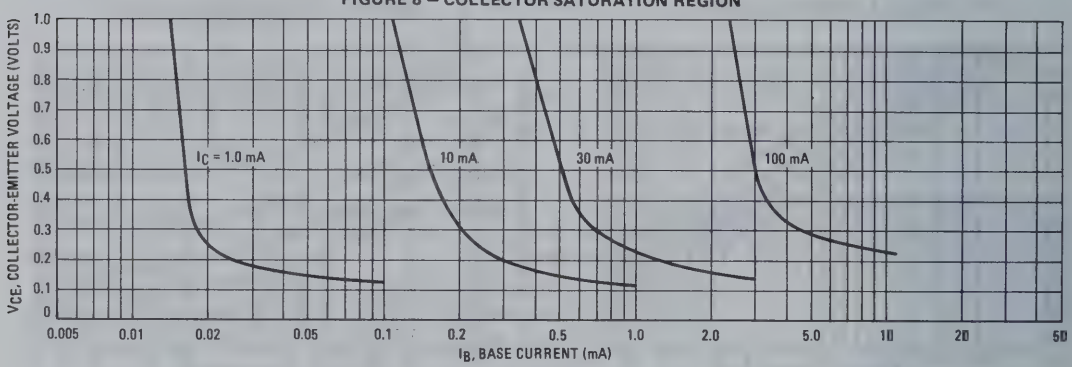


FIGURE 9 – COLLECTOR CUT-OFF REGION

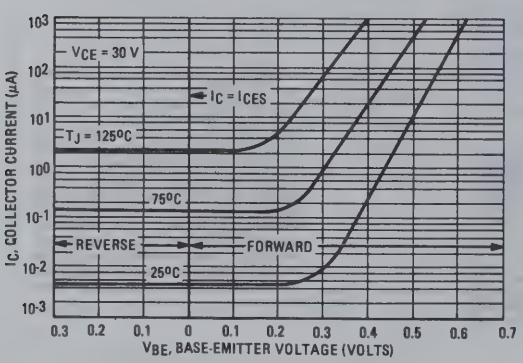


FIGURE 10 – EFFECTS OF BASE-EMITTER RESISTANCE

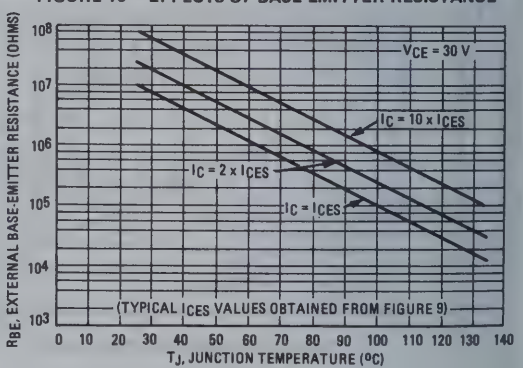


FIGURE 11 – "ON" VOLTAGES

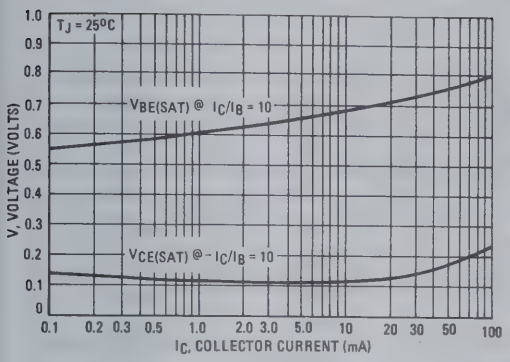


FIGURE 12 – TEMPERATURE COEFFICIENTS

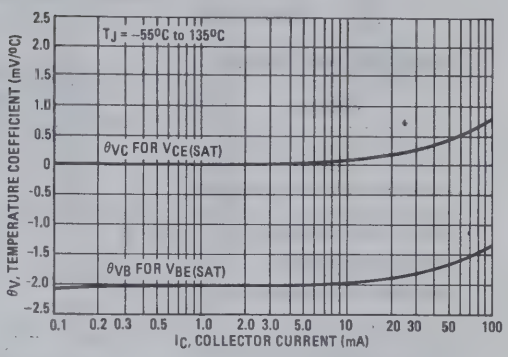


FIGURE 13 – SWITCHING TIME TEST CIRCUIT

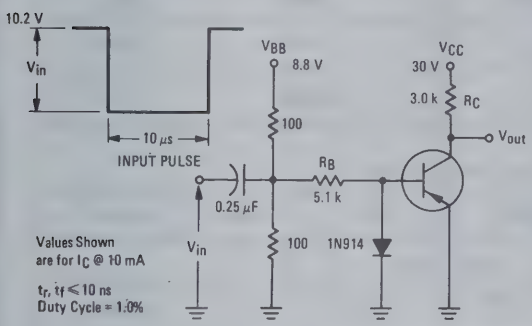


FIGURE 14 – CAPACITANCES

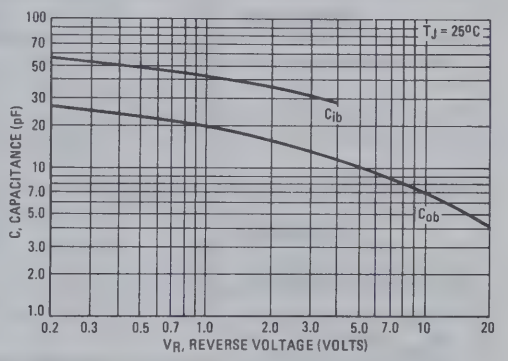


FIGURE 15 – TURN-ON TIME

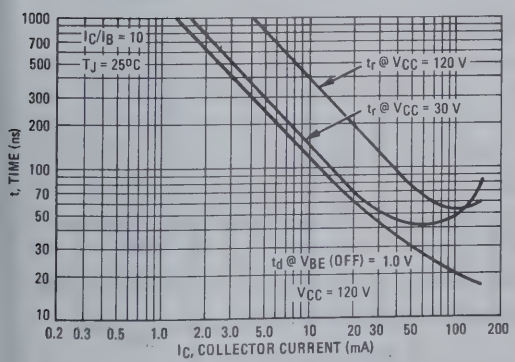
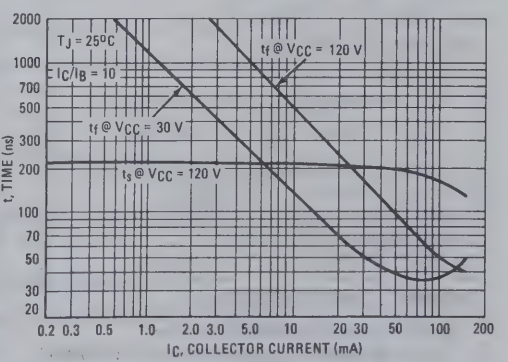


FIGURE 16 – TURN-OFF TIME



MPS-U01 (SILICON)



CASE 152

NPN silicon annular transistors designed for audio circuits. Complement to PNP MPS-U51.

Collector connected to tab

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector Current-Continuous	I_C	1.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 9.10	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.0 72.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	13.7	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	0.110	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}††	-	1.0	mAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)††	h_{FE}	70 50	- -	-
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter On Voltage†† (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$††	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	30	pF

†† Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

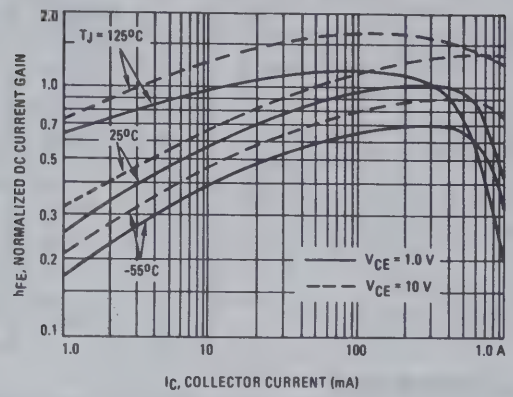


FIGURE 2 – COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT

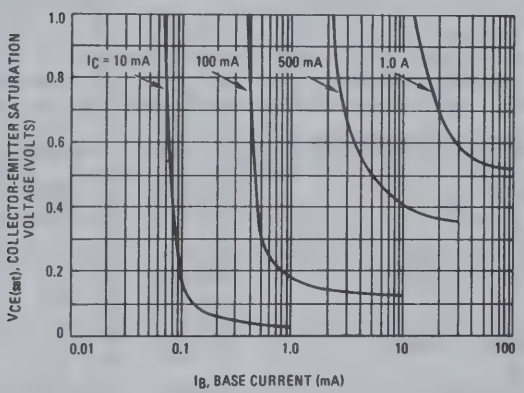


FIGURE 3 – TRANSCONDUCTANCE

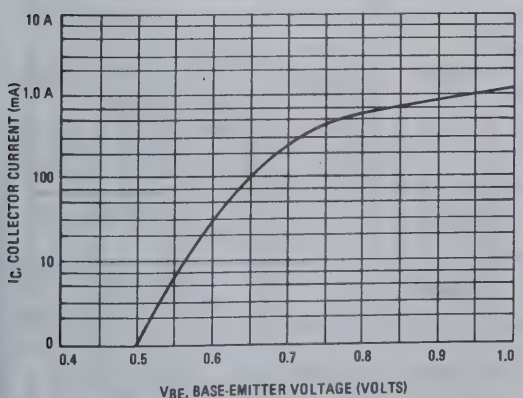
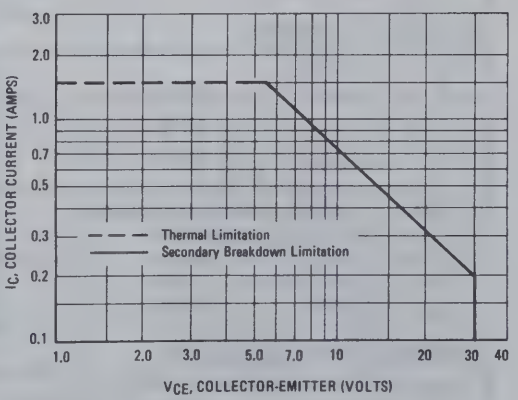


FIGURE 4 – DC SAFE OPERATING AREA



MPS-U02 (SILICON)

NPN silicon annular amplifier transistors designed for general-purpose amplifier and driver applications. Complement to PNP MPS-U52.



Collector connected to tab

CASE 152

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 9.1	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	6.0 54.5	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	18.3	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	0.110	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	h_{FE}	 50 50 30	 - 300 -	-
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	150	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	8.0	pF

FIGURE 1 – NORMALIZED DC CURRENT GAIN

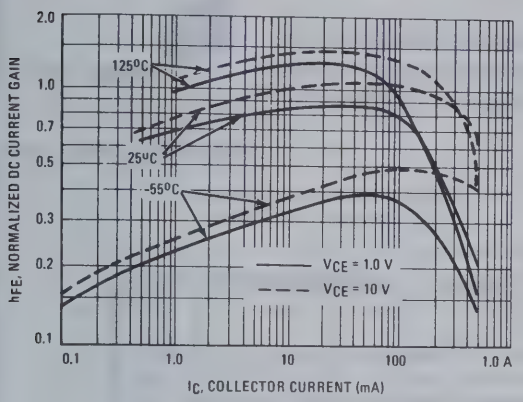


FIGURE 2 – COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT

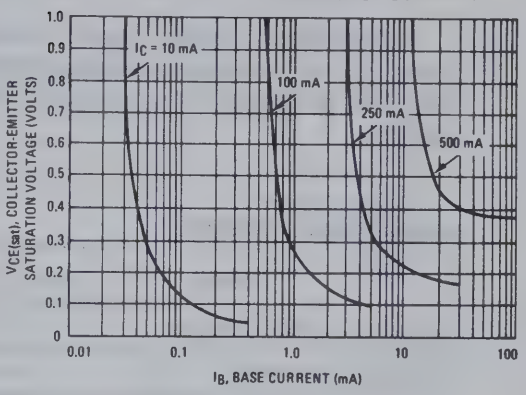


FIGURE 3 – BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

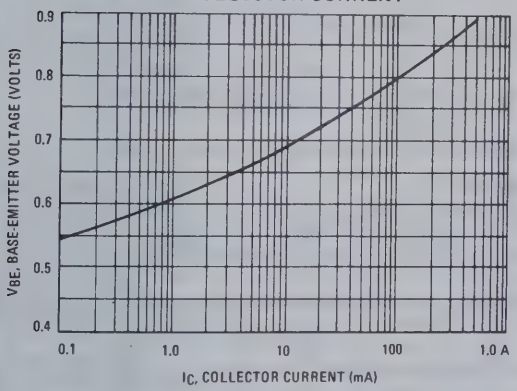


FIGURE 4 – CAPACITANCE versus VOLTAGE

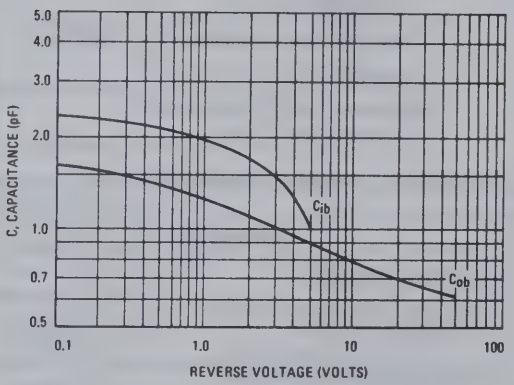


FIGURE 5 – CURRENT-GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

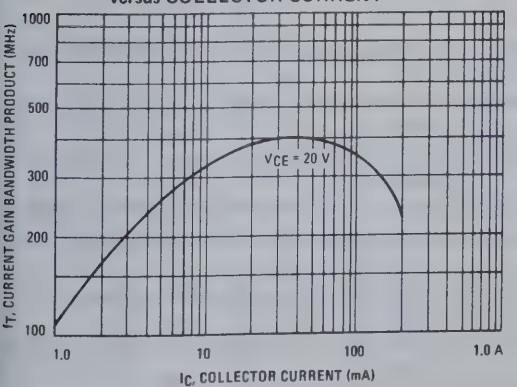
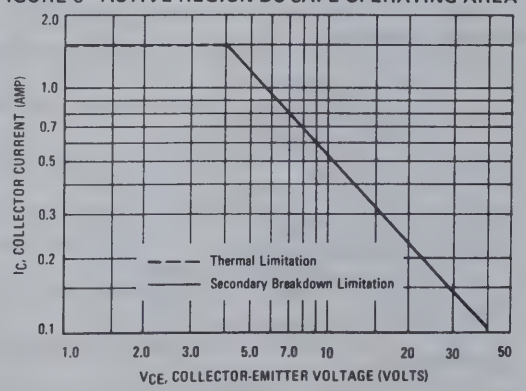


FIGURE 6– ACTIVE REGION DC SAFE OPERATING AREA



MPS-U03 (SILICON)
MPS-U04

NPN silicon annular plastic transistors designed for video output circuits utilizing an emitter-follower driver and for horizontal driver applications in television receivers.



CASE 152

Collector connected to tab

MAXIMUM RATINGS

Rating	Symbol	MPS-U03	MPS-U04	Unit
Collector-Emitter Voltage	V_{CEO}	120	180	Vdc
Collector-Base Voltage	V_{CB}	120	180	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C	P_D	1.0		Watt
Derate above 25°C		9.09		mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	8.0		Watts
Derate above 25°C		72.8		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPSU03	BV_{CEO}	120	-	Vdc
	MPSU04		180	-	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPSU03	BV_{CBO}	120	-	Vdc
	MPSU04		180	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)	MPSU03	I_{CBO}	-	0.1	μAdc
(V_{CB} = 150 Vdc, I_E = 0)	MPSU04		-	0.1	
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)		h_{FE}	40	-	-
Collector-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc)		$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter On Voltage (I_C = 200 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	100	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	110	pF

MPS-U05 (SILICON)
MPS-U06

NPN SILICON ANNULAR
AMPLIFIER TRANSISTORS

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 60 Vdc (Min) @ I_C = 1.0 mAdc – MPS-U05
  80 Vdc (Min) @ I_C = 1.0 mAdc – MPS-U06
- High Power Dissipation – P_D = 5.0 W @ T_C = 25°C
- Complements to MPS-U55 and MPS-U56

NPN SILICON
AMPLIFIER TRANSISTORS

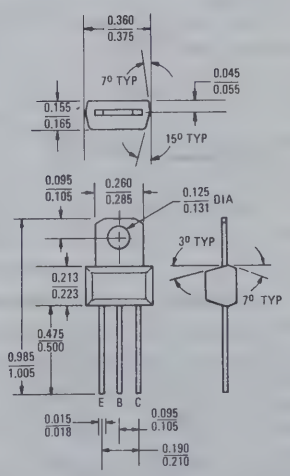


MAXIMUM RATINGS

Rating	Symbol	MPS-U05	MPS-U06	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 9.10		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 45.4		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	22	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	110	°C/W



Collector connected to tab

CASE 152

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPS-U05	BV_{CEO}	60	–	–	Vdc
	MPS-U06		80	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				nAdc
(V_{CB} = 40 Vdc, I_E = 0)	MPS-U05		–	–	100	
(V_{CB} = 60 Vdc, I_E = 0)	MPS-U06		–	–	100	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)			100	180	–	
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)			–	125	–	
(I_C = 250 mAdc, V_{CE} = 5.0 Vdc)			50	170	–	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)			–	100	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 250 mAdc, I_B = 10 mAdc)			–	0.25	0.6	
(I_C = 250 mAdc, I_B = 25 mAdc)			–	0.1	–	
Base-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 25 mAdc)		$V_{BE(sat)}$	–	0.83	–	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	0.75	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 250 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	50	150	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	6.0	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	14	–	pF

FIGURE 1 — TYPICAL DC CURRENT GAIN

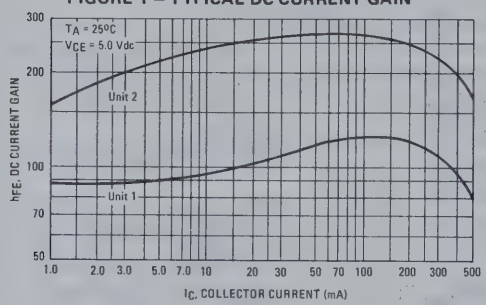


FIGURE 2 — "SATURATION" AND "ON" VOLTAGES

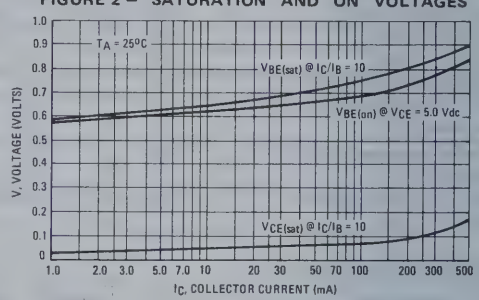
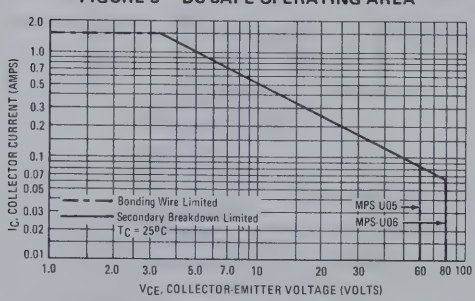


FIGURE 3 — DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

MPS-U10 (SILICON)

NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-voltage video output stages in TV receivers.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 300 Vdc (Min) @ I_C = 1.0 mAdc
- Low Collector-Base Capacitance –
  C_{cb} = 3.0 pF (Max) @ V_{CB} = 20 Vdc

HIGH VOLTAGE NPN SILICON AMPLIFIER TRANSISTOR

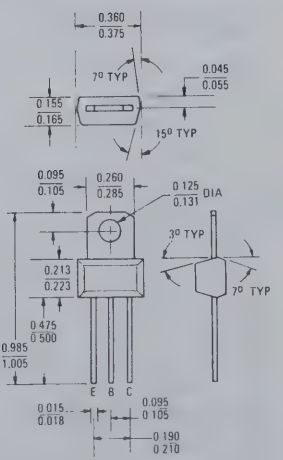


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CB}	300	Vdc
Emitter-Base Voltage	V_{EB}	8.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 9.10	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	22	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	110	°C/W



Collector Connected to Tab

CASE 152

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	300	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	300	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	8.0	–	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	–	0.2	μAdc
Emitter Cutoff Current (V_{BE} = 6.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 15 Vdc)		25	–	
(I_C = 10 mAdc, V_{CE} = 15 Vdc)		40	–	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		40	–	
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	–	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	–	0.8	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	60	–	MHz
Collector Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	3.0	pF

MPS-U51 (SILICON)

PNP silicon annular transistors designed for audio circuits. Complement to NPN MPS-U01.



CASE 152

Collector connected to tab

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector Current-Continuous	I_C	1.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 9.10	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.0 72.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	13.7	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	0.110	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}††	-	1.0	mAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	-	0.1	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)††	h_{FE}	70 50	- -	-
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter On Voltage†† (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$††	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	30	pF

†† Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

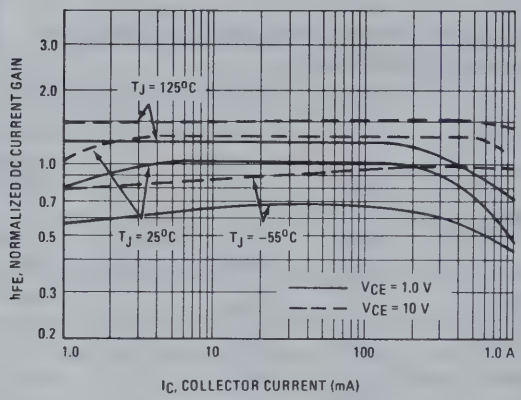


FIGURE 2 – COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT

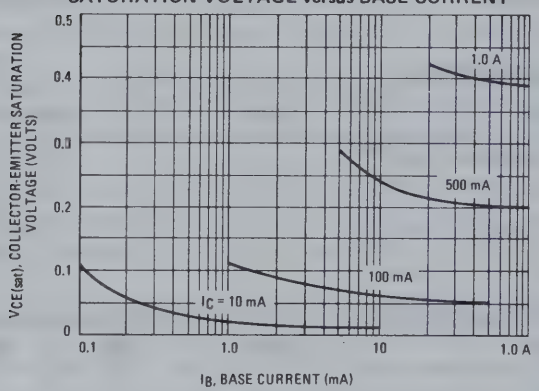


FIGURE 3 – TRANSCONDUCTANCE

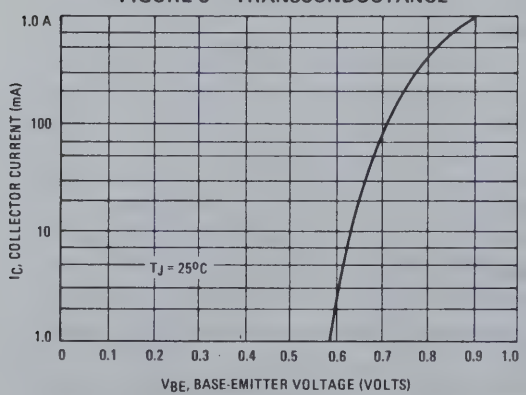
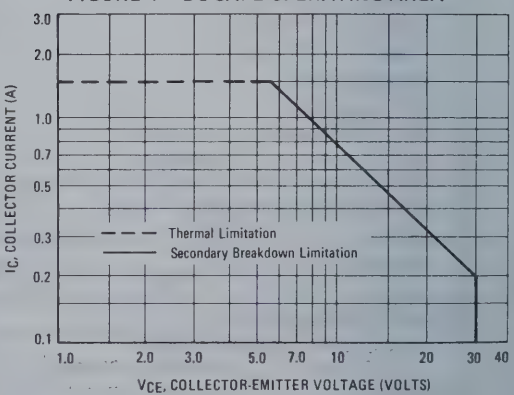


FIGURE 4 – DC SAFE OPERATING AREA



MPS-U52 (SILICON)

PNP silicon annular amplifier transistors designed for general-purpose amplifier and driver applications. Complement to NPN MPS-U02.



CASE 152

Collector connected to tab

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 9.1	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	6.0 54.5	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	18.3	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	0.110	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	-	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (I_C = 500 mAdc, V_{CE} = 10 Vdc)	h_{FE}	50 50 30	- 300 -	-
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	150	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	8.0	pF

FIGURE 1 – NORMALIZED DC CURRENT GAIN

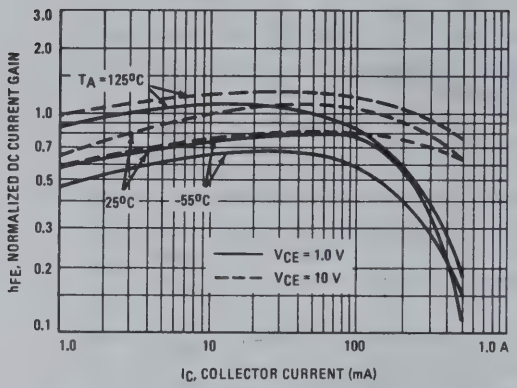


FIGURE 2 – COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT

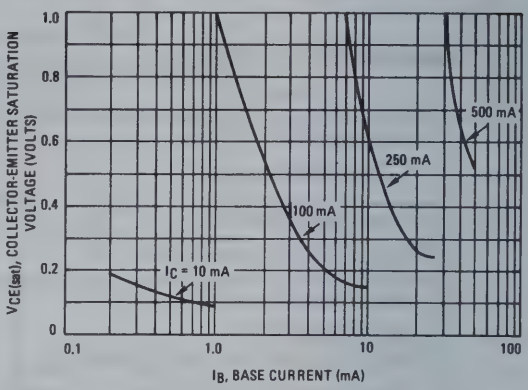


FIGURE 3 – TRANSCONDUCTANCE

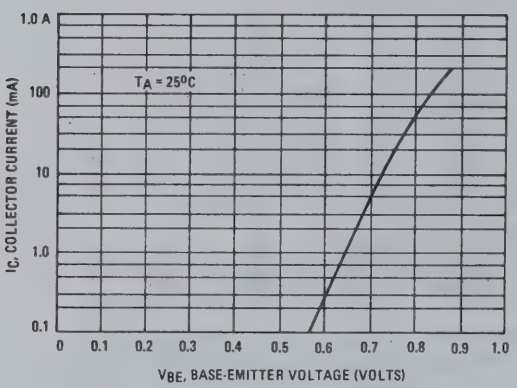


FIGURE 4 – CAPACITANCE versus VOLTAGE

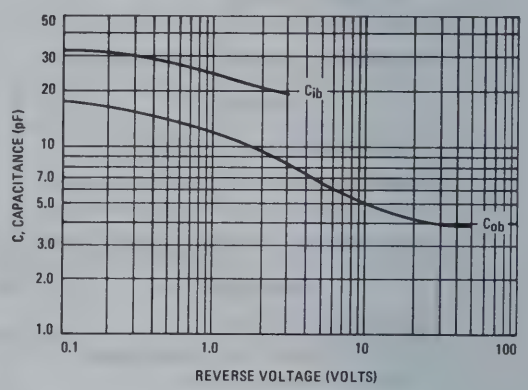


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT versus COLLECTOR CURRENT

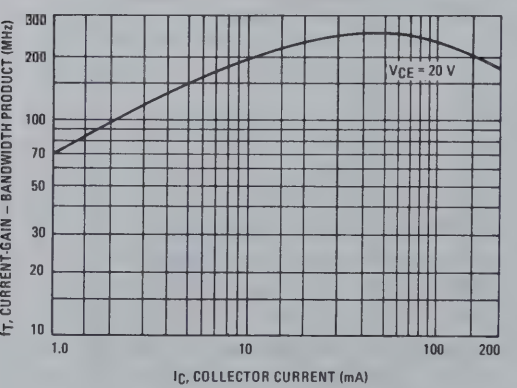
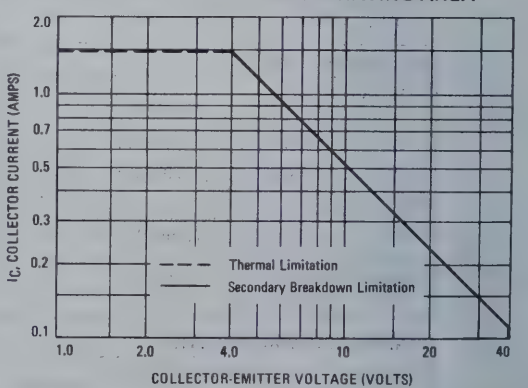


FIGURE 6 – ACTIVE DC SAFE OPERATING AREA



MPS-U55 (SILICON)
MPS-U56

PNP SILICON ANNULAR
AMPLIFIER TRANSISTORS

. . . designed for general-purpose, high-voltage amplifier and driver applications.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 60 Vdc (Min) @ I_C = 1.0 mAdc – MPS-U55
  80 Vdc (Min) @ I_C = 1.0 mAdc – MPS-U56
- High Power Dissipation – P_D = 5.0 W @ T_C = 25°C
- Complements to MPS-U05 and MPS-U06

PNP SILICON ANNULAR
AMPLIFIER TRANSISTORS

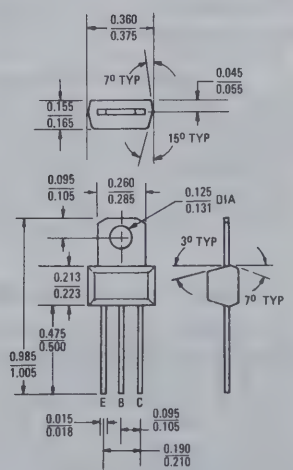


MAXIMUM RATINGS

Rating	Symbol	MPS-U55	MPS-U56	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 9.10		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 45.4		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	22	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	110	°C/W



Collector connected
to tab
CASE 152

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	MPS-U55	BV_{CEO}	60	–	–	Vdc
	MPS-U56		80	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				nAdc
(V_{CB} = 40 Vdc, I_E = 0)	MPS-U55		–	–	100	
(V_{CB} = 60 Vdc, I_E = 0)	MPS-U56		–	–	100	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)			100	180	–	
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)			–	100	–	
(I_C = 250 mAdc, V_{CE} = 5.0 Vdc)			50	140	–	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)			–	90	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 250 mAdc, I_B = 10 mAdc)			–	0.3	0.6	
(I_C = 250 mAdc, I_B = 25 mAdc)			–	0.15	–	
Base-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 25 mAdc)		$V_{BE(sat)}$	–	0.86	–	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	0.78	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 250 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	50	125	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	8.5	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	20	–	pF

FIGURE 1 – TYPICAL DC CURRENT GAIN

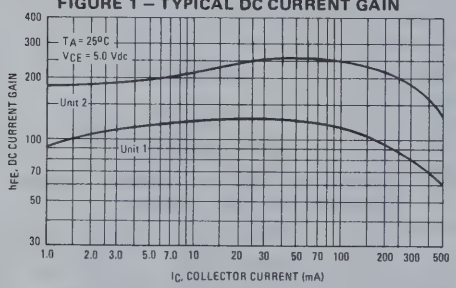


FIGURE 2 – "SATURATION" AND "ON" VOLTAGES

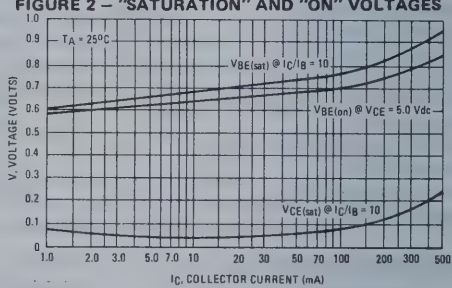
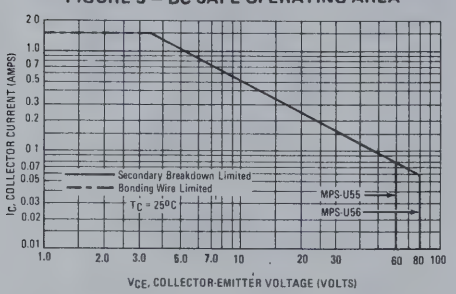


FIGURE 3 – DC SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)}$ = 135°C; T_C is variable depending on conditions. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

MPT20 (SILICON)



CASE 182
(Formerly CASE 29 B)

Plastic silicon 3-layer bilateral triggers are two-terminal devices that exhibit bi-directional negative resistance switching characteristics. These economical, durable devices have been developed for use in thyristor triggering circuits for lamp drivers and universal motor speed controls.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Pulse Current (30 μs duration, 120 Hz repetition rate)	I_{pulse}	2.0	Amp
Power Dissipation @ T_A = -40 to +25°C	P_D	300	mW
Derate above 25°C		4.0	mW/°C
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Plastic Trigger (MPT) devices have bi-directional characteristics and as such the terminal leads are interchangeable. For purposes of symbol clarification, the leads have arbitrarily been designated 1 and 2. A 12 designation indicates that terminal 1 is positive with respect to terminal 2, vice versa for a 21 designation. (See Figure 1)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakover (Switching) Voltage - both directions	$V_{(BR)12}$ & $V_{(BR)21}$	16	20	24	Volt
Breakover (Switching) Current - both directions	$I_{(BR)12}$ & $I_{(BR)21}$	-	35	100	μAmp
Switchback (Delta) Voltage - both directions ($I_{12} = I_{21}$ = 10 mAdc)	ΔV_{12} & ΔV_{21}	5.0	7.0	-	Volt
Peak Blocking Current - both directions Voltage Applied = 14 V	$I_{(BL)12}$ & $I_{(BL)21}$	-	0.5	10	μA

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – VOLT-AMPERE CHARACTERISTICS

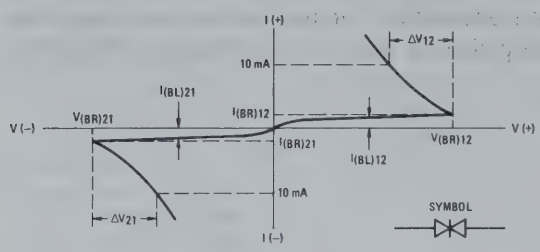


FIGURE 2 – INSTANTANEOUS "ON" VOLTAGE

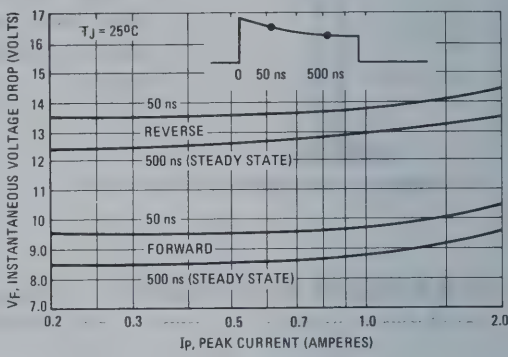


FIGURE 3 – BREAKOVER VOLTAGE BEHAVIOR

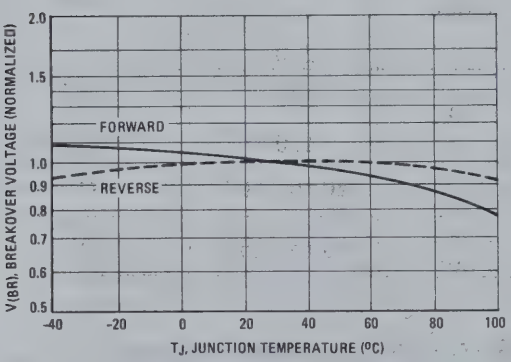


FIGURE 4 – NORMALIZED OUTPUT VOLTAGE BEHAVIOR

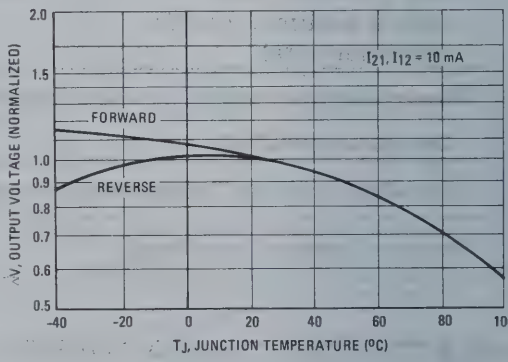


FIGURE 5 – SWITCHING TIMES

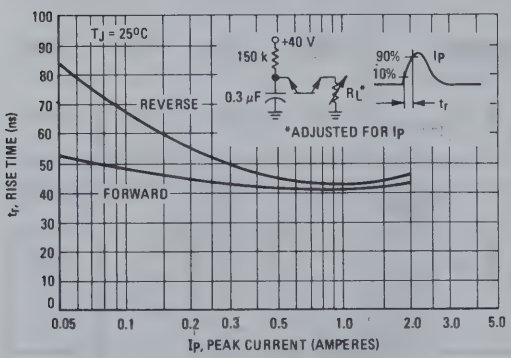
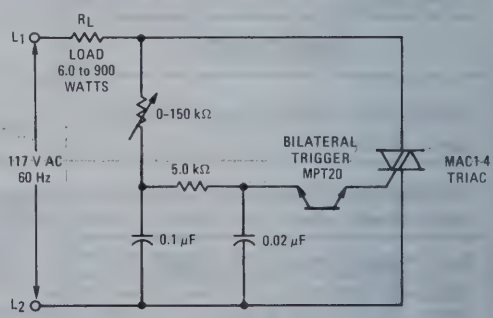


FIGURE 6 – CONTROL CIRCUIT



MPT28 (SILICON)
MPT32



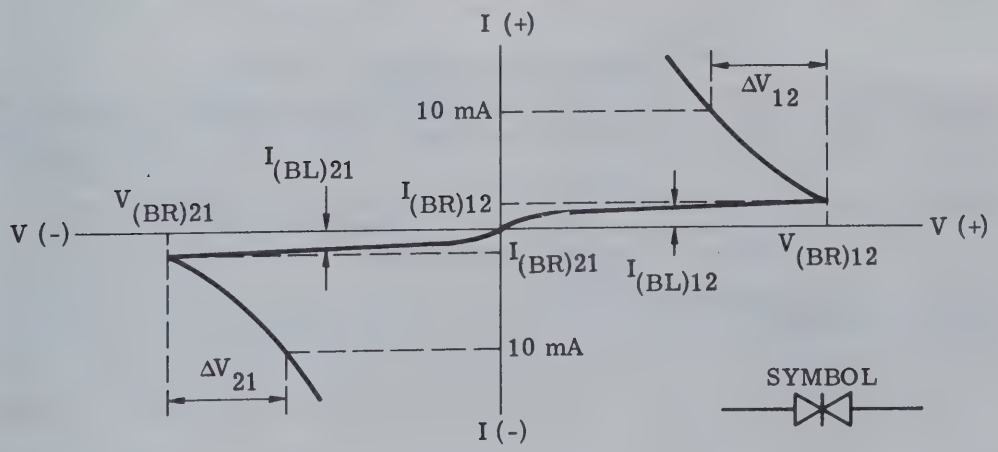
CASE 182
(Formerly CASE 29 B)

Plastic silicon annular 3-layer bilateral triggers, two-terminal devices which exhibit symmetrical negative resistance switching characteristics. These economical, durable devices have been developed for use in thyristor triggering circuits, signal switching and detection circuits.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Pulse Current (30 μs duration, 120 Hz repetition rate)	I_{pulse}	2.0	Amp
Power Dissipation @ T_A = -40 to +25°C	P_D	300	mW
Derate above 25°C		4.0	mW/°C
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

FIGURE 1 — VOLT AMPERE CHARACTERISTICS

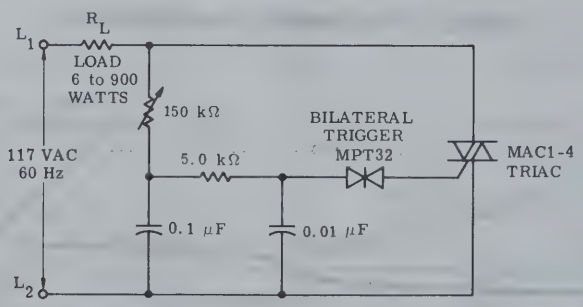


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakover (switching) Voltage – both directions MPT28 MPT32	$V_{(BR)12}$ & $V_{(BR)21}$	 24 28	 28 32	 32 36	Volt
Breakover (switching) Current – both directions	$I_{(BR)12}$ & $I_{(BR)21}$	-	20	50	μAmp
Switchback (delta) Voltage – both directions MPT28 MPT32	ΔV_{12} & ΔV_{21}	 7.0 7.0	 10 10	 - -	Volt
Peak Blocking Current – both directions Voltage Applied = 18 V	$I_{(BL)12}$ & $I_{(BL)21}$	-	0.5	10	μA
Breakover (switching) Voltage Temperature Coefficient, T_A = -40°C to +100°C		-	0.03	-	%/°C

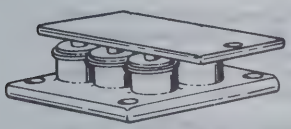
Plastic trigger devices have symmetrical characteristics and as such the terminal leads are interchangeable. For purposes of symbol clarification, the leads have arbitrarily been designated 1 and 2. A 12 designation indicates that terminal 1 is positive with respect to terminal 2, vice versa for a 21 designation.

FIGURE 2 — TYPICAL CONTROL CIRCUIT



MPZ5-16 series (SILICON)
MPZ5-32 series
MPZ5-180 series

Silicon power transient suppressor designed for applications requiring protection of voltage sensitive electronic devices in danger of destruction by high energy voltage transients. Individual cells are matched to insure current-sharing under high current pulse conditions.



CASE 119

MAXIMUM RATINGS

Transient Power Dissipation: 40 kW
Pulse Width: 0.1 ms, (See Figure 1)

DC Power Dissipation: 350 Watts @ T_C = 25°C
(Derate 2.33 W/°C above 25°C)

Operating Junction & Storage Temperature
Range: −65°C to +175°C

Polarity:
Anode-to-Case is Standard
Cathode-to-Case Available Upon Request

ELECTRICAL CHARACTERISTICS (T_A = 25°C) (V_F = 1.5 V max @ 10 A for all types)

Type	Nominal Operating Voltage (Note 1) $V_{OP(PK)}$ Vdc	Nominal Operating Voltage (Note 1) $V_{OP(RMS)}$ V rms	Maximum Device Clamping Factor $CF = \frac{V_Z @ I_{Z(pulse)}}{V_Z @ I_{ZT}}$ (Note 2)	Minimum Zener Voltage $V_{Z(min)}$ Vdc	Minimum Zener Voltage @ I_{ZT} Adc	Maximum Zener Voltage Pulse Width = 1.0 ms $V_{Z(max)}$ Vdc	Maximum Zener Voltage Pulse Width = 1.0 ms @ $I_{Z(pulse)}$ Adc	Maximum Reverse Current $I_{R(max)}$ @ $V_R = V_{OP(PK)}$ μAdc	Typical Capacitance C (typ) @ $V_R = V_{OP(PK)}$ μF
MPZ5-16A	14	10	1.25	16	0.4	24	200	50	0.025
-16B	14	10	1.25	16	0.4	20	200		0.025
-32A	28	20	1.25	32	0.2	50	100		0.011
-32B	28	20	1.25	32	0.2	45	100		0.011
-32C	28	20	1.25	32	0.2	40	100		0.011
-180A	165	117	1.14	180	0.03	250	20		0.0012
-180B	165	117	1.14	180	0.03	225	20		0.0012
-180C	165	117	1.14	180	0.03	205	20	50	0.0012

FIGURE 1 – MAXIMUM NON-REPETITIVE SURGE POWER
(RECTANGULAR WAVEFORM)

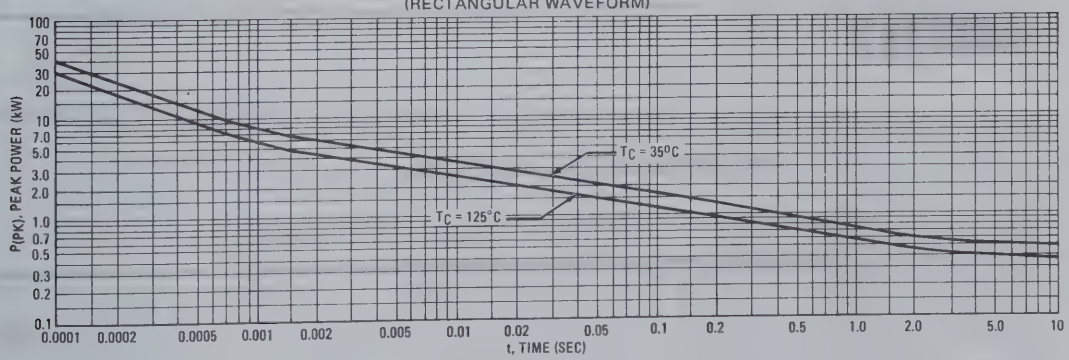
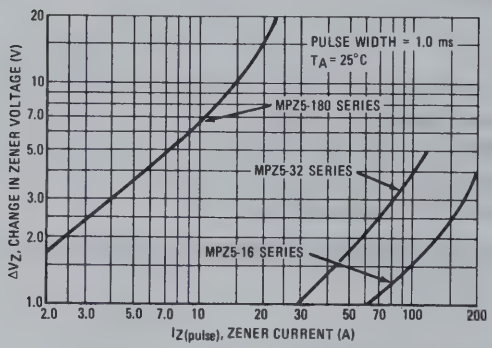


FIGURE 2 – TYPICAL DYNAMIC ZENER VOLTAGE CHARACTERISTICS (Note 2)



NOTE 1: Nominal operating voltage is defined as normal input voltage to device for non-operating condition. If non-sinusoidal wave or dc input is present, peak voltage input values $V_{OP(PK)}$ should be used to select device type.

NOTE 2: The maximum device clamping factor C_F is a ratio of V_Z measured at I_Z (pulse) given in the Electrical Characteristics Table divided by V_Z measured at I_{ZT} under steady state conditions. This value guarantees the sharpness of the voltage breakdown of individual devices. Figure 2 demonstrates the typical sharpness of the breakdown, and indicates the voltage regulation over a wide range of currents.

$$\Delta V_Z = V_Z @ I_{Z(pulse)} - V_Z @ I_{ZT}$$

MQ3467

For Specifications, See MD3467 Data.

MQ3725

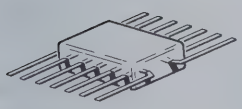
For Specifications, See MD3725 Data.

MQ3762

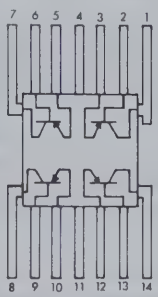
For Specifications, See MD3762 Data.

MQ3799 (SILICON)
MQ3799A

Quad PNP silicon annular transistors specifically designed for differential amplifier applications.



CASE 83
(TO-86)



Lead 1 identified by color dot or by elbow on lead. All leads electrically isolated from package.

MAXIMUM RATINGS (each transistor)

Rating	Symbol	Value		Unit
		One Device	Four Devices	
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	50		mAdc
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
Total Device Dissipation @ T_A = 25°C	P_D	250	500	mW
Derate above 25°C		1.5	2.85	mW/°C

ELECTRICAL CHARACTERISTICS (each transistor) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	60	90	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	-	-	0.01	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		-	-	10	
Emitter Cutoff Current ($V_{BE(off)}$ = 4.0 Vdc, I_C = 0)	I_{EBO}	-	-	20	nAdc

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS					
DC Current Gain*	h_{FE}*				-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)		225	-	-	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		300	-	900	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)		300	-	900	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		300	-	900	
Collector-Emitter Saturation Voltage*	$V_{CE(sat)}$*				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)		-	-	0.2	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		-	-	0.25	
Base-Emitter Saturation Voltage*	$V_{BE(sat)}$*				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)		-	-	0.7	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		-	-	0.8	
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	-	-	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	100	-	500	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	-	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	-	-	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	-	12	-	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	-	2.5	-	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	-	500	-	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	-	12	-	μmhos
Noise Figure	NF				dB
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 100 Hz)		-	2.5	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz)		-	0.8	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, f = 10 kHz)		-	0.8	-	
(I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 k ohms, Noise Bandwidth = 10 Hz to 15.7 kHz)		-	1.5	-	
MATCHING CHARACTERISTICS					
DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) MQ3799A	h_{FEi}/h_{FEj}** ①	0.9	-	1.0	-
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) MQ3799A	$\lvert V_{BEi} - V_{BEj} \rvert$ ①	-	-	3.0	mVdc
Base Voltage Differential Gradient (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +125°C) MQ3799A	$\frac{\Delta(V_{BEi} - V_{BEj})}{\Delta T_A}$ ①	-	-	10	μV/°C

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%

** $h_{FEi} \leq h_{FEj}$

① i = Transistor 1, 2, 3 or 4

① j = Transistor 1, 2, 3 or 4

① j > i

FIGURE 1 — BASE-EMITTER "ON" VOLTAGE versus TEMPERATURE

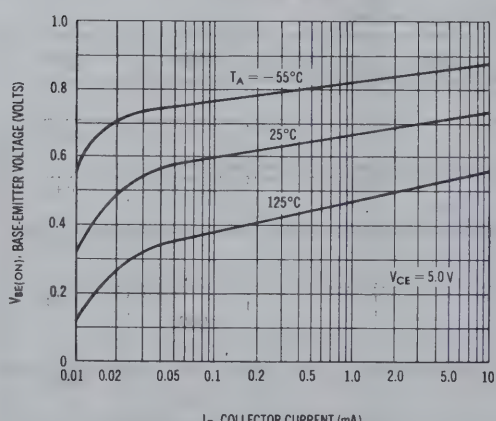


FIGURE 2 — NOISE FIGURE versus FREQUENCY AND SOURCE RESISTANCE

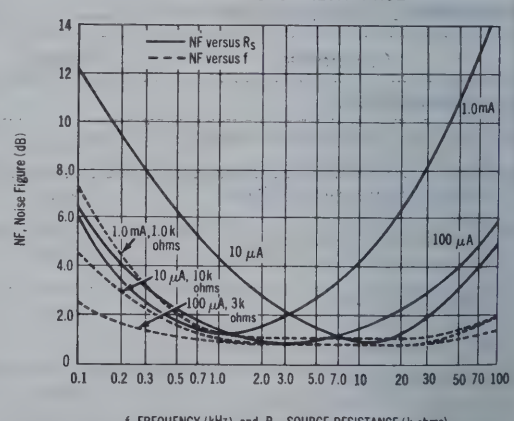
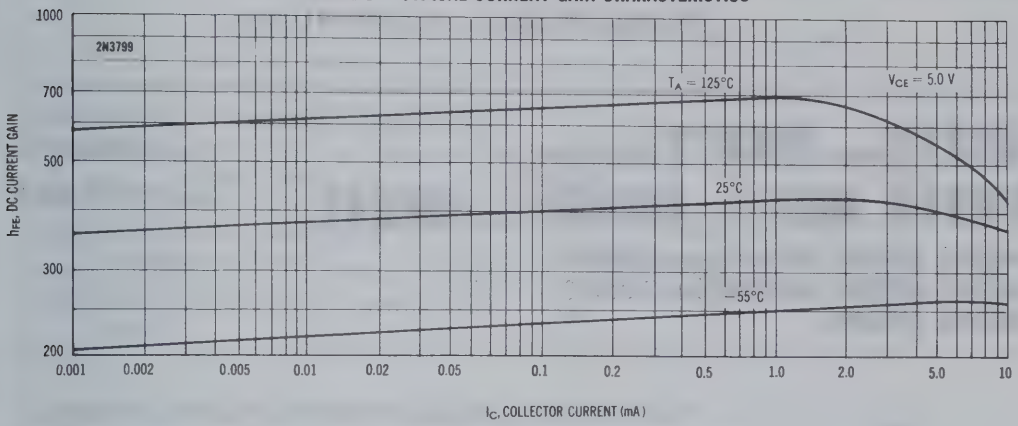


FIGURE 3 — TYPICAL CURRENT GAIN CHARACTERISTICS



SMALL SIGNAL h PARAMETERS

(V_{CE} = 10 Vdc, T_A = 25°C, f = 1.0 kHz)

FIGURE 4 — CURRENT GAIN

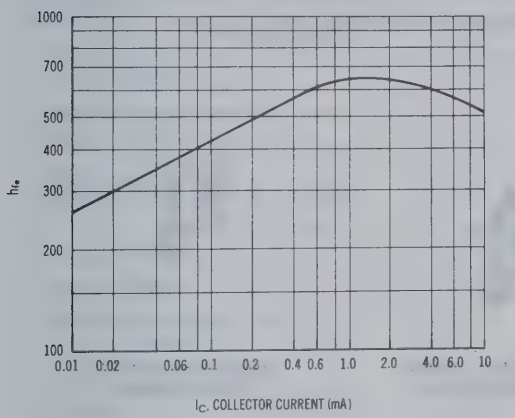


FIGURE 5 — OUTPUT ADMITTANCE

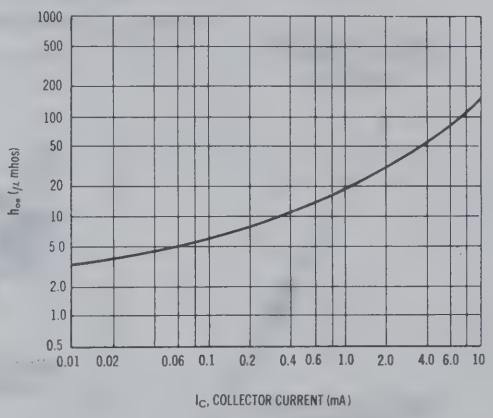


FIGURE 6 — INPUT IMPEDANCE

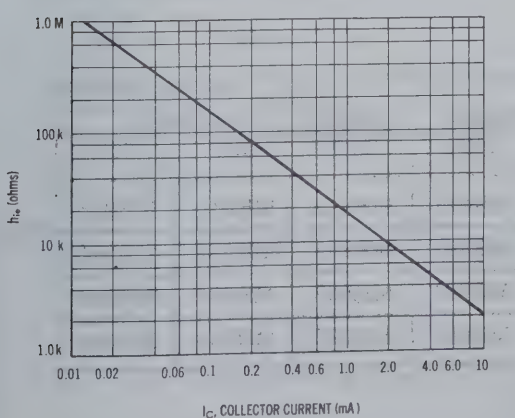
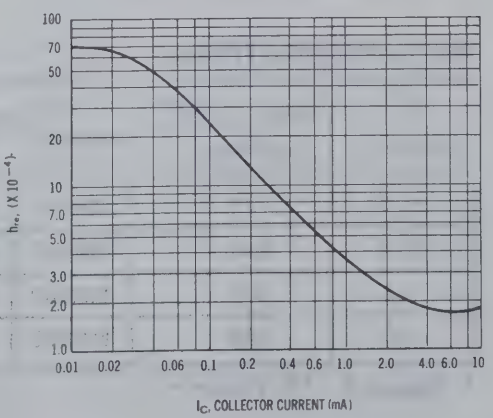


FIGURE 7 — VOLTAGE FEEDBACK RATIO



MR322 thru MR326
MR327, MR328, MR330, MR331

For Specifications, See 1N3491 Data.

MR810 thru MR812 (SILICON)
MR814, MR816, MR840 thru MR842

V_R = 50-600 V
I_O = 0.75-30 A

MR844, MR846, MR880 thru MR882
MR884, MR886, MR890 thru MR892
MR894, MR896

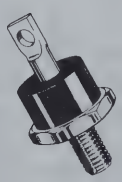


MR840 thru MR842
MR844, MR846
CASE 60

Fast recovery silicon rectifiers designed for special applications such as high frequency rectification, inverters, free-wheeling diodes, and other fast switching circuits. A complete line of rectifiers having typical recovery time of 0.5 microseconds providing high efficiency at frequencies of 50 kHz and higher.



MR810 thru MR812
MR814, MR816
CASE 59
(DO-41)



MR890 thru MR892
MR894, MR896
CASE 42
(DO-5)



MR880 thru MR882
MR884, MR886
CASE 56A
(DO-4)

MAXIMUM RATINGS

I_o * Ampere	$I_{FM(surge)}$ ** Ampere	$V_{RM(rep)}$, $V_{RM(wkg)}$, V_R (volts)				
		50	100	200	400	600
0.75	30	MR810	MR811	MR812	MR814	MR816
3.0	100	MR840	MR841	MR842	MR844	MR846
12	200	MR880	MR881	MR882	MR884	MR886
30	350	MR890	MR891	MR892	MR894	MR896

* Figure 3 ** Figure 4

THERMAL CHARACTERISTICS

Characteristic	Symbol	Value	Unit
Maximum Junction Operating Temperature Range	T_J	-65 to +150	°C
Maximum Case Storage Temperature Range	T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
MR810 - MR816			
DC Forward Voltage Drop (I_F = 1.0 Adc, T_A = 25°C)	V_F	1.4	Vdc
DC Reverse Current (Rated V_R) T_A = 25°C	I_R	0.01	mA
T_A = 100°C		0.2	
MR840 - MR846			
DC Forward Voltage Drop (I_F = 3.0 Adc, T_A = 25°C	V_F	1.4	Vdc
DC Reverse Current (Rated V_R) T_A = 25°C	I_R	0.075	mA
T_A = 100°C		3.5	
MR880 - MR886			
DC Forward Voltage Drop (I_F = 12 Adc, T_C = 25°C)	V_F	1.4	Vdc
DC Reverse Current (Rated V_R) T_C = 25°C	I_R	0.5	mA
T_C = 100°C		4.0	
MR890 - MR896			
DC Forward Voltage Drop (I_F = 30 Adc, T_C = 25°C)	V_F	1.4	Vdc
DC Reverse Current (Rated V_R) T_C = 25°C	I_R	1.2	mA
T_C = 100°C		15	

REVERSE RECOVERY TIME CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Maximum Reverse Recovery Time (I_F = 1 Amp min, Figure 2 test circuit) All Types	t_{rr}	1.0	μs
Maximum Overshoot Current (Figure 2)	I_{os}		
MR810, 840, 880 Series		2.0	Amp
MR890 Series		3.0	

FIGURE 1 — TYPICAL RECOVERY PATTERN

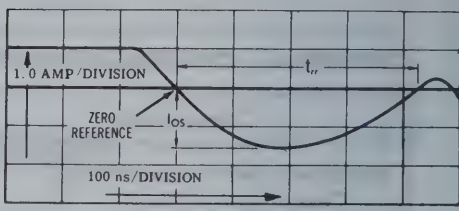
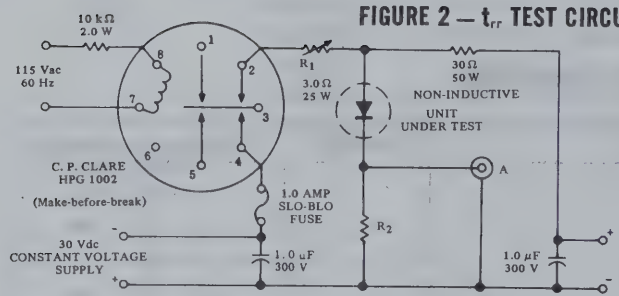


FIGURE 2 — t_{rr} TEST CIRCUIT



A — TEKTRONIX 545A, K PLUG-IN PRE-AMP, P6000 PROBE OR EQUIVALENT

R_1 — ADJUST TO APPROXIMATELY 1.4 Ω TO GIVE A MAX I_{os} WHICH IS NOT GREATER THAN THE MAX SPECIFIED VALUE. t_{rr} IS THEN MEASURED.

R_2 — TEN 1.0 W, 10 Ω, 1% CARBON COMPOUND RESISTORS IN PARALLEL

$T_A = 25\,^{+10}_{-0}$ °C FOR RECTIFIER

MINIMIZE ALL LEAD LENGTHS

1.0 Adc FROM CONSTANT VOLTAGE SUPPLY
RIPPLE = 3.0 mV RMS MAX
Z_{out} = 1/2 Ω Max dc to 2.0 kHz.

FIGURE 3 — MAXIMUM CURRENT RATING

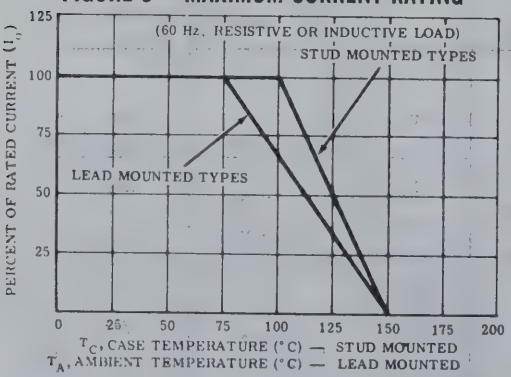
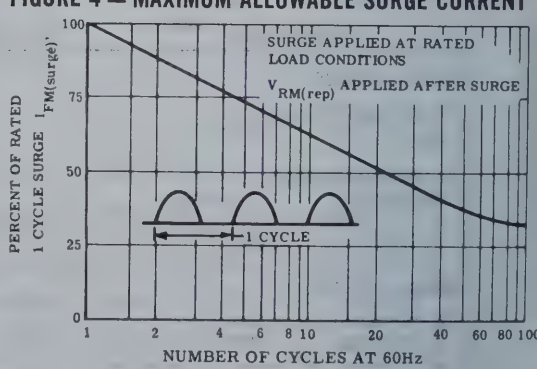


FIGURE 4 — MAXIMUM ALLOWABLE SURGE CURRENT



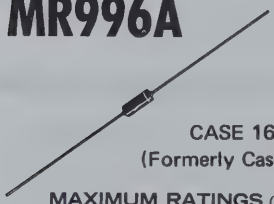
MR830 thru MR836

For Specifications, See 1N4933 Data.

MR840 thru MR842
MR844
MR846
MR880 thru MR882
MR884, MR886
MR890 thru MR892
MR894
MR896

For Specifications, See MR810 Data.

MR990A (SILICON) thru MR996A



CASE 169
(Formerly Case 59A)

High-voltage, low-current rectifiers designed for applications where high-voltages in subminiature packages are required. These devices feature efficient high-temperature current-handling performance, high surge-current capabilities and surface passivation.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	MR990A	MR991A	MR992A	MR993A	MR994A	MR995A	MR996A	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	1000	1500	2000	2500	3000	4000	5000	Volts
RMS Reverse Voltage	V_r	700	1050	1400	1750	2100	2800	3500	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_A = 75°C)	I_O	250							mA
Peak Repetitive Forward Current (T_A = 75°C)	$I_{FM(rep)}$	2.0							Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 75°C)	$I_{FM(surge)}$	15 (for 1/2 cycle)							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150							°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (1 inch lead length)	θ_{JA}	100	°C/W

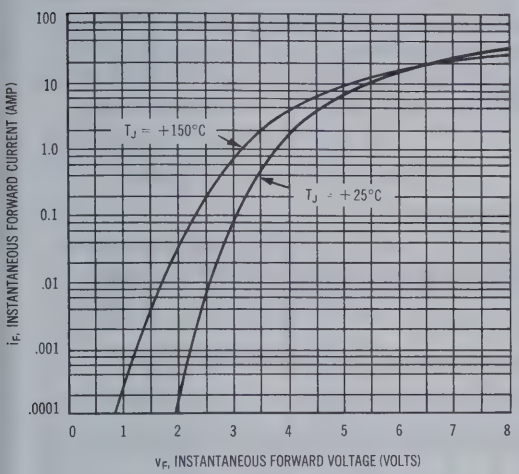
ELECTRICAL CHARACTERISTICS (At 60 Hz Sinusoidal, Resistive or Inductive)

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (I_O = 0.25 Amp and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$V_{F(AV)}$	1.7	Volts
DC Forward Voltage Drop (I_F = 0.25 Adc, T_A = 25°C)	V_F	3.5	Volts
Full Cycle Average Reverse Current (I_O = 0.25 Amp and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$I_{R(AV)}$	100	μA
DC Reverse Current (Rated V_R, T_A = 25°C)	I_R	10	μA

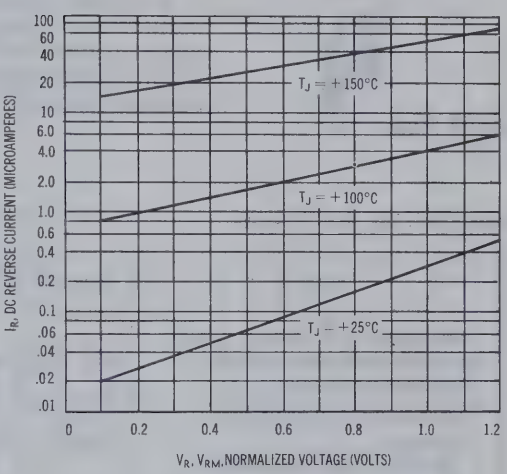
MECHANICAL CHARACTERISTICS

CASE: Void free, flame-proof silicone polymer case
FINISH: All external surfaces corrosion-resistant and leads readily solderable
POLARITY: Indicated by polarity band
MOUNTING POSITIONS: Any
WEIGHT: 0.40 Gram (approx)
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C, 3/8" from case for 10 seconds

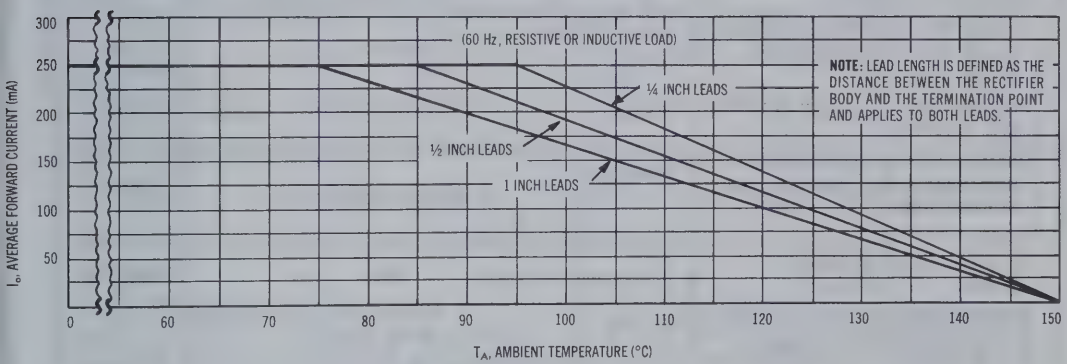
TYPICAL FORWARD CHARACTERISTICS



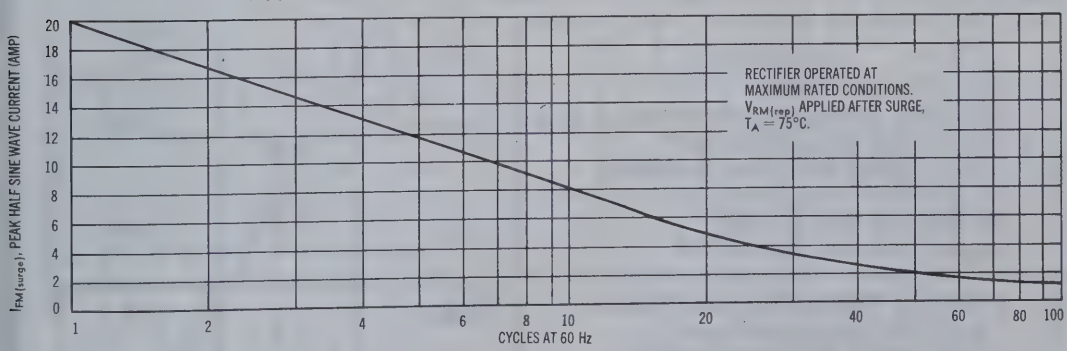
TYPICAL REVERSE CHARACTERISTICS



CURRENT DERATING



MAXIMUM ALLOWABLE NON-REPETITIVE SURGE CURRENT



MR1030 thru MR1036
MR1038, MR1040

For Specifications, See 1N4719 Data.

MR1120 thru MR1126 (SILICON)
MR1128
MR1130

V_R — to 1000V
I_O = 12 A



CASE 56A
(DO-4)

Medium-current silicon rectifiers feature high surge current capacity, and low forward voltage drop. Devices have cathode-to-case polarity, but reverse polarity units may be obtained by adding the suffix "R" to the device number i. e. MR1130R.

MAXIMUM RATINGS

Rating	Symbol	MR 1120	MR 1121	MR 1122	MR 1123	MR 1124	MR 1125	MR 1126	MR 1128	MR 1130	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	500	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	300	400	500	600	720	1000	1200	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	350	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, T_C = 150°C)	I_O	12.0									Amp
Peak Repetitive Forward Current (T_C = 150°C)	$I_{FM(rep)}$	75									Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_C = 150°C)	$I_{FM(surge)}$	300 (for 1/2 cycle)									Amp
I^2t Rating (non-repetitive, 1 msec <t <8.3 ms)	I^2t	375									$A_{(rms)}{}^2s$
Maximum Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +190									°C

ELECTRICAL CHARACTERISTICS (All Types)

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (I_O = 12.0 Amps and Rated V_r, T_C = 150°C, Half Wave Rectifier)	$V_{F(AV)}$	0.55	Volts
DC Forward Voltage Drop (I_F = 12.0 Adc, T_C = 25°C)	V_F	1.0	Volts
Full Cycle Average Reverse Current (I_O = 12.0 Amps and Rated V_r, T_C = 150°C, Half Wave Rectifier)	$I_{R(AV)}$	1.5	mA
DC Reverse Current (Rated V_R, T_C = 25°C)	I_R	0.5	mA

THERMAL CHARACTERISTICS

Maximum Steady State DC Thermal Resistance, θ_{JC}: 2.5°C/Watt

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

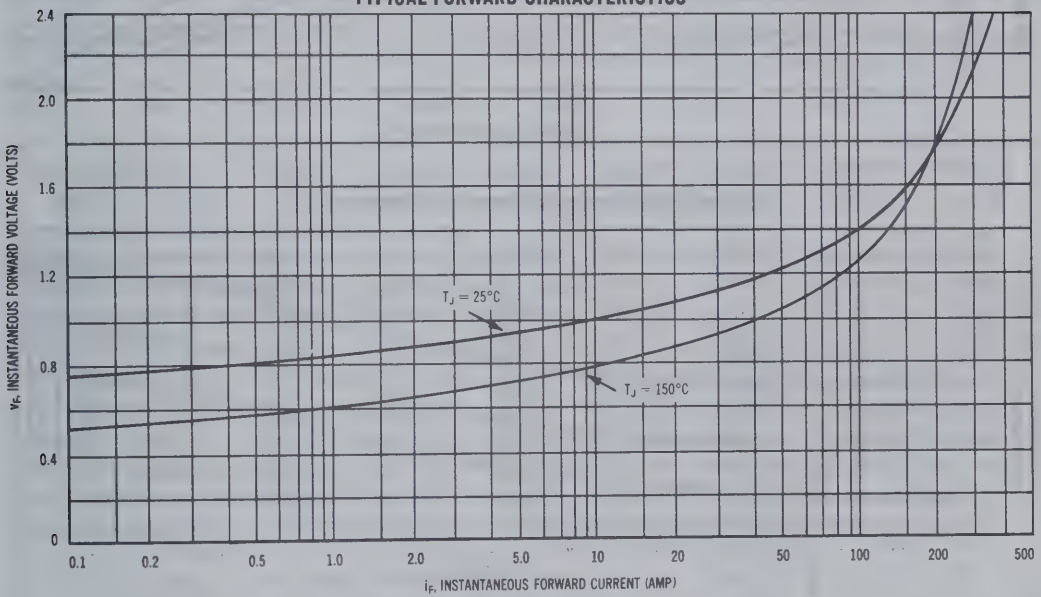
FINISH: All external surfaces corrosion-resistant and the terminal lug is readily solderable.

POLARITY: CATHODE-TO-CASE (reverse polarity units are available upon request and are designated by an "R" suffix i. e. MR1120R).

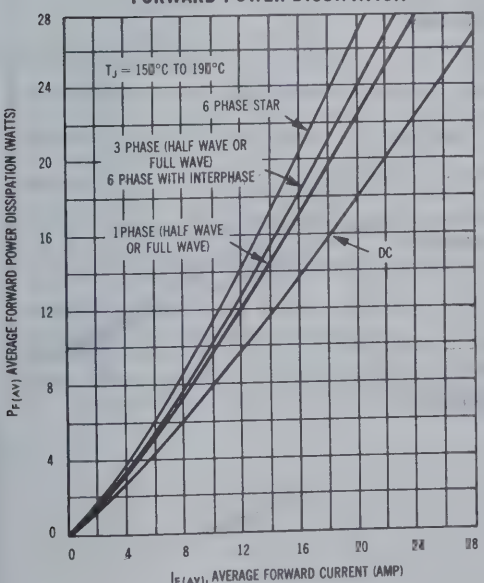
MOUNTING POSITIONS: Any

STUD TORQUE: 15 in-lbs maximum.

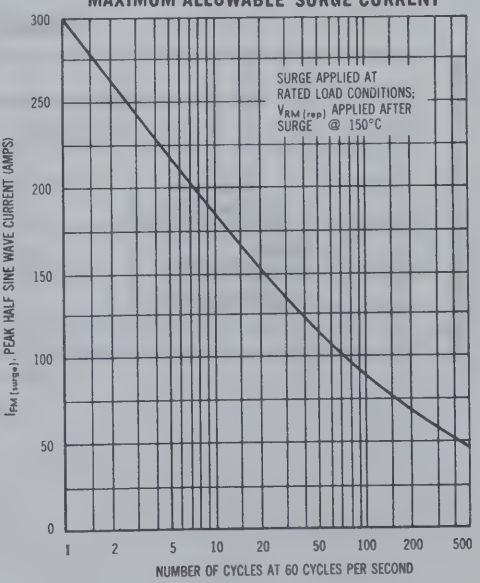
TYPICAL FORWARD CHARACTERISTICS



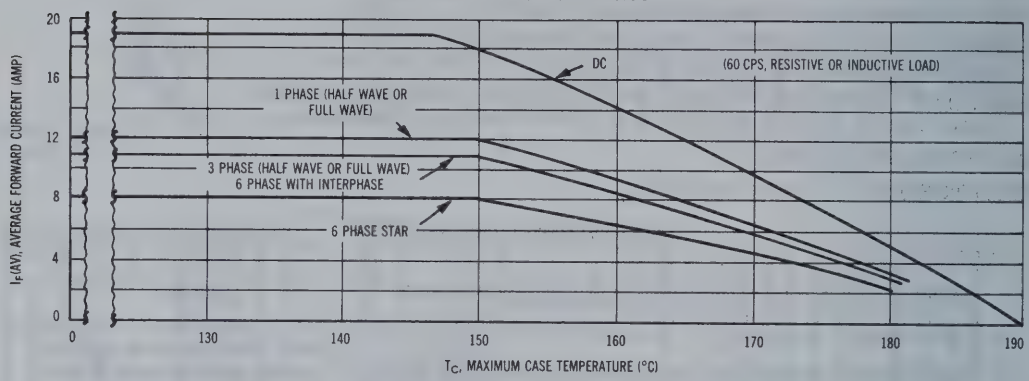
FORWARD POWER DISSIPATION



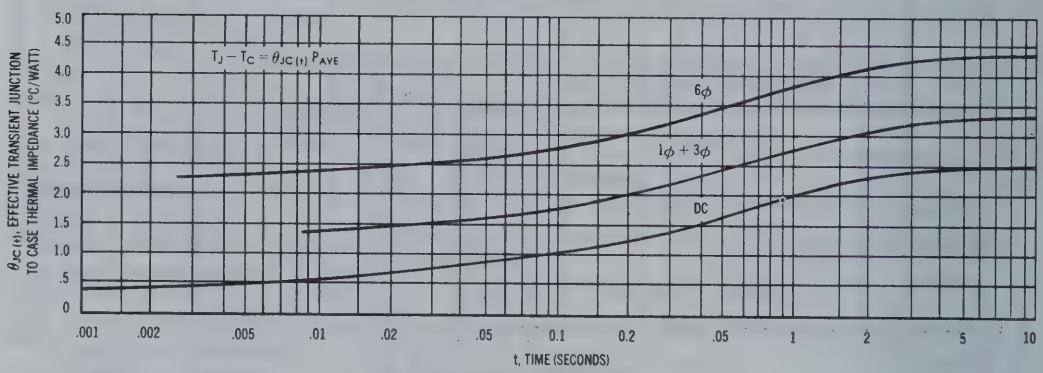
MAXIMUM ALLOWABLE SURGE CURRENT



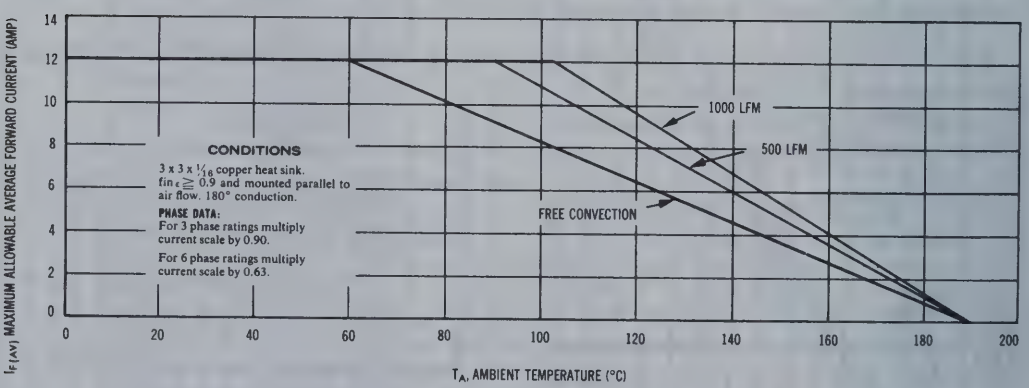
MAXIMUM CURRENT RATINGS



EFFECTIVE TRANSIENT THERMAL IMPEDANCE



CURRENT DERATING DATA



RECTIFIER SUBSTITUTION GUIDE

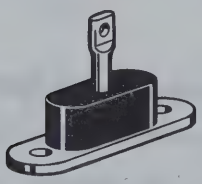
Due to its optimized design, this 12-ampere rectifier series (types MR1120 - MR1130) provides a high performance, economical solution to your specification and procurement requirements. Only nine types, covering the complete voltage range from 50 to 1000 volts, can substitute for a multitude of devices as typified in the table below. This table is only a guide and general reference to the EIA registered types which can be replaced; minor specification variations may exist.

MR1120 50V	MR1121 100V	MR1122 200V	MR1123 300V	MR1124 400V	MR1125 500V	MR1126 600V	MR1128 800V	MR1130 1000V
1N607	1N253	1N254	1N334	1N255	1N554	1N256	1N562	1N563
1N607A	1N338	1N336	1N335	1N332	1N613	1N555	1N3649	1N3650
1N1199	1N339	1N337	1N343	1N333	1N613A	1N614	1N3670	1N3672
1N1199A	1N340	1N345	1N344	1N341	1N1119	1N614A	1N3670A	1N3672A
1N1341	1N348	1N346	1N552	1N342	1N1127	1N1120	1N3671	1N3673
1N1341A	1N349	1N551	1N611	1N553	1N1127A	1N1128	1N3671A	1N3673A
1N1537	1N550	1N609	1N611A	1N612	1N1205	1N1128A	1N3987	1N3989
1N1612	1N608	1N609A	1N1117	1N612A	1N1205A	1N1206	1N3988	1N3990
	1N608A	1N610	1N1125	1N1118	1N1347	1N1206A		
	1N1115	1N610A	1N1125A	1N1126	1N1347A	1N1348		
	1N1200	1N1116	1N1203	1N1126A	1N1543	1N1348A		
	1N1200A	1N1124	1N1203A	1N1204	1N3573	1N1544		
	1N1342	1N1124A	1N1345A	1N1204A		1N1616		
	1N1342A	1N1201	1N1541	1N1346		1N3574		
	1N1538	1N1201A	1N3571	1N1346A				
	1N1613	1N1202		1N1542				
	1N3569	1N1202A		1N1615				
		1N1343		1N3572				
		1N1343A						
		1N1344						
		1N1344A						
		1N1539						
		1N1540						
		1N1614						
		1N3570						

NOTE: While the MR1120 through MR1130 are preferred device types, the above listed EIA types are also available upon request.

MR1200 thru MR1203 (SILICON)
MR1205, MR1207 thru MR1209

V_R — to 600 V
I_O = 50 A



CASE 100

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1200	MR 1201	MR 1202	MR 1203	MR 1205	MR 1207	MR 1208	MR 1209	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) T_C = 150°C	I_O	50								Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 5) T_C = 150°C	$I_{FM(surge)}$	800 (for 1/2 cycle) 500 (for six consecutive cycles)								Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	1,300								$A_{(rms)}{}^2s$
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190								°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$I_{R(AV)}$	10	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.60	°C/Watt

MECHANICAL CHARACTERISTICS

PACKAGE CONFIGURATION:

MR1200FL rectifiers are designed for flat mounting and have a solid lug terminal.

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE-TO-CASE.

Reverse polarity devices are ANODE-TO-CASE and are designated by an "R" suffix i.e. MR1205FLR.

MOUNTING POSITION: Any.

MOUNTING BOLT TORQUES:

For Flat Mounted "FL" rectifiers use 8-32 bolts torqued to 30 in-lbs min., 40 in-lbs max. Use an alternating procedure when torquing the two bolts and do not tighten one bolt completely without tightening the other.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

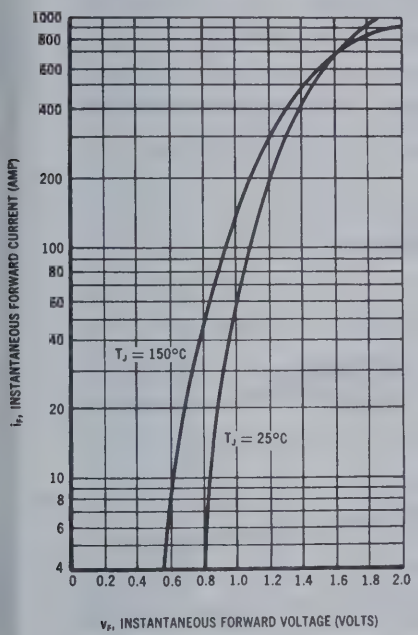


FIGURE 2 — FORWARD POWER DISSIPATION

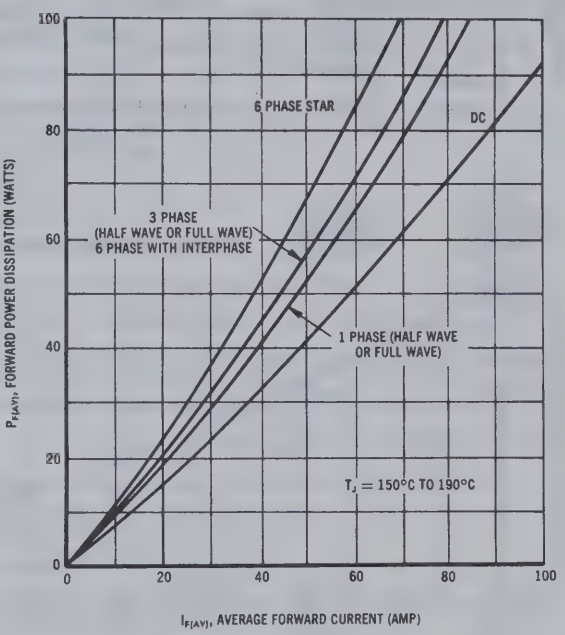


FIGURE 3 — MAXIMUM CURRENT RATINGS

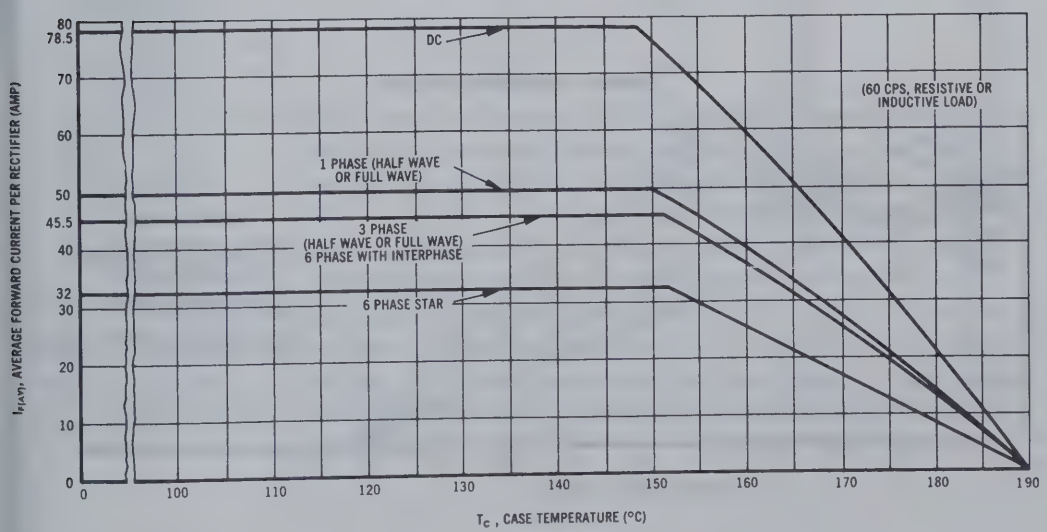


FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

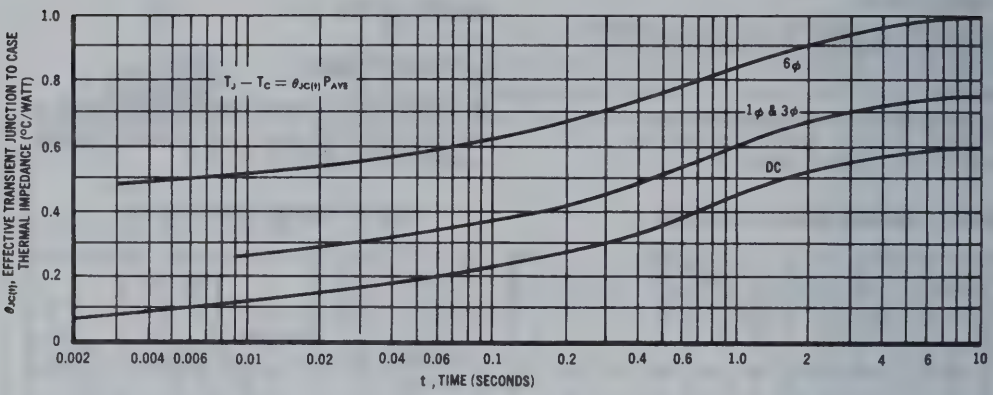


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT

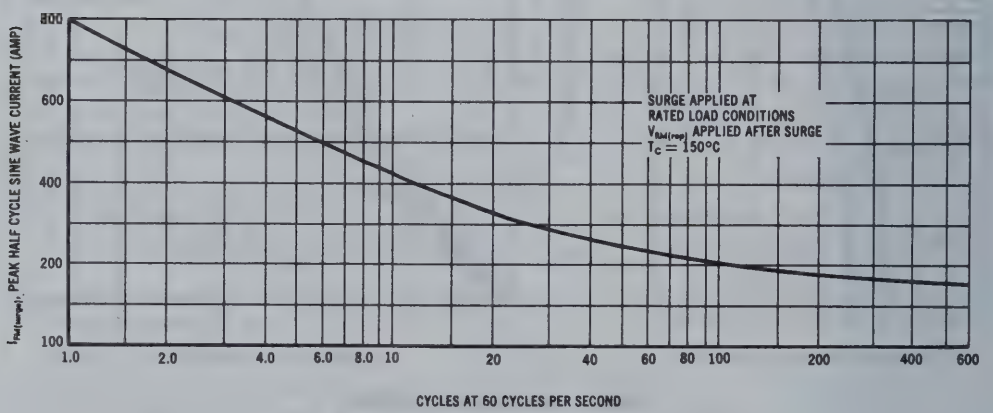
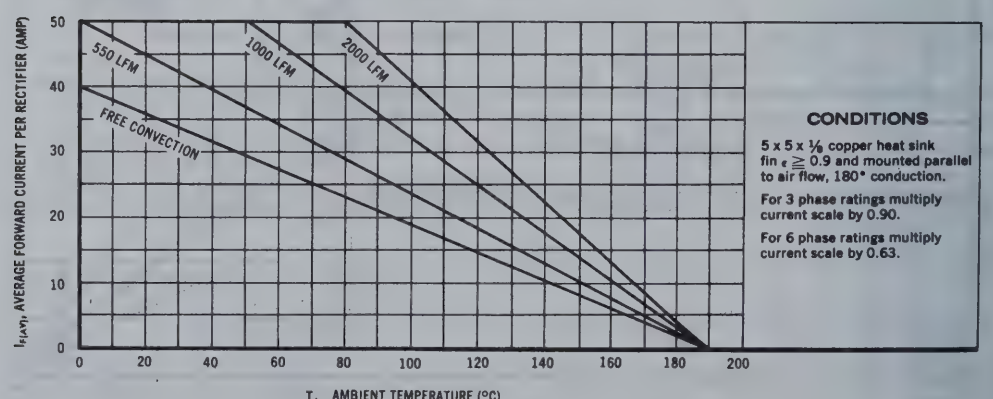


FIGURE 6 — CURRENT DERATING DATA



MR1210 thru MR1219 (SILICON)
MR1810 thru MR1819

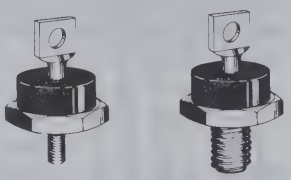
UNIQUE, MULTI-CELL RECTIFIERS OFFERING HIGHEST ORDER OF RELIABILITY IN POWER APPLICATIONS

Designers Data for "Worst Case" Conditions

Motorola DESIGNERS Data Sheets are prepared to facilitate "worst-case" circuit design entirely from information presented on these pages. To do this, the usual typical curves which provided some guidance to the engineer, have been supplemented by limit curves which are directly applicable to "worst-case" rectifier circuit design. Limit curves represent boundaries on parameters and does not necessarily indicate typical rectifier behavior.

HIGH-CURRENT SILICON RECTIFIERS

80/100 AMPERE
50-600 VOLTS
DIFFUSED JUNCTIONS

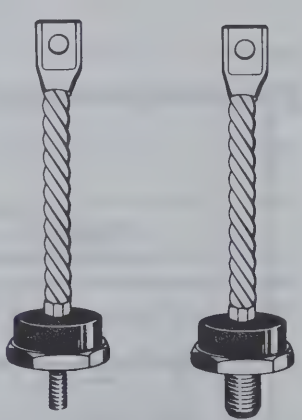


MR1210SL thru MR1219SL
CASE 167

MR1810SL thru MR1819SL
CASE 189

MAXIMUM RATINGS

Rating	Symbol	MR 1210	MR 1211	MR 1212	MR 1213	MR 1214	MR 1215	MR 1216	MR 1217	MR 1218	MR 1219	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	MR 1810 50	MR 1811 100	MR 1812 150	MR 1813 200	MR 1814 250	MR 1815 300	MR 1816 350	MR 1817 400	MR 1818 500	MR 1819 600	 Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 Hz peak)	$V_{RM(non-rep)}$	100	200	250	300	350	400	450	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	175	210	245	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) $T_C = 135^oC$ $T_C = 150^oC$	I_O	100 80										Amp
Non-Repetitive Peak Surge Currents (surge applied at rated load conditions, see Figure 5) $T_C = 150^oC$	$I_{FM(surge)}$	2,000 (for 1/2 cycle) 1,200 (for six consecutive cycles)										Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	8,300										A^2s
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190										^oC



MR1210SB thru MR1219SB
CASE 168

MR1810SB thru MR1819SB
CASE 190

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, $T_C = 150^oC$)	$V_{F(AV)}$	0.4	Volt
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, $T_C = 150^oC$)	$I_{R(AV)}$	15	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.40	$^oC/Watt$

FIGURE 1 – MAXIMUM FORWARD VOLTAGE DROP

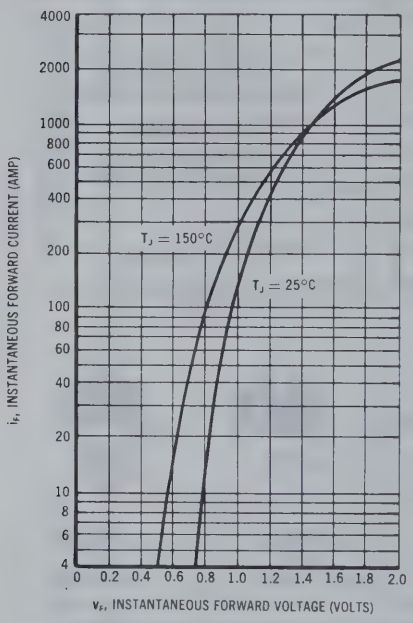


FIGURE 2 – MAXIMUM FORWARD POWER DISSIPATION

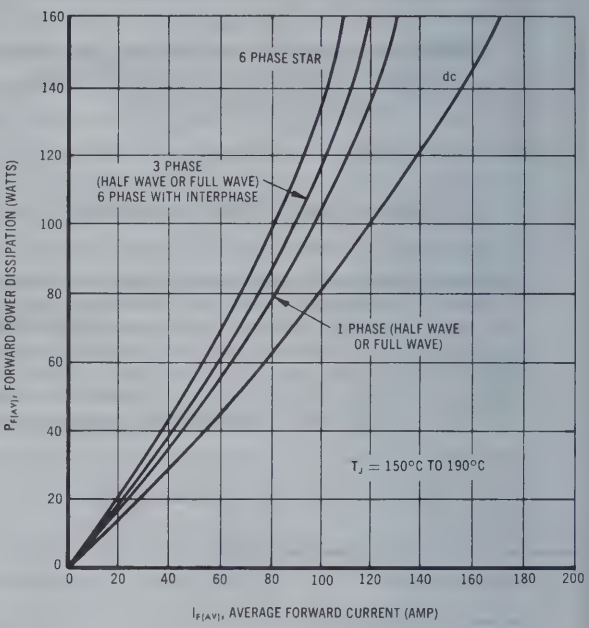


FIGURE 3 – MAXIMUM CURRENT RATINGS

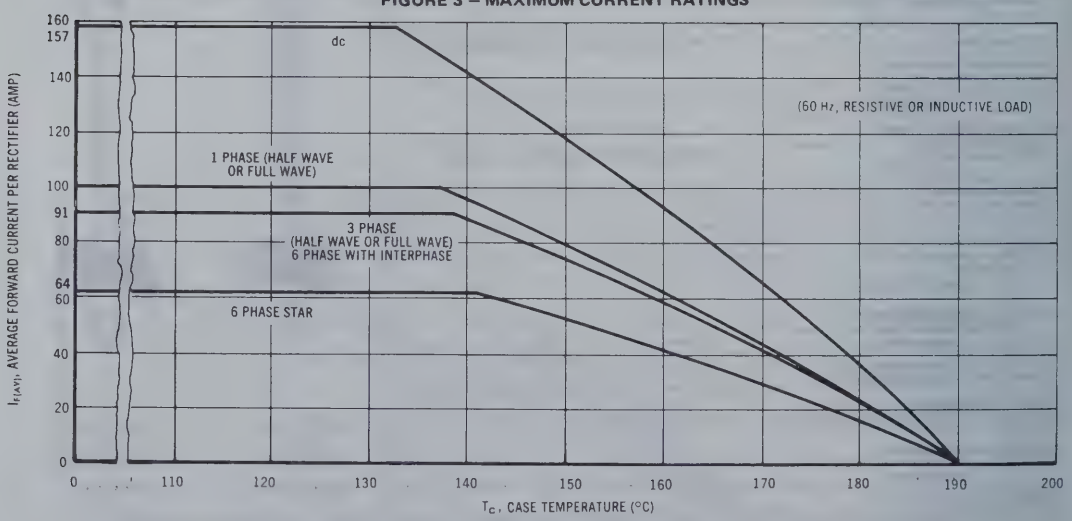


FIGURE 4 – EFFECTIVE TRANSIENT THERMAL IMPEDANCE

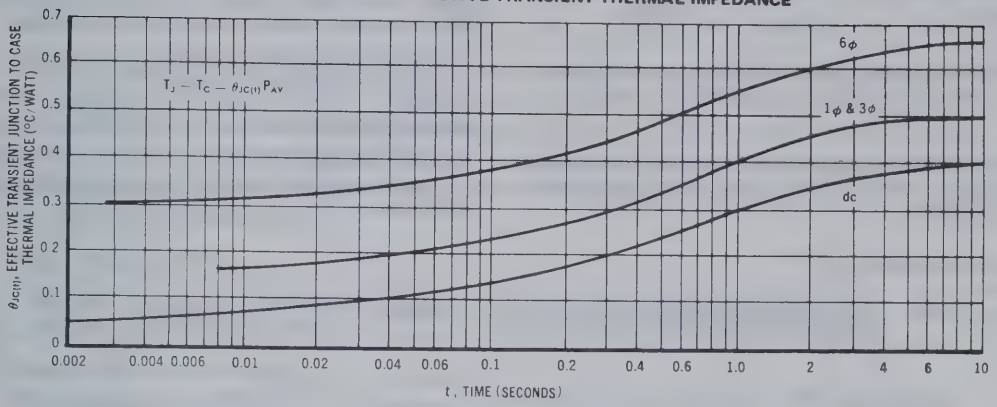


FIGURE 5 – MAXIMUM ALLOWABLE SURGE CURRENT

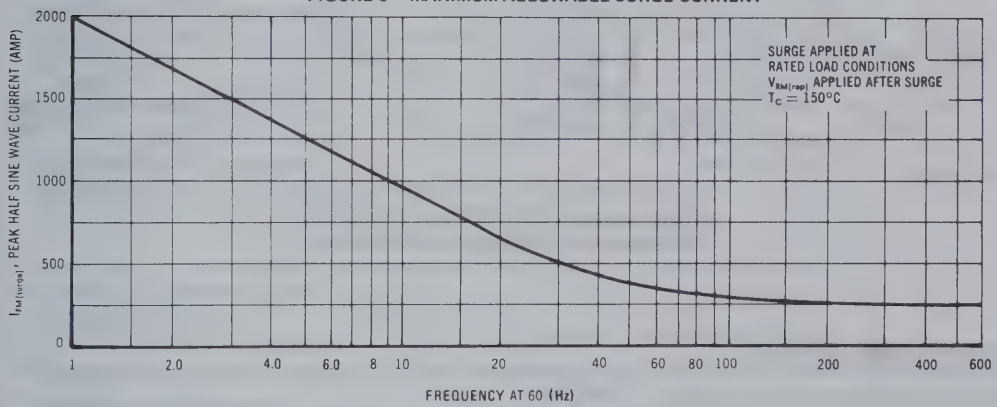
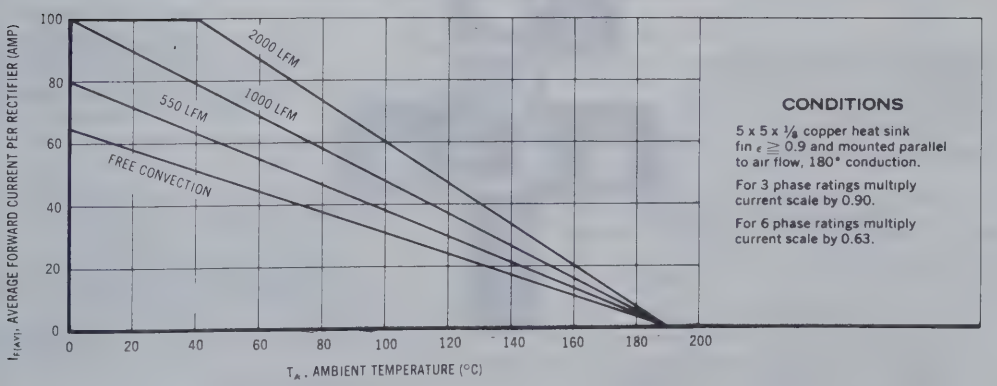


FIGURE 6 – MAXIMUM CURRENT DERATING DATA



PACKAGE CONFIGURATIONS:

MR1210SB and MR1810SB rectifiers are designed for stud mounting and have a flexible braided lead terminal (See Outline 1).

MR1210SL and MR1810SL rectifiers are designed for stud mounting and have a solid lug terminal (See Outline 2).

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells

POLARITY:

Standard polarity devices are CATHODE TO CASE. Reverse polarity devices are ANODE TO CASE and are designated by an "R" suffix i.e. MR1215SLR. These devices have a molded plastic top for mechanical strength and seal. The color of the plastic indicates the polarity of the cells inside.

"RED PLASTIC CATHODE TO CASE"
"BLACK PLASTIC ANODE TO CASE"

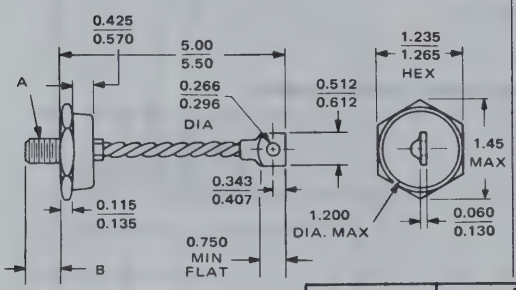
MOUNTING POSITION: Any

STUD MOUNTING TORQUES:

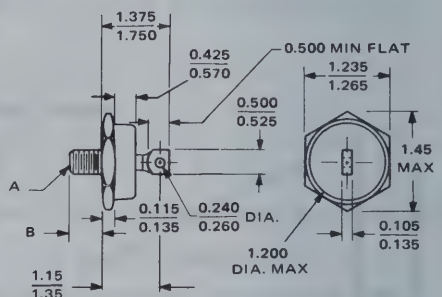
For Stud Mounted "SB" and "SL" rectifiers, 25 in-lb min., 30 in-lb max.

OUTLINE DIMENSIONS

OUTLINE 1 – MR1210SB THRU MR1219SB – CASE 168
MR1810SB THRU MR1819SB – CASE 190



OUTLINE 2 – MR1210SL THRU MR1219SL – CASE 167
MR1810SL THRU MR1819SL – CASE 189



	A	B
MR1210 Series	No 10-32-UNF-2A	0.424/0.500
MR1810 Series	3/8-24-UNF-2A	0.593/0.657

CONSTRUCTIONAL FEATURES

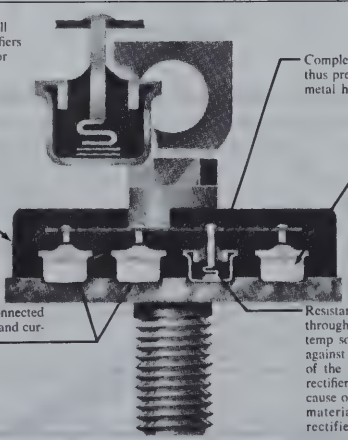
Motorola's advanced and unique double-case, multiple cell construction offers numerous advantages which result in rectifiers possessing "designed-in" ruggedness, reliability and superior performance characteristics.

Void-free, molded external case for added mechanical strength and electrical isolation in addition to being corrosion resistant. Color coding of the external case provides easy polarity identification.

RED — CATHODE TO CASE

BLACK — ANODE TO CASE

Plated copper base and/or stud integrally connected to the inner cases for optimum heat transfer and current balance between cells.



Complete seal strength is afforded by the outer case thus preventing any excessive stress on the glass-to-metal hermetic inner seal.

Internal, hermetically sealed, welded metal case rectifier cells. All individual cells are specially processed, tested and matched for similarity of forward characteristics to assure balanced current sharing and reliable parallel operation.

Resistance to thermal fatigue of each cell is assured through the use of double back-up discs and high temp solder construction to protect the silicon die against stresses. In addition, the small junction areas of the individual paralleled cells result in a total rectifier which can better resist thermal fatigue because of the smaller excursion of dissimilar bonded materials as opposed to a large single-junction rectifier.

MR1220 thru MR1223 (SILICON)
MR1225, MR1227 thru MR1229

V_R — to 600 V
I_O = 200 A


CASE 130
SB


CASE 137
FB


SL CASE 126


FL CASE 133

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number. Available in a variety of packages, all of which have the same ratings and characteristics. Desired package can be selected by adding suffix "SB", "FB", "SL", or "FL" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1220	MR 1221	MR 1222	MR 1223	MR 1225	MR 1227	MR 1228	MR 1229	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) T_C = 135°C T_C = 150°C	I_O	200 160								Amp
Non-Repetitive Peak Surge Currents (surge applied at rated load conditions, see Figure 5) T_C = 150°C	$I_{FM(surge)}$	3,600 (for 1/2 cycle) 2,000 (for six consecutive cycles)								Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	27,000								A^2s
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190								°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$I_{R(AV)}$	20	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.20	°C/Watt

MECHANICAL CHARACTERISTICS

PACKAGE CONFIGURATIONS:

MR1220SB rectifiers are designed for stud mounting and have a flexible braided lead terminal.

MR1220FB rectifiers are designed for flat mounting and have a flexible braided lead terminal.

MR1220SL rectifiers are designed for stud mounting and have a solid lug terminal.

MR1220FL rectifiers are designed for flat mounting and have a solid lug terminal.

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE-TO-CASE.
Reverse polarity devices are ANODE-TO-CASE and are designated by an "R" suffix i.e. MR1225FLR.

MOUNTING POSITION: Any.

STUD AND MOUNTING BOLT TORQUES:

For Stud Mounted "SB" and "SL" rectifiers, 300 in-lbs min., 400 in-lbs max.
For Flat Mounted "FB" and "FL" rectifiers use No. 10 bolts torqued to 25 in-lbs min., 30 in-lbs max. Use an alternating procedure when torquing the four bolts and do not tighten one bolt completely without tightening the others.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

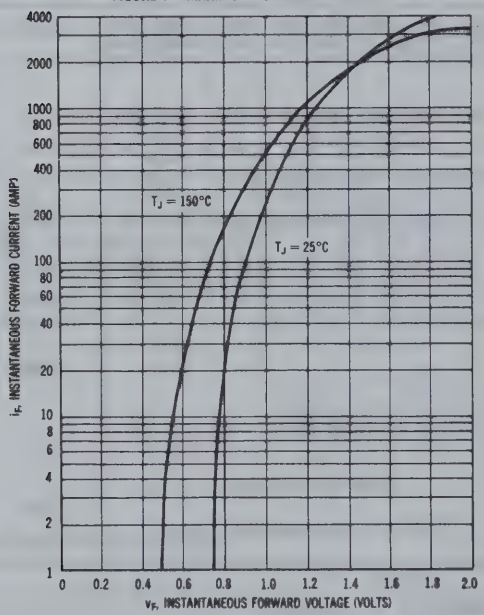


FIGURE 2 — FORWARD POWER DISSIPATION

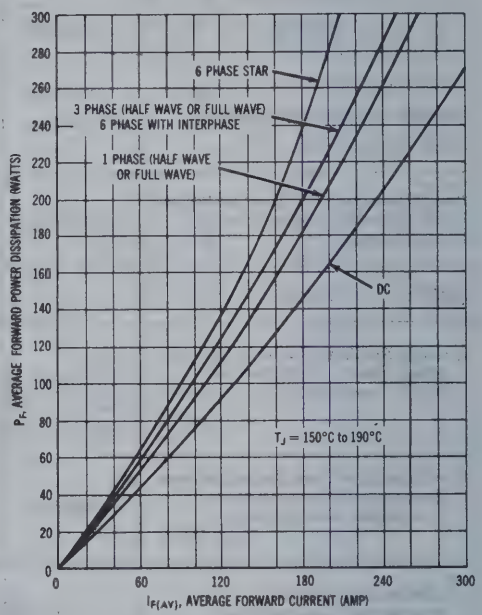


FIGURE 3 — MAXIMUM CURRENT RATING

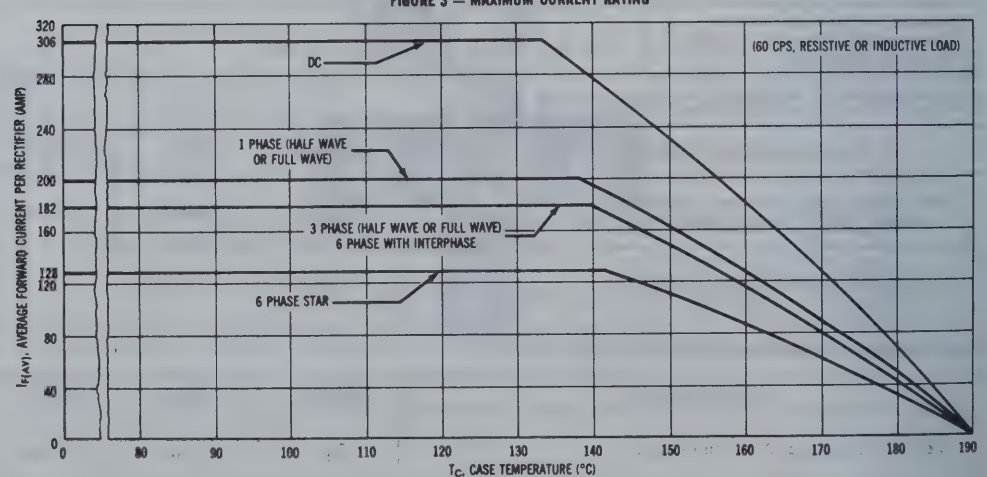


FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

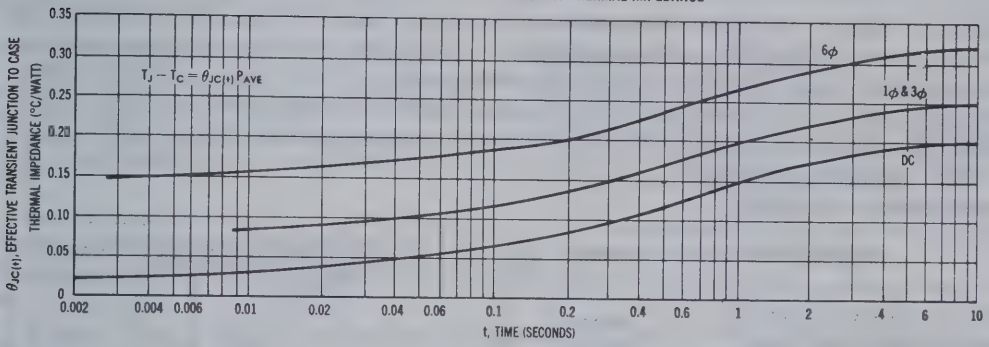


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT

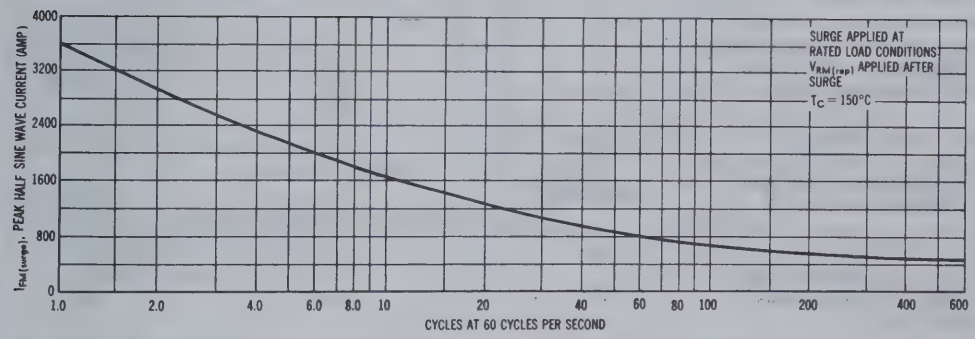
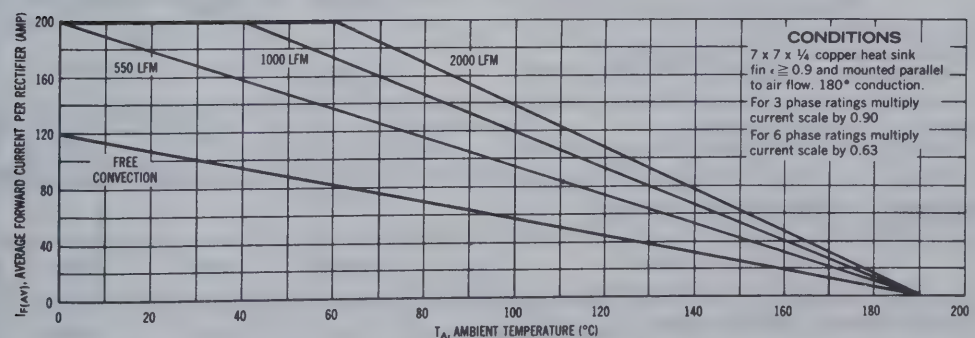
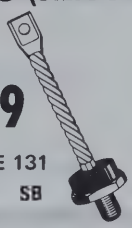


FIGURE 6 — CURRENT DERATING DATA



MR1230 thru MR1233 (SILICON)
MR1235
MR1237 thru MR1239

V_R = to 600 V
I_O = 300 A


CASE 131
SB


CASE 138
FB


SL CASE 127


FL CASE 134

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number. Available in a variety of packages, all of which have the same ratings and characteristics. Desired package can be selected by adding suffix "SB", "FB", "SL", or "FL" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1230	MR 1231	MR 1232	MR 1233	MR 1235	MR 1237	MR 1238	MR 1239	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) T_C = 135°C T_C = 150°C	I_O	300 240								Amp
Non-Repetitive Peak Surge Currents (surge applied at rated load conditions, see Figure 5) T_C = 150°C	$I_{FM(surge)}$	5,000 (for 1/2 cycle) 3,000 (for six consecutive cycles)								Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	52,000								A^2s
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190								°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$I_{R(AV)}$	35	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.12	°C/Watt

MECHANICAL CHARACTERISTICS

PACKAGE CONFIGURATIONS:

MR1230SB rectifiers are designed for stud mounting and have a flexible braided lead terminal.

MR1230FB rectifiers are designed for flat mounting and have a flexible braided lead terminal.

MR1230SL rectifiers are designed for stud mounting and have a solid lug terminal.

MR1230FL rectifiers are designed for flat mounting and have a solid lug terminal.

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE-TO-CASE.
Reverse polarity devices are ANODE-TO-CASE and are designated by an "R" suffix i.e. MR1235FLR.

MOUNTING POSITION: Any.

STUD AND MOUNTING BOLT TORQUES:

For Stud Mounted "SB" and "SL" rectifiers, 300 in-lbs min., 400 in-lbs max.
For Flat Mounted "FB" and "FL" rectifiers use ¼ inch bolts torqued to 60 in-lbs min., 80 in-lbs max. Use an alternating procedure when torquing the four bolts and do not tighten one bolt completely without tightening the others.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

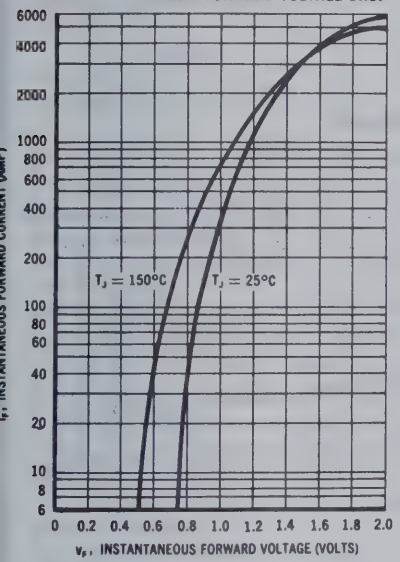


FIGURE 2 — FORWARD POWER DISSIPATION

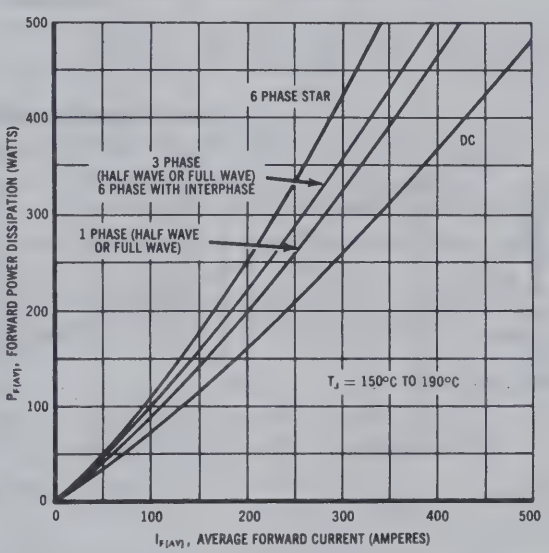


FIGURE 3 — MAXIMUM CURRENT RATINGS

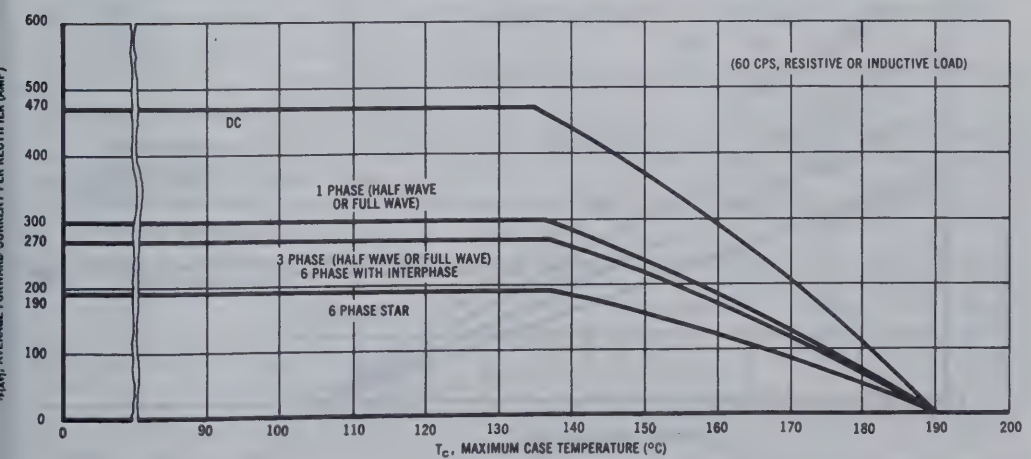


FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

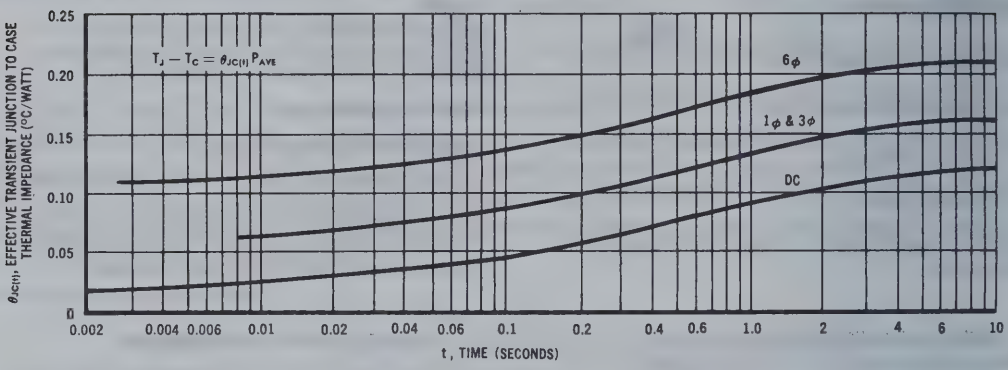


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT

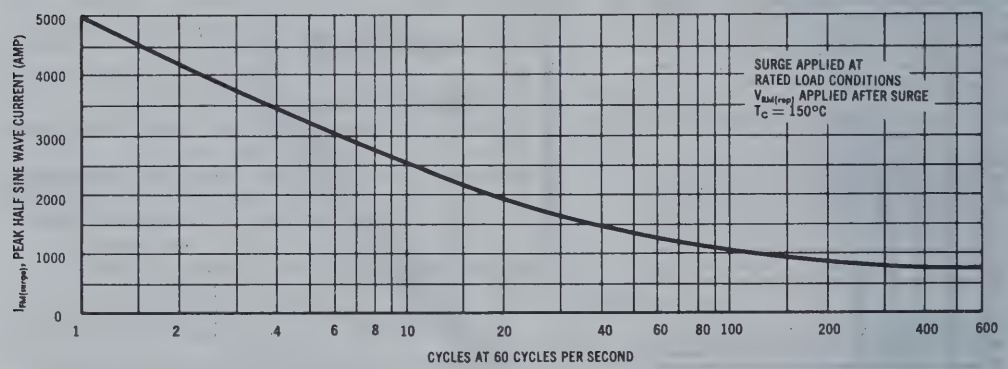
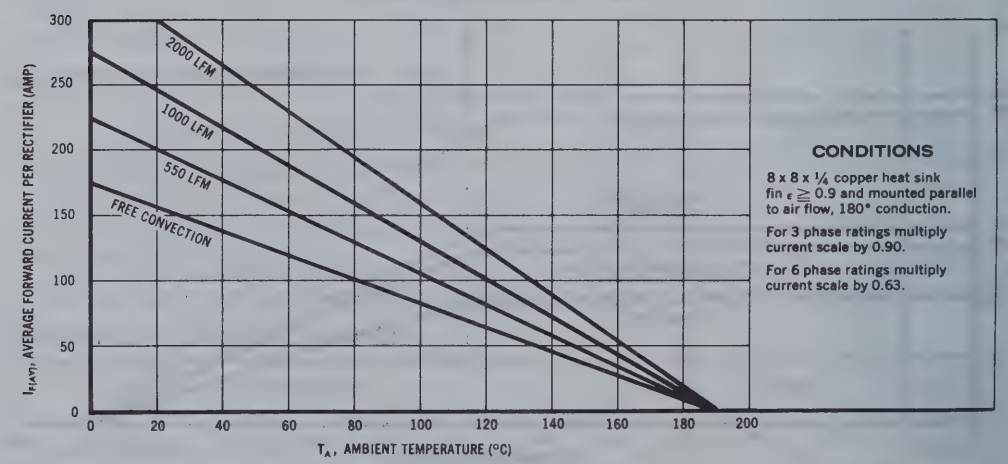


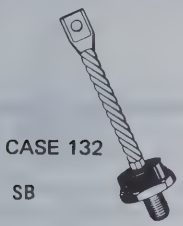
FIGURE 6 — CURRENT DERATING DATA



MR1240 thru MR1243 (SILICON)

MR1245, MR1247 thru MR1249

V_R — to 600 V
I_O = 400 A


CASE 132
SB


CASE 139
FB


SL CASE 128


FL CASE 135

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number. Available in a variety of packages, all of which have the same ratings and characteristics. Desired package can be selected by adding suffix "SB", "FB", "SL", or "FL" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1240	MR 1241	MR 1242	MR 1243	MR 1245	MR 1247	MR 1248	MR 1249	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	150	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_C = 150° C	I_O	400								Amperes
Non-Repetitive Peak Surge Currents (superimposed on rated current at rated voltage, T_C = 150° C)	$I_{FM(surge)}$	8,000 (for 1/2 cycle) 4,500 (for six consecutive 1/2 cycles)								Amperes
I^2t Rating (non-repetitive for t greater than 1.0 ms and less than 8.3 ms)	I^2t	133,000								A^2s
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +190								°C

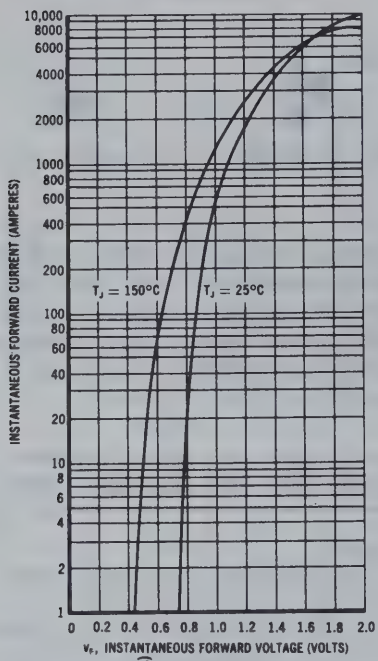
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.075	°C/W

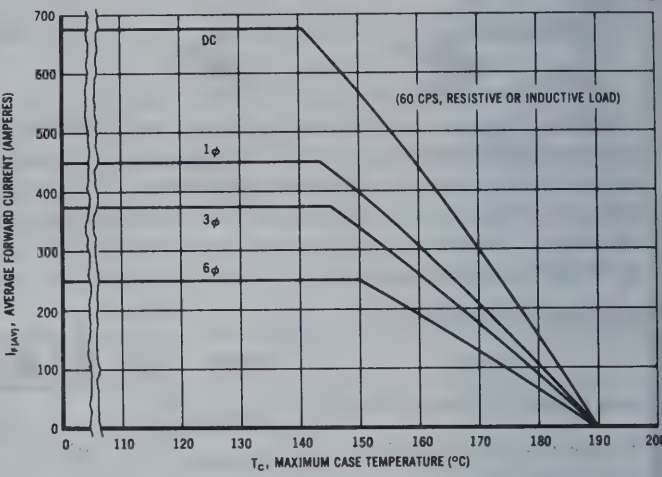
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase 60 Hz, T_C = 150° C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase 60 Hz, T_C = 150° C)	$I_{R(AV)}$	50	mA

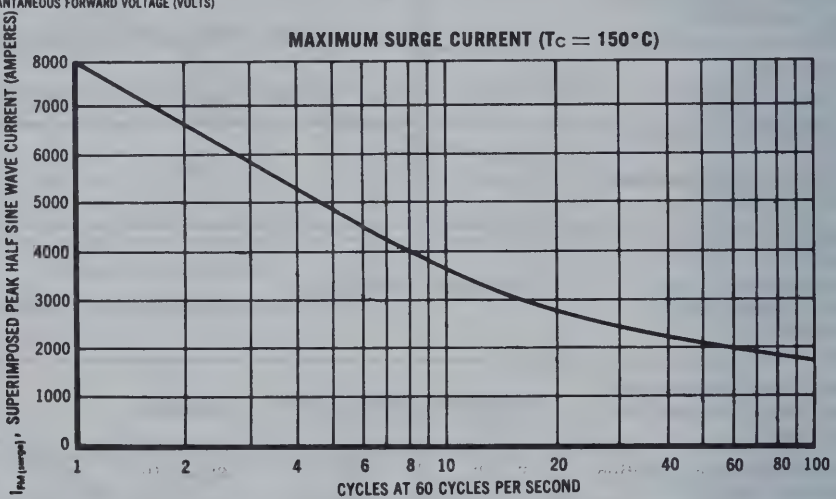
FORWARD VOLTAGE CHARACTERISTICS



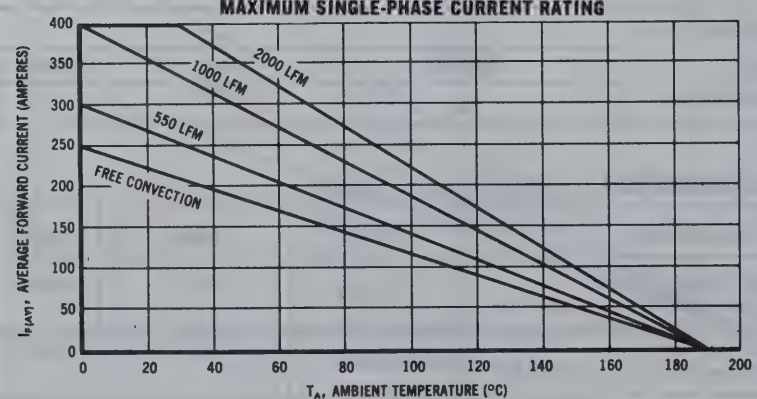
MAXIMUM FORWARD CURRENT versus MAXIMUM CASE TEMPERATURE



MAXIMUM SURGE CURRENT ($T_C = 150°C$)



MAXIMUM SINGLE-PHASE CURRENT RATING



CONDITIONS

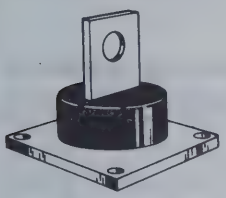
8 x 8 x ¼ copper heat sink fin€ ≧ 0.9 and mounted paralle to air flow. 180° conduction.

For 3 phase ratings multiply current scale by 0.85.

For 6 phase ratings multiply current scale by 0.60.

MR1260 thru MR1263 (SILICON)
MR1265, MR1267 thru MR1269

V_R — to 600 V
I_O = 650 A



CASE 136

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1260	MR 1261	MR 1262	MR 1263	MR 1265	MR 1267	MR 1268	MR 1269	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	150	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_C = 150°C)	I_O	650								Amperes
Non-Repetitive Peak Surge Currents (superimposed on rated current at rated voltage, T_C = 150°C)	$I_{FM(surge)}$	12,000 (for 1/2 cycle) 8,000 (for six consecutive 1/2 cycles)								Amperes
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	300,000								A^2s
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +190								°C

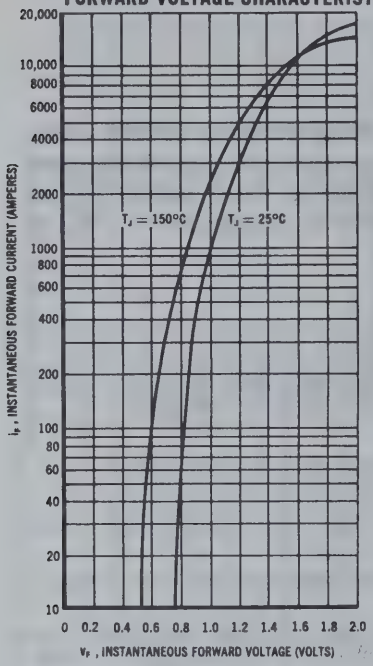
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.045	°C/Watt

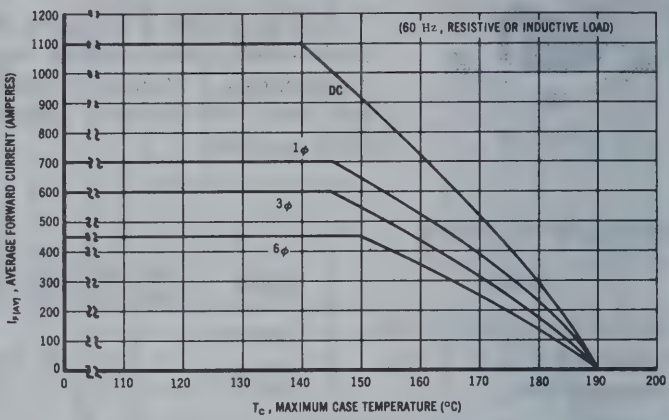
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$I_{R(AV)}$	100	mA

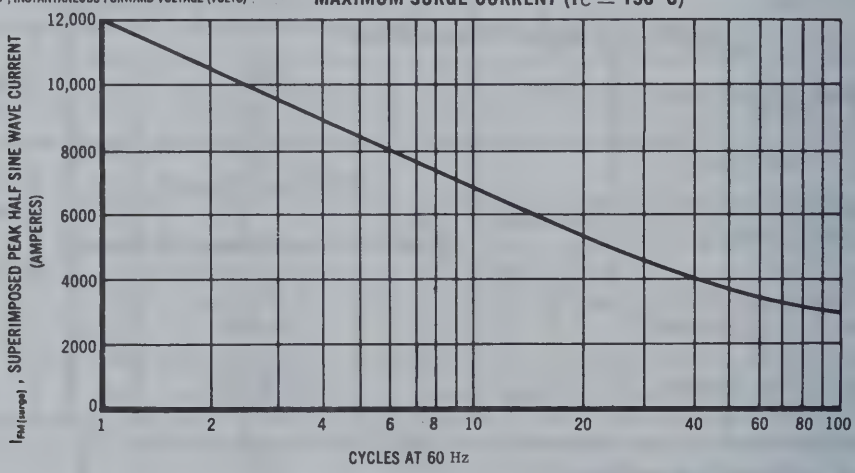
FORWARD VOLTAGE CHARACTERISTICS



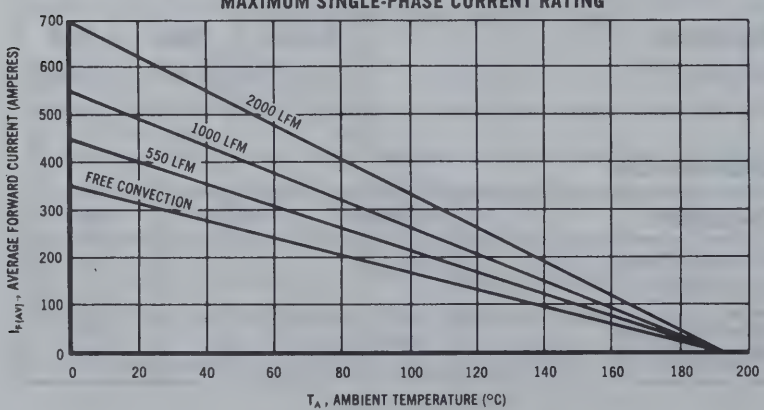
MAXIMUM FORWARD CURRENT versus MAXIMUM CASE TEMPERATURE



MAXIMUM SURGE CURRENT ($T_C = 150°C$)



MAXIMUM SINGLE-PHASE CURRENT RATING



CONDITIONS

10 x 10 x ¼ copper heat sink fin $\epsilon \geqq 0.9$ and mounted parallel to air flow, 180° conduction.

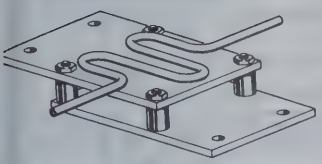
For 3 phase ratings multiply current scale by 0.85.

For 6 phase ratings multiply current scale by 0.60.

MR1290 thru MR1293 (SILICON)

MR1295, MR1297 thru MR1299

V_R — to 600 V
I_O = 1000 A



CASE 105

Silicon power rectifiers designed with multi-cell construction for extreme reliability and ruggedness. Standard polarity is cathode-to-water-cooled case, but reverse polarity devices are available designated by an "R" suffix. i.e. MR1295R

MAXIMUM RATINGS

Rating	Symbol	MR 1290	MR 1291	MR 1292	MR 1293	MR 1295	MR 1297	MR 1298	MR 1299	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Continuous Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_C = 150°C)	I_O	1000								Amperes
Non-Repetitive Peak Surge Currents (superimposed on rated current at rated voltage, T_C = 150°C)	$I_{FM(surge)}$	18,000 (for 1/2 cycle) 13,500 (for six consecutive 1/2 cycles)								Amperes
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +190								°C

Case Temperature Reference Point: T_C measured at center edge of the water cooled mounting bus.

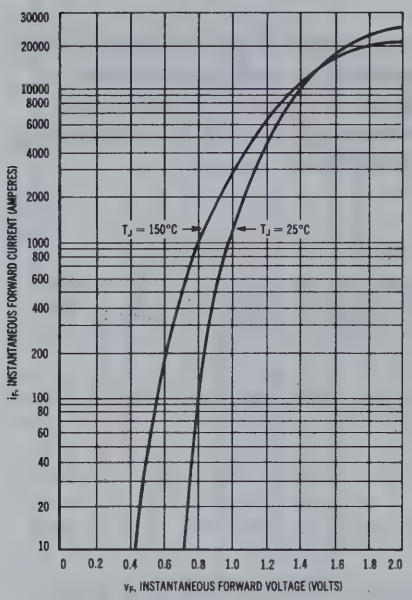
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case DC 1 and 3 phase 6 phase	θ_{JC}	 0.035 0.045 0.060	°C/Watt

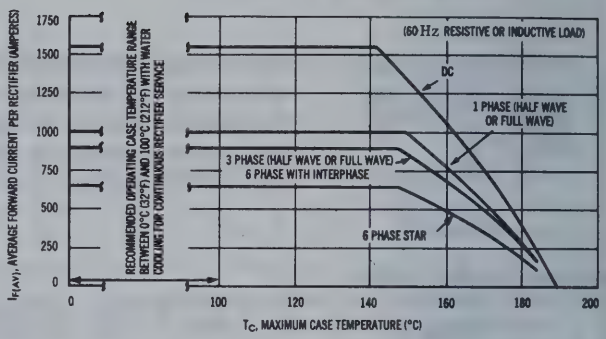
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$I_{R(AV)}$	0.2	Amperes

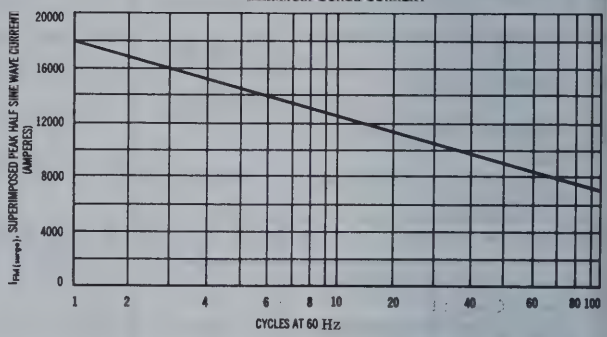
FORWARD VOLTAGE CHARACTERISTICS



MAXIMUM FORWARD CURRENT versus MAXIMUM CASE TEMPERATURE (100% DUTY)



MAXIMUM SURGE CURRENT



TYPICAL COOLING RATES AT RATED LOAD CONDITIONS

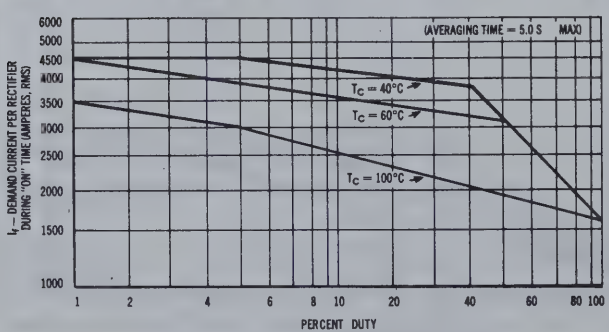
Inlet Water Temperature (°C)	Minimum Water Flow Required (Gallons/Hour)	Approx. Water Temp. Rise at Specified Flow Rate (°C)
15	2	10
50	5	8
75	10	5

NOTE: Water flow rates may be decreased at lighter load demands provided maximum case temperatures are not exceeded. In some applications where cooling systems are operated in series, it may be desirable to increase flow rates in order to minimize water temperature rises.

COOLING REQUIREMENTS

Type of Cooling — Water
Min Inlet Water Temp. — 0°C
Max Inlet Water Temp. — 75°C

MAXIMUM RMS DEMAND CURRENT versus PERCENT DUTY



NOTE:

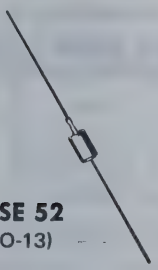
Curves apply to normal rectifier service conditions with maintained Rectifier Case Temperature (T_C) equal to or less than the values specified.

To determine the Maximum Average Current [$I_{F(AV)}$] per rectifier, multiply the RMS Current [I_f] rating by the factor given for the operating condition.

- $I_{F(AV)} = .64I_f$ for Single Phase
- $I_{F(AV)} = .57I_f$ for Three Phase and Six Phase with interphase
- $I_{F(AV)} = .40I_f$ for Six Phase Star

MR1337-1 thru MR1337-5 (SILICON)

V_R — to 400 V
I_O = 1.0



CASE 52
(DO-13)

Fast recovery silicon rectifiers designed for high-frequency power supply, inverter, and converter applications. Typical recovery time of 100 nsec extends practical frequency limit of current rectification to more than 300,000 Hz thus permitting the design of power supplies with smaller, lighter, and less expensive associated components.

MAXIMUM RATINGS

Rating	Symbol	MR 1337-1	MR 1337-2	MR 1337-3	MR 1337-4	MR 1337-5	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	300	400	500	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	Volts
Average Rectified Forward Current (single-phase resistive load) T_A=25°C Figure 2 T_A=75°C	I_O	1.0 0.75					Amp
Non-Repetitive Peak Surge Current Figure 3 (superimposed on rated current at rated voltage, T_A = 75 °C)	$I_{FM(surge)}$	30					Amp
Peak Repetitive Forward Current (T_A = 75°C)	$I_{FM(rep)}$	4.0					Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	3.75					$A^2_{(rms)}s$
Maximum Junction Operating Temperature Range	T_J	-65 to +150					°C
Maximum Case Storage Temperature Range	T_{stg}	-65 to +175					°C
Maximum Steady State DC Thermal Resistance	θ_{JA}	100					°C/Watt

FIGURE 1 — TYPICAL FORWARD CHARACTERISTICS

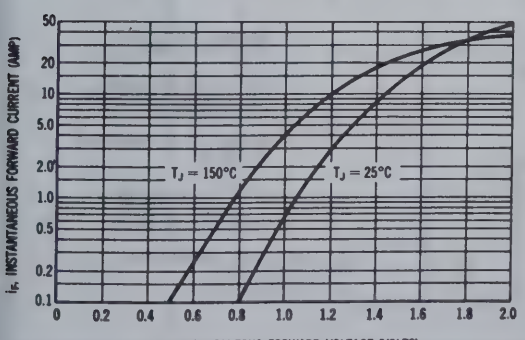
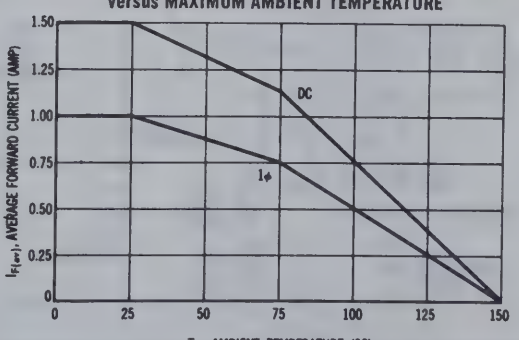


FIGURE 2 — MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM AMBIENT TEMPERATURE



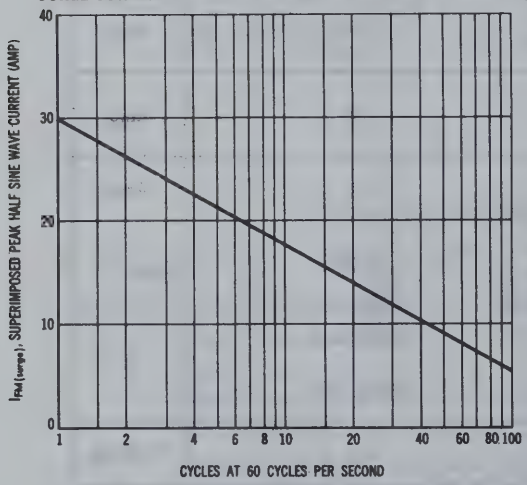
MR1337-1 thru MR1337-5 (continued)

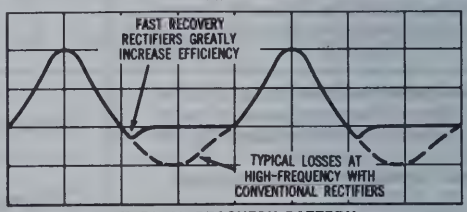
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
DC Forward Voltage Drop (I_F = 1.0 Adc, T_A = 25°C)	V_F	1.1	Vdc
Full Cycle Average Forward Voltage Drop (I_O = 0.75 Amp and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$V_{F(AV)}$	0.55	Volts
Full Cycle Average Reverse Current (I_O = 0.75 Amp and Rated V_r, T_A = 75°C, single phase)	$I_{R(AV)}$	0.75	mA
DC Reverse Current (Rated V_R, T_A = 25°C)	I_R	0.25	mA
Maximum Reverse Recovery Time (I_F = 1 Amp min)	t_{rr}	200	ns
Maximum Overshoot Current	I_{os}	2.0	Amp

FIGURE 3 — MAXIMUM ALLOWABLE NON-REPETITIVE SURGE CURRENT

(SUPERIMPOSED ON RATED CONDITIONS, $V_{RM(rep)}$ APPLIED AFTER SURGE, T_A = 75°C)





TYPICAL RECOVERY PATTERN

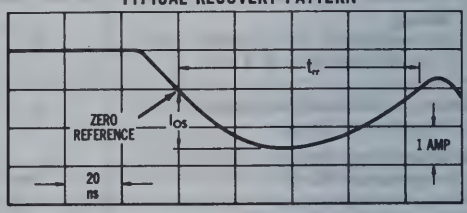
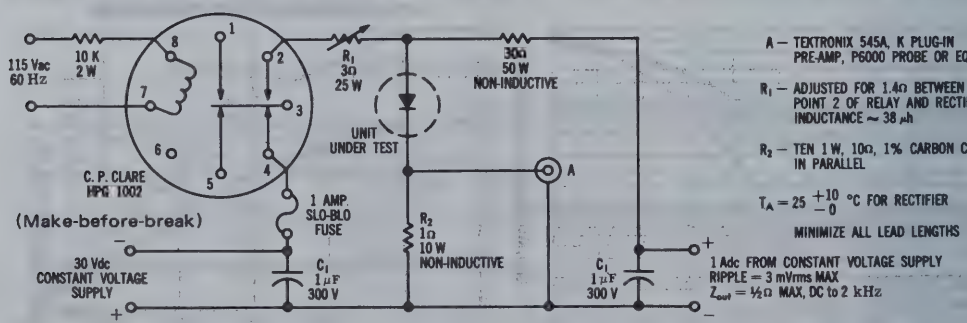


FIGURE 4 — t_{rr} TEST CIRCUIT

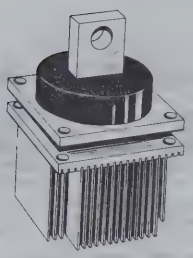


MR1366, MR1376, MR1386, MR1396

For Specifications, See 1N4933 Data.

MR2080HA (SILICON)
thru
MR2084HA

V_R = 50–400 V
I_o = 750 A



CASE 159

Multi-Cell II, power rectifier diodes designed for high-current rectifier service. The MR2080HA through MR2084HA provide single-output, high-current dc with forced air cooling.

MAXIMUM DIODE RATINGS

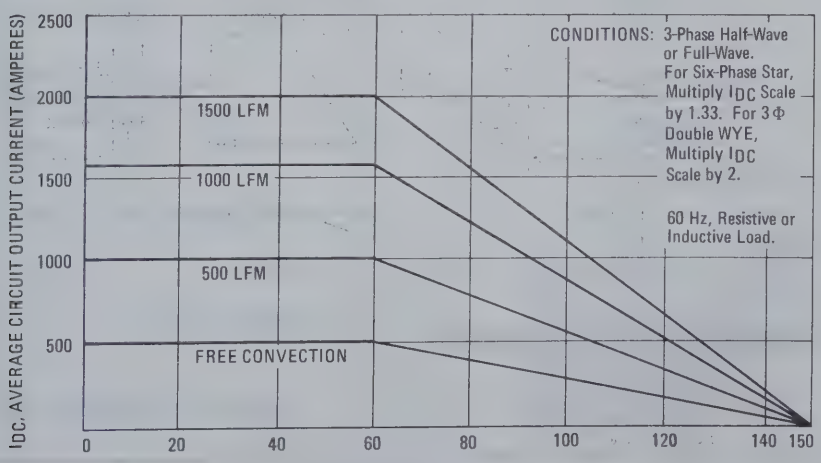
Rating	Symbol	MR2080HA	MR2081HA	MR2082HA	MR2083HA	MR2084HA	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (single-phase, resistive load, 60 Hz, T_C = 150°C)	I_o	750					Amperes
Non-Repetitive Surge Currents at Rated Conditions	$I_{FM(surge)}$	12,000 for 1/2 cycle 8,000 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150°C$, See Figure 1)

Circuit Configuration	Total Diodes Required	Total Circuit DC Output Current
Three-Phase Half-Wave (3-1-1-Y)	3 Diodes Either Polarity	2,000 Amperes
Three-Phase Full-Wave (6-1-1-B)	6 Diodes Either Polarity or 3 Diodes Each Polarity	2,000 Amperes
Six-Phase Star (6-1-1-S)	6 Diodes Either Polarity	2,600 Amperes
Six-Phase with Interphase, 3 Φ Double WYE (6-1-1-Y)	6 Diodes Either Polarity	4,000 Amperes

Maximum Operating and Storage Temperature: −65°C to +150°C (All Types)

FIGURE 1 – MAXIMUM CIRCUIT RATINGS



ELECTRICAL CHARACTERISTICS (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^oC$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^oC$	$I_{R(AV)}$	80	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^oC$	I_R	4.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150^oC. (See Figure 1).

MECHANICAL CHARACTERISTICS

POLARITY:

Standard polarity devices are CATHODE-TO-CASE, reverse polarity devices are ANODE-TO-CASE and designated by an "R" suffix, i.e., MR2083HAR.

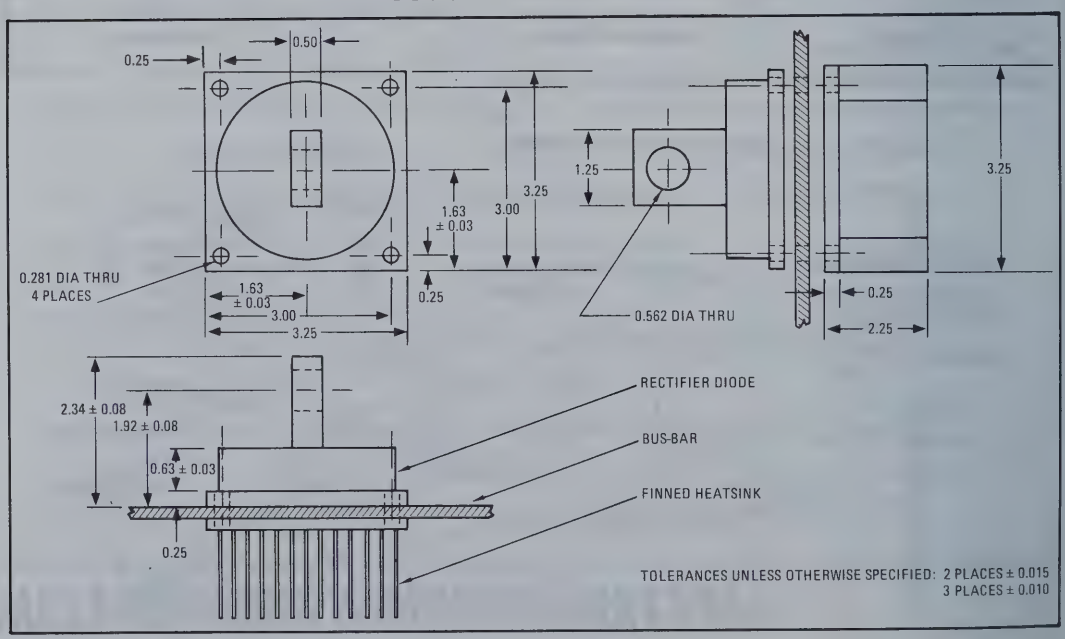
MOUNTING POSITION:

Cooling fins vertical for convection cooling or parallel to forced air flow.

MOUNTING CONFIGURATION:

The MR2080HA series is designed to be mounted as an integral part of the current carrying bus-bar network of the rectifier system as shown in the outline dimensions. The rectifier diode and finned heatsink are supplied as two separate pieces under one common type number.

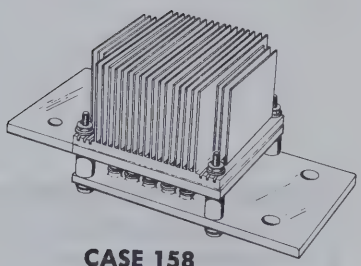
OUTLINE DIMENSIONS



MR2100HA (SILICON)
thru
MR2104HA

V_R = 50–400 V
I_o = 1100 A

Multi-Cell II, power rectifier diodes designed for high-current rectifier service. The MR2100HA through MR2104HA provide single-output, high-current dc with forced air cooling.



CASE 158

MAXIMUM DIODE RATINGS

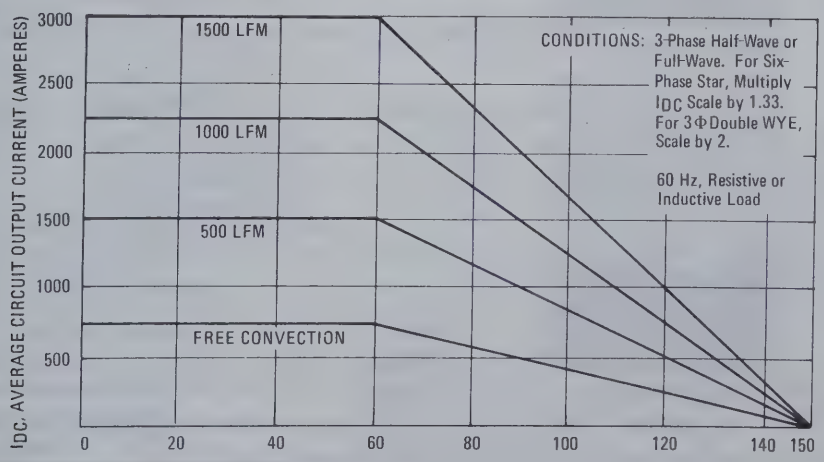
Rating	Symbol	MR2100HA	MR2101HA	MR2102HA	MR2103HA	MR2104HA	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (single-phase, resistive load, 60 Hz, T_C = 150°C)	I_o	1,100					Amperes
Non-Repetitive Surge Current at Rated Conditions	$I_{FM(surge)}$	18,000 for 1/2 cycle 14,000 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150^oC$, See Figure 1)

Circuit Configuration	Total Diodes Required	Total Circuit DC Output Current
Three-Phase Half-Wave (3-1-1-Y)	3 Diodes Either Polarity	3,000 Amperes
Three-Phase Full-Wave (6-1-1-B)	6 Diodes Either Polarity or 3 Diodes Each Polarity	3,000 Amperes
Six-Phase Star (6-1-1-S)	6 Diodes Either Polarity	4,000 Amperes
Six-Phase with Interphase, 3 Φ Double WYE (6-1-1-Y)	6 Diodes Either Polarity	6,000 Amperes

Maximum Operating and Storage Temperature: −65°C to +150°C (All Types)

FIGURE 1 MAXIMUM CIRCUIT RATINGS



ELECTRICAL CHARACTERISTICS (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, $T_C = 150^oC$	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, $T_C = 150^oC$	$I_{R(AV)}$	100	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, $T_C = 25^oC$	I_R	5.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150°C (See Figure 1).

MECHANICAL CHARACTERISTICS

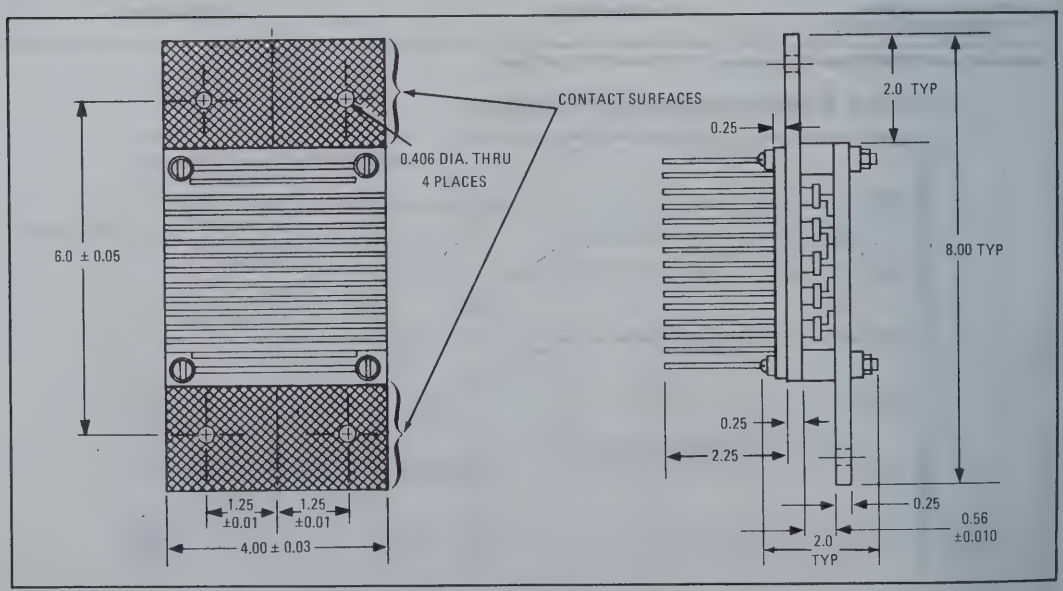
POLARITY:

Standard polarity devices are CATHODE-TO-FINNED BUS TERMINAL, reverse polarity devices are ANODE-TO-FINNED BUS TERMINAL and are designated by an "R" suffix, i.e., MR2102HAR.

MOUNTING POSITION:

Bus terminals and cooling fins vertical for convection cooling or parallel to forced air flow.

OUTLINE DIMENSIONS



MR2266 (SILICON)
MR2273

V_R to 800 V
I_O = 1.0 A



CASE 59
(DO-41)

High-voltage, axial-lead, silicon rectifiers, designed for television "damper" diode service, feature subminiature packages, high current-handling capability, excellent reliability, and economy. Flame-proof silicone polymer case.

MAXIMUM RATINGS

Rating	Symbol	MR2273	MR2266	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	200	800	Volts
RMS Reverse Voltage (Sine wave operation)	V_r	140	560	Volts
Average Rectified Forward Current (single-phase, resistive load, 60 Hz) (75°C Ambient) (100°C Ambient)	I_O	1.0 0.75	1.0 0.75	Amp
Peak Repetitive Forward Current (T_A = 25°C)	$I_{FM(rep)}$	10		Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 25°C)	$I_{FM(surge)}$	30 (for 1/2 cycle)		Amp
Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +175		°C

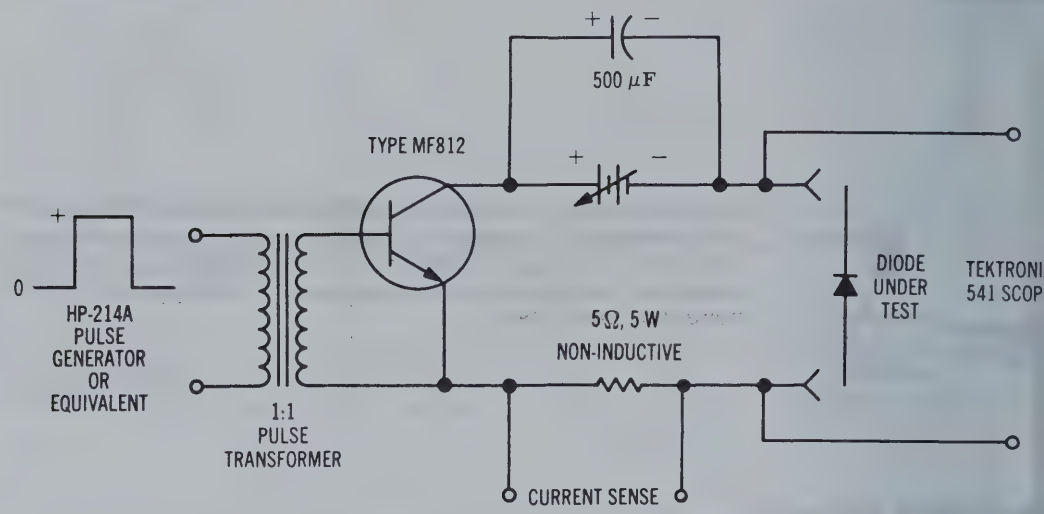
THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Ambient: θ_{JA} = 100°C/W MAX

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics		Symbol	Max	Unit
Full-Cycle Average Forward Voltage Drop (Rated Current @ 25°C, sine wave operation)		$V_{F(AV)}$	0.8	Volts
DC Forward Voltage Drop (1 Amp Continuous DC, 25°C)		V_F	1.1	Volts
DC Reverse Current @ Rated V_r	(25°C) (100°C)	I_R	0.01 0.05	mA
			Typical	
Typical Forward Peak Voltage Overshoot (Figure 1, Figure 2)	MR2266, I_F = 2 A	V_{fp}	10	Volts
	MR2273, I_F = 5 A	V_{fp}	28	Volts

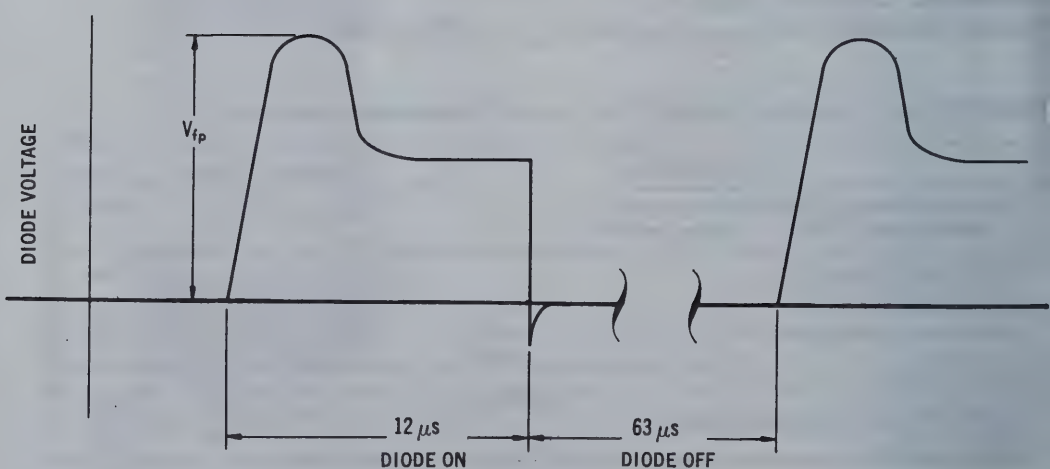
FIGURE 1 — FORWARD PEAK VOLTAGE OVERSHOOT TEST CIRCUIT



TEST PROCEDURE:

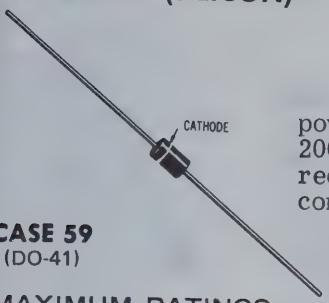
1. Adjust input pulse from generator to saturate MF812 transistor
2. Adjust battery voltage for the specified forward current after the voltage overshoot.
   I_F = 2 Amps, for MR2266
   I_F = 5 Amps, for MR2273
3. Read peak voltage overshoot across diode under test. (See Waveform Diagram).

FIGURE 2 — DIODE UNDER TEST, WAVEFORM DIAGRAM



MR2271 (SILICON)

$V_R = 300V$
$I_O = 1.0A$



CASE 59
(DO-41)

Fast recovery silicon rectifier designed for video power supply applications. Typical recovery time of 200 nsec extends practical frequency limit of current rectification to more than 150,000 Hz . Cathode is connected to case.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	300	Volts
Non-Repetitive Peak Reverse Voltage (half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	400	Volts
RMS Reverse Voltage (Sine wave operation)	V_r	210	Volts
Average Rectified Forward Current (Sine wave operation) (single-phase resistive load) $T_A = 25°C$ $T_A = 75°C$	I_O	1.0 0.75	Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, $T_A = 75°C$)	$I_{FM(surge)}$	30 (for 1/2 cycle) @ 60 Hz	Amp
Peak Repetitive Forward Current ($T_A = 75°C$)	$I_{FM(rep)}$	4.0	Amp
Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Ambient: $\theta_{JA} = 100^{o}C/W$ MAX

ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Maximum DC Forward Voltage Drop ($I_F = 1.0$ Adc, $T_A = 25°C$)	V_F	1.1	Vdc
Maximum Full Cycle Average Forward Voltage Drop ($I_O = 0.75$ Amps and Rated V_r, $T_A = 75°C$, Half Wave Rectifier, 60 Hz)	$V_{F(AV)}$	0.55	Volts
Maximum Full Cycle Average Reverse Current ($I_O = 0.75$ Amp and Rated V_r, $T_A = 75°C$, single phase, 60 Hz)	$I_{R(AV)}$	0.75	mA
Maximum DC Reverse Current (Rated V_R, $T_A = 25°C$)	I_R	0.25	mA
Maximum Reverse Recovery Time ($I_{RR} = 50$ mA) Test Circuit Figure 3	t_{rr}	200	ns
Typical Rectification Efficiency Test Circuit Figure 6	RE	Typical 90	%

FIGURE 1

FORWARD CHARACTERISTICS

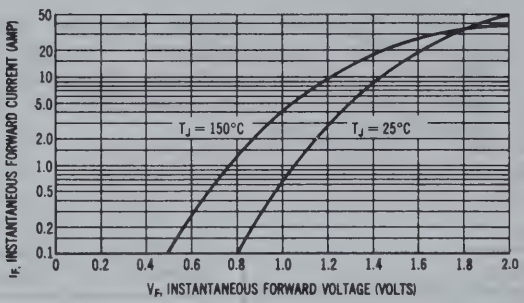


FIGURE 2

MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM AMBIENT TEMPERATURE

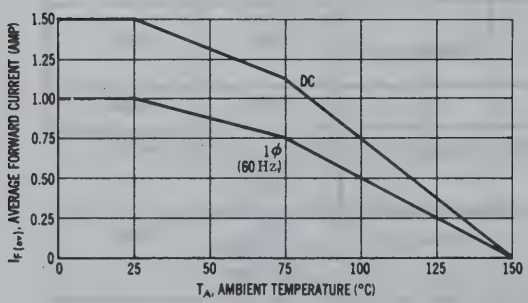


FIGURE 3

RECOVERY TIME TEST CIRCUIT

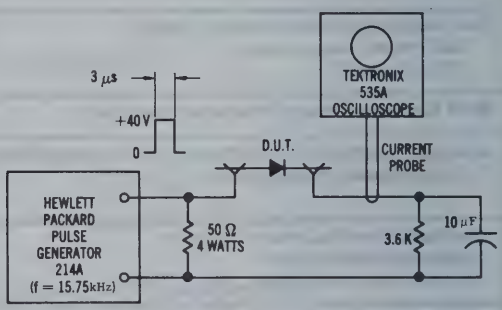


FIGURE 4

DIODE CURRENT WAVEFORM IN CIRCUIT OF FIGURE 6

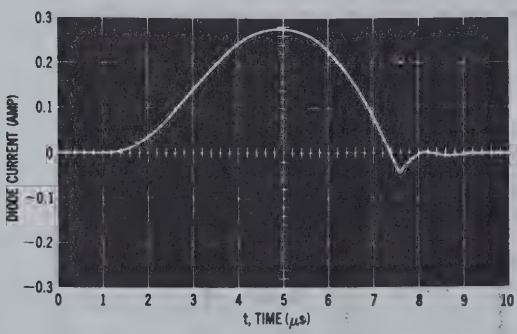


FIGURE 5

RECOVERY WAVEFORM IN CIRCUIT

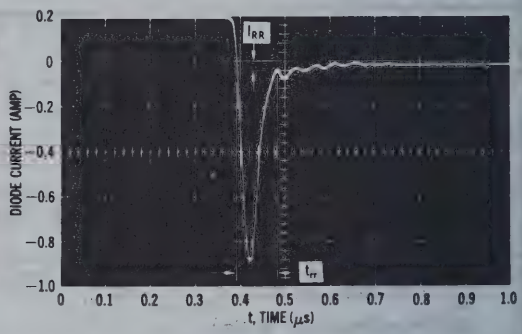
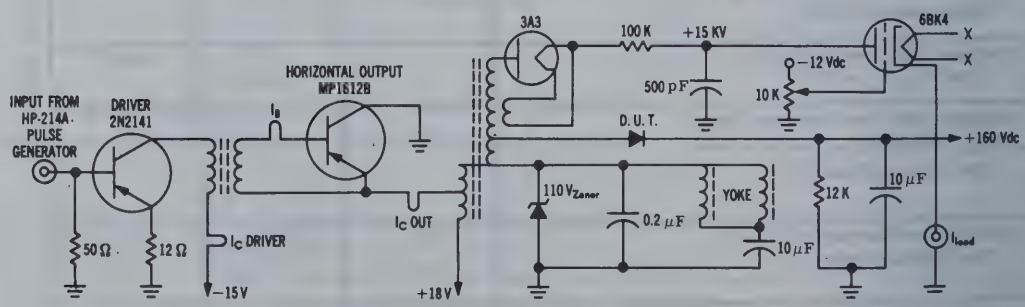


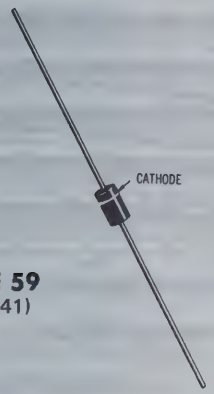
FIGURE 6

LOW VOLTAGE HORIZONTAL DEFLECTION TEST CIRCUIT



MR2272 (SILICON)

$V_R = 400$ V
$I_O = 1.0$ A



CASE 59
(DO-41)

Subminiature axial-lead silicon rectifier designed for video power-supply applications in low-voltage television receivers where video supply-voltage is obtained from horizontal deflection system.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	400	Volts
RMS Reverse Voltage (Sine wave operation)	V_r	280	Volts
Average Rectified Forward Current (Sine wave operation) (75°C Ambient) (100°C Ambient)	I_O	 1.0 0.75	Amp
Peak Repetitive Forward Current ($T_A = 75°C$)	$I_{FM(rep)}$	10	Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, $T_A = 75°C$)	$I_{FM(surge)}$	30 (for 1/2 cycle) @ 60 Hz	Amp
Juction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +175	°C

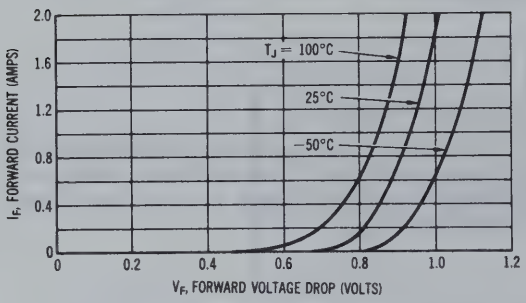
THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Ambient: $\theta_{JA} = 100°C/W$ MAX

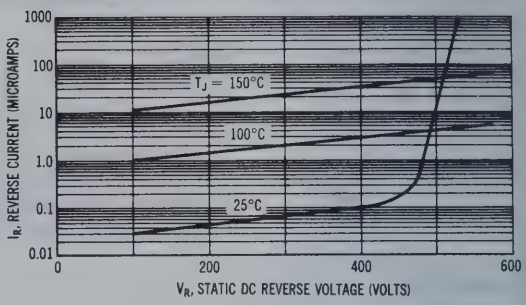
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristics	Symbol	Value	Unit
Maximum Forward Voltage Drop (1 Amp Continuous DC, 25°C)	V_F	1.1	Volts
Maximum Full Cycle Average Forward Voltage Drop ($I_O = 0.75$ Amps and Rated V_r, $T_A = 75°C$, Half Wave Rectifier, 60 Hz)	$V_{F(AV)}$	0.5	Volts
Maximum Reverse Current @ Rated DC Voltage (25°C)	I_R	0.01	mA
Maximum Reverse Recovery Time ($I_{RR} = 0.5$ Amp)	t_{rr}	1.5	μs
Rectification Efficiency (Typical)	RE	55	%

TYPICAL FORWARD CHARACTERISTICS

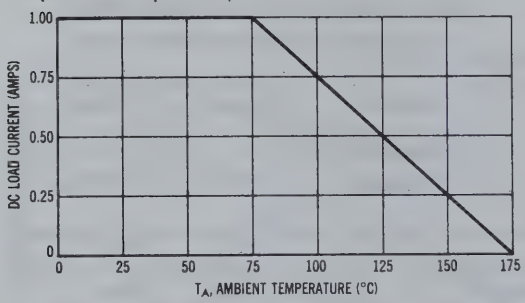


TYPICAL REVERSE CHARACTERISTICS

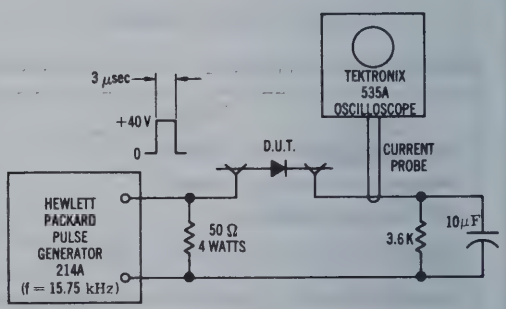


MAXIMUM ALLOWABLE DC OUTPUT

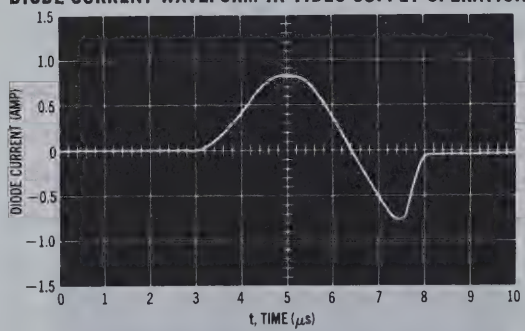
(Sine Wave Operation, Resistive or Inductive Load)



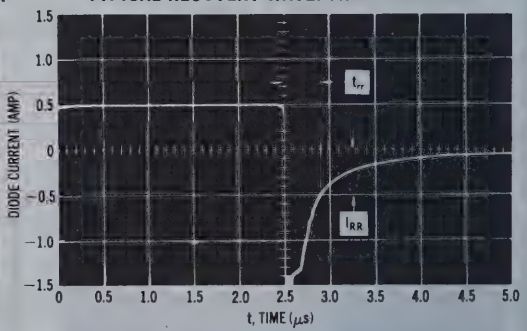
RECOVERY TIME TEST CIRCUIT



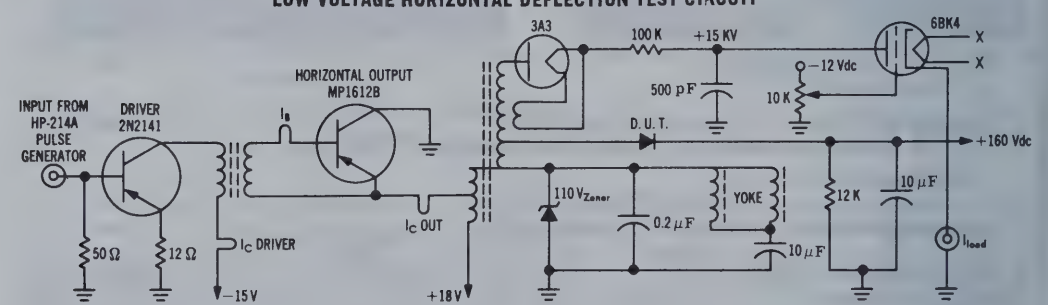
DIODE CURRENT WAVEFORM IN VIDEO SUPPLY OPERATION



TYPICAL RECOVERY WAVEFORM IN CIRCUIT



LOW VOLTAGE HORIZONTAL DEFLECTION TEST CIRCUIT



MR2273 (SILICON)

For Specifications, See MR2266 Data.

MRA130 (SILICON) thru MRA134

V_R = 50–400 V
I_{DC} = 300 A

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA130 series are air-cooled, integral rectifier assemblies engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	MRA130	MRA131	MRA132	MRA133	MRA134	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (single-phase, resistive load, 60 Hz, T_C = 150°C)	I_o	150					Amperes
Non-Repetitive Surge Currents at Rated Conditions	$I_{FM(surge)}$	3000 for 1/2 cycle 1800 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150°C$, See Figure 1)

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Single-Phase, Center Tap (2-1-1-C)	1 Diode Assembly Either Polarity	300 Amperes
Single-Phase Bridge (4-1-1-B)	2 Diode Assemblies, One Each Polarity	300 Amperes

Maximum Operating and Storage Temperature: −65°C to +150°C (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, T_C = 150°C	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, T_C = 150°C	$I_{R(AV)}$	20	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, T_C = 25°C	I_R	1.5	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150°C. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

POLARITY:

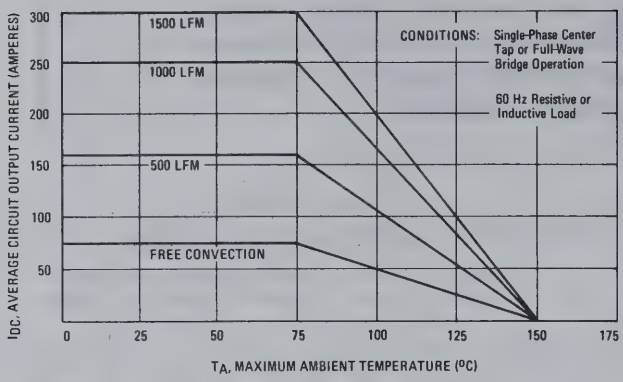
Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e., MRA131R. (See Figure 2.)

MOUNTING POSITION: Diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e., MRA132B. The bridges are composed of one common cathode and one common anode assembly. (See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

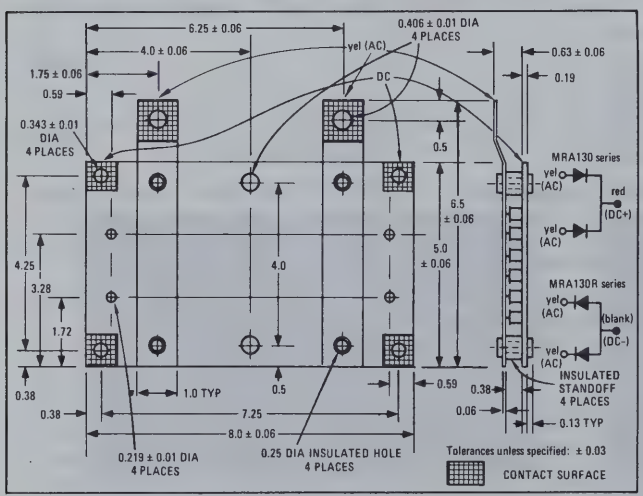
FIGURE 1 – MAXIMUM CIRCUIT RATINGS

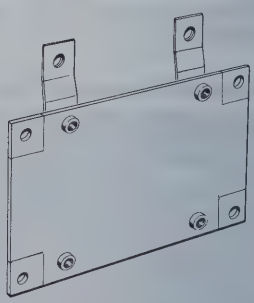




"C" CIRCUIT FOR SINGLE-PHASE OPERATION

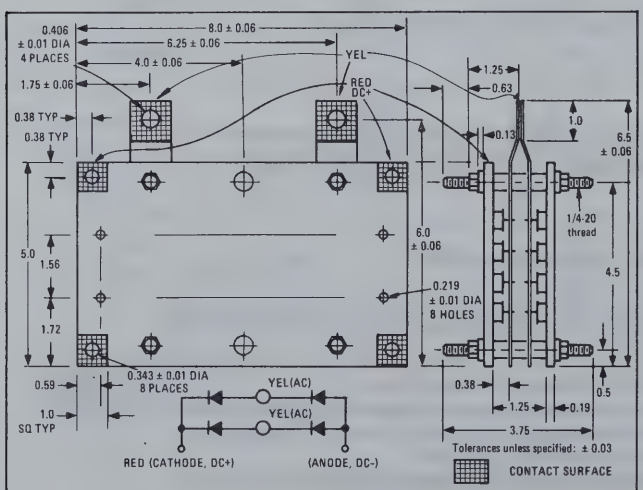
FIGURE 2 – MRA130 ("C" CIRCUIT)

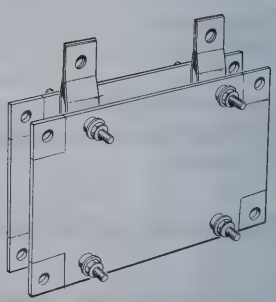




CASE 154A

FIGURE 3 – MRA130B (BRIDGE CIRCUIT)





CASE 155A

MRA160 (SILICON) thru MRA164

V_R = 50-400 V
I_{DC} = 600 A

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA160 series are air-cooled, integral rectifier assemblies engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	MRA160	MRA161	MRA162	MRA163	MRA164	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (single-phase, resistive load, 60 Hz, T_C = 150°C)	I_o	300					Amperes
Non-Repetitive Surge Currents at Rated Conditions	$I_{FM(surge)}$	6000 for 1/2 cycle 3600 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150°C$, See Figure 1)

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Single-Phase, Center Tap (2-1-1-C)	1 Diode Assembly Either Polarity	600 Amperes
Single-Phase Bridge (4-1-1-B)	2 Diode Assemblies One Each Polarity	600 Amperes

Maximum Operating and Storage Temperature: −65°C to +150°C (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, T_C = 150°C	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, T_C = 150°C	$I_{R(AV)}$	40	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, T_C = 25°C	I_R	3.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150°C. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

POLARITY:

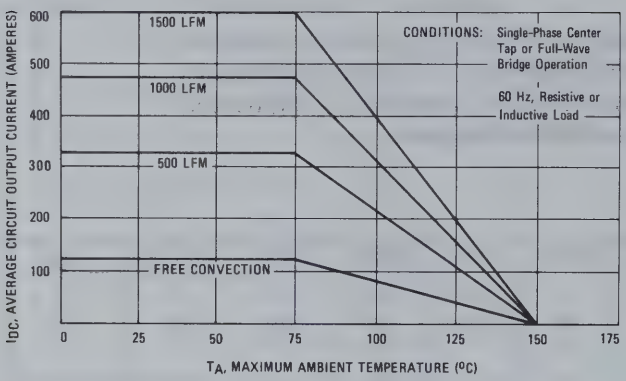
Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e.,MRA161R. (See Figure 2.)

MOUNTING POSITION: Cooling fins and diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e.,MRA162B. The bridges are composed of one common cathode and one common anode assembly. (See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

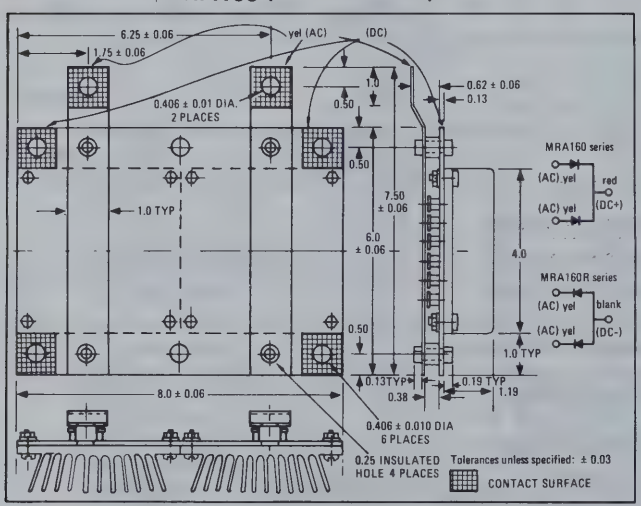
FIGURE 1 – MAXIMUM CIRCUIT RATINGS

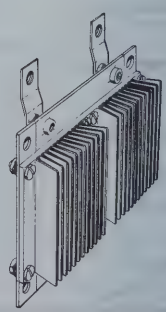




"C" CIRCUIT FOR SINGLE-PHASE OPERATION

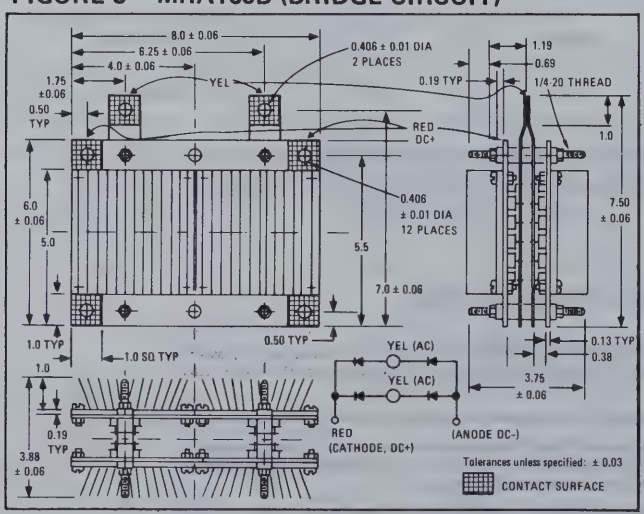
FIGURE 2 – MRA160 ("C" CIRCUIT)

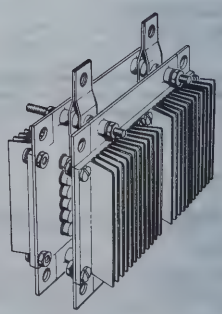




CASE 156A

FIGURE 3 – MRA160B (BRIDGE CIRCUIT)





CASE 157A

MRA330 (SILICON) thru MRA334

V_R = 50-400 V
I_{DC} = 300 A

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA330 series are air-cooled, integral rectifier assemblies engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	MRA330	MRA331	MRA332	MRA333	MRA334	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (three-phase, resistive load, 60 Hz, T_C = 150°C)	$I_{F(AV)}$	100					Amperes
Non-Repetitive Surge Currents at Rated Conditions	$I_{FM(surge)}$	2000 for 1/2 cycle 1200 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150°C$, See Figure 1)

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Three-Phase Half-Wave (3-1-1-Y)	1 Diode Assembly, Either Polarity	300 Amperes
Three-Phase Full-Wave (6-1-1-B)	2 Diode Assemblies, One Each Polarity	300 Amperes
Six-Phase Star (6-1-1-S)	2 Diode Assemblies Same Polarity	400 Amperes
Six-Phase with Interphase, 3Φ Double WYE (6-1-1-Y)	2 Diode Assemblies Same Polarity	600 Amperes

Maximum Operating and Storage Temperature: –65°C to +150°C (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, T_C = 150°C	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, T_C = 150°C	$I_{R(AV)}$	15	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, T_C = 25°C	I_R	1.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150°C. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

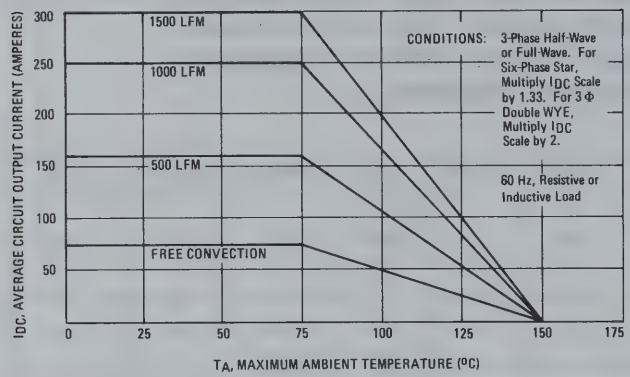
POLARITY:
Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e., MRA331R. (See Figure 2.)

MOUNTING POSITION: Diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e., MRA332B. The bridges are composed of one common cathode and one common anode assembly. (See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

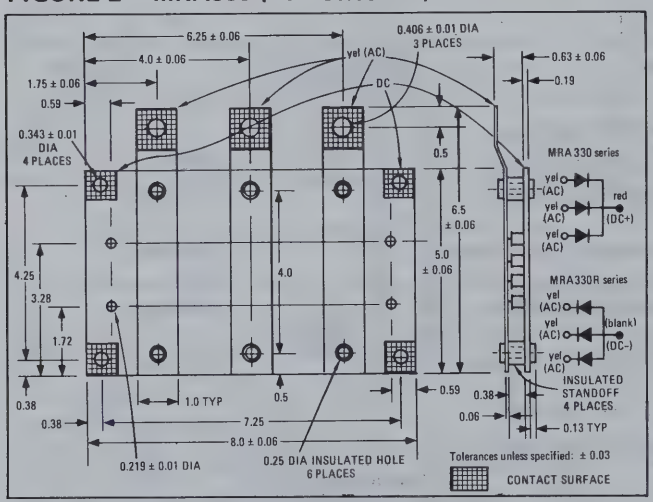
FIGURE 1 – MAXIMUM CIRCUIT RATINGS

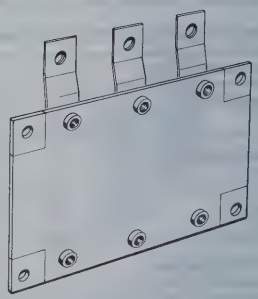




"Y" CIRCUIT
FOR POLYPHASE OPERATION

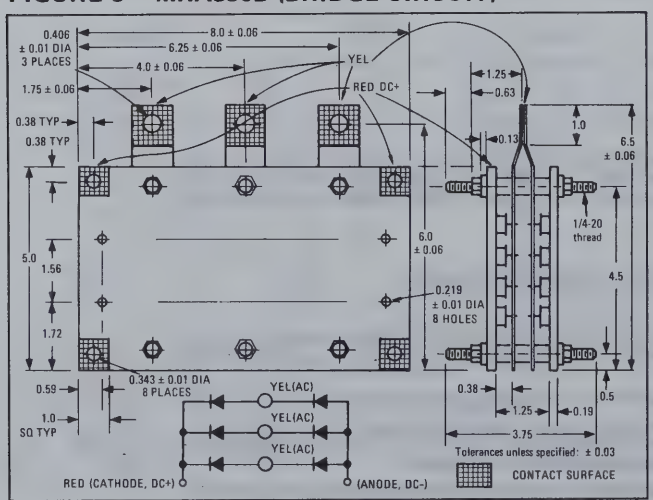
FIGURE 2 – MRA330 ("Y" CIRCUIT)

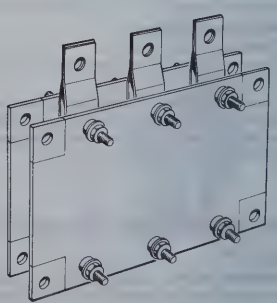




CASE 154

FIGURE 3 – MRA330B (BRIDGE CIRCUIT)





CASE 155

MRA360 (SILICON) thru MRA364

V_R = 50-400 V
I_{DC} = 650 A

Multi-Cell II, power rectifier diode circuits designed for high-current rectifier service. The MRA360 series are air-cooled, integral rectifier assemblies engineered for optimum diode/heatsink utilization.

MAXIMUM DIODE RATINGS PER CIRCUIT LEG

Rating	Symbol	MRA360	MRA361	MRA362	MRA363	MRA364	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single-phase, 60 cycle peak)	$V_{RM(non-rep)}$	75	150	300	400	500	Volts
Continuous Average Rectified Forward Current (three-phase, resistive load, 60 Hz, T_C = 150°C)	$I_{F(AV)}$	220					Amperes
Non-Repetitive Surge Currents at Rated Conditions	$I_{FM(surge)}$	5000 for 1/2 cycle 3000 for 6 cycles					Peak Amperes

MAXIMUM CIRCUIT RATINGS (All Types, $T_C \leq 150°C$, See Figure 1).

Circuit Configuration	Total Diodes Required	Max Total Circuit DC Output Current
Three-Phase Half-Wave (3-1-1-Y)	1 Diode Assembly Either Polarity	650 Amperes
Three-Phase Full-Wave (6-1-1-B)	2 Diode Assemblies, One Each Polarity	650 Amperes
Six-Phase Star (6-1-1-S)	2 Diode Assemblies Same Polarity	870 Amperes
Six-Phase with Interphase, 3ΦDouble WYE (6-1-1-Y)	2 Diode Assemblies Same Polarity	1300 Amperes

Maximum Operating and Storage Temperature: −65°C to +150°C (All Types)

ELECTRICAL CHARACTERISTICS PER CIRCUIT LEG (All Types)

Characteristic And Conditions	Symbol	Maximum Limit	Units
Full-Cycle Average Forward Voltage Drop at Rated Load, T_C = 150°C	$V_{F(AV)}$	0.5	Volts
Full-Cycle Average Reverse Current at Rated Load, T_C = 150°C	$I_{R(AV)}$	40	Milliamperes
DC Reverse Current at Rated Reverse Voltage, V_R, T_C = 25°C	I_R	3.0	Milliamperes

NOTE: A portion of the internal power losses of the rectifier may be conducted from the device by the connecting bus-bar or cables and can vary depending on mounting conditions. The above ratings are based on conditions where at any rating point of output current, ambient temperature and air flow, the assembly case temperature is not allowed to exceed 150°C. (See Figure 1).

OUTLINE DIMENSIONS AND MECHANICAL CHARACTERISTICS

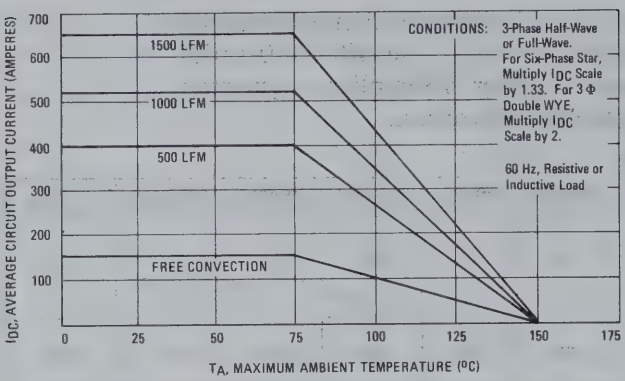
POLARITY:
Standard polarity assemblies are CATHODES-TO-HEATSINK, (COMMON CATHODE). Reverse polarity assemblies are ANODES-TO-HEATSINK (COMMON ANODE) and are designated by an "R" suffix, i.e., MRA361R. (See Figure 2)

MOUNTING POSITION: Cooling fins and diode legs vertical for convection cooling or parallel to forced air flow.

FULL-WAVE BRIDGE ASSEMBLIES are available completely assembled with electrically insulated hardware suitable for easy mounting. The bridge assembly is designated by a "B" suffix, i.e., MRA362B. The bridges are composed of one common cathode and one common anode assembly. (See Figure 3)

CUSTOM RECTIFIER ASSEMBLIES are available in a variety of current and voltage ranges using the basic MULTI-CELL II construction techniques.

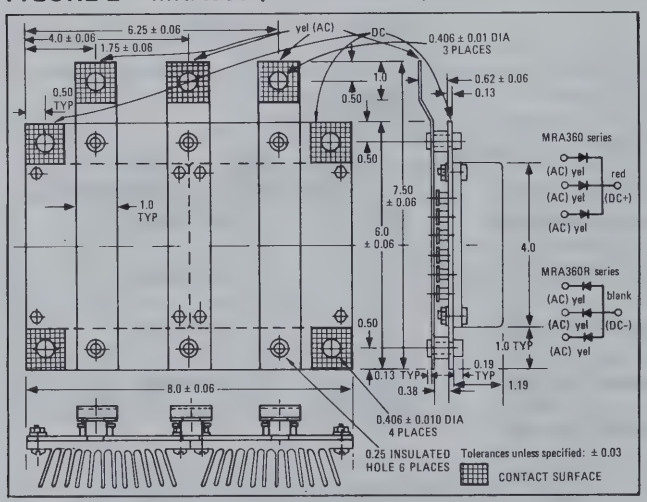
FIGURE 1 – MAXIMUM CIRCUIT RATINGS

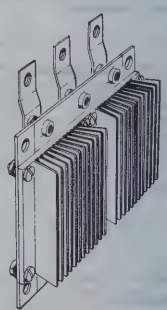




"Y" CIRCUIT
FOR POLYPHASE OPERATION

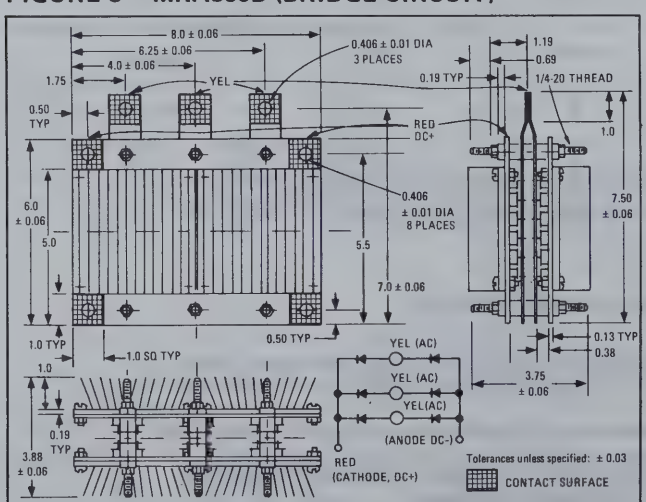
FIGURE 2 – MRA360 ("Y" CIRCUIT)

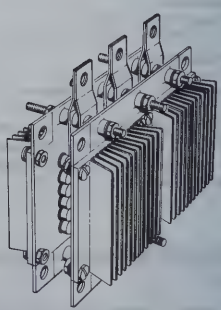




CASE 156

FIGURE 3 – MRA360B (BRIDGE CIRCUIT)





CASE 157

MRD100 (SILICON)
MRD150

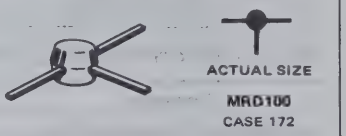
PLASTIC NPN SILICON PHOTO TRANSISTORS

. . . designed for application in punched card and tape readers, pattern and character recognition equipment, shaft encoders, industrial inspection processing and control, counters, sorters, switching and logic circuits, or any design requiring radiation sensitivity, stable characteristics and high-density mounting.

- Economical Plastic Package
- Available With External Base Lead (MRD100) or Without External Base Lead (MRD150)
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wide Application
- Small Size for High-Density Mounting
- Minimum Sensitivity (0.04 mA/mW/cm^2) for Design Flexibility
- Annular Passivated Structure for Stability and Reliability

40 VOLT MICRO-T PHOTO TRANSISTORS NPN SILICON

50 MILLIWATTS

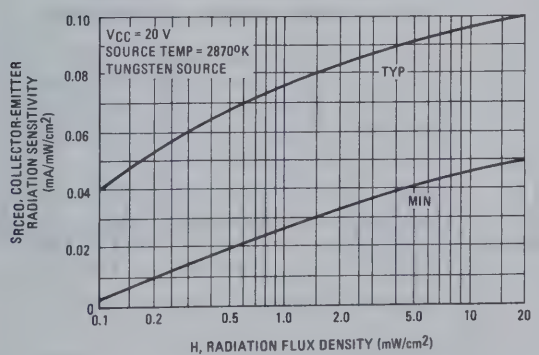


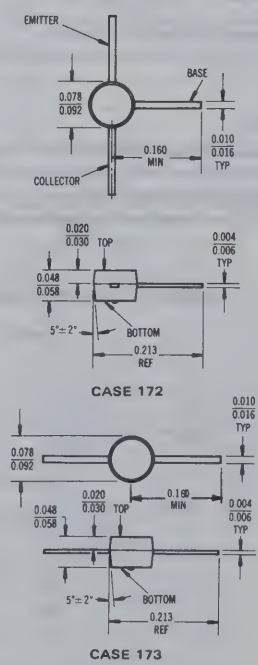


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Volts
Emitter-Collector Voltage	V_{ECO}	6.0	Volts
Collector-Base Voltage	V_{CBO}	80	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	50 0.7	mW mW/°C
Operating Junction Temperature Range Storage Temperature Range	T_J T_{stg}	−40 to +85 −40 to +100	°C °C

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY





CASE 172

CASE 173

Collector indicated by arrow on bottom of device.

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Units
Collector Dark Current (V_{CC} = 20 V; R_L = 100 ohms; Base Open) (Note 2) T_A = 25°C T_A = 85°C	–	I_{CEO}	– –	– 5.0	0.10 –	μA
Collector-Base Breakdown Voltage (I_C = 100 μA; Emitter Open; Note 2 and 4)	–	BV_{CBO}	80	–	–	Volts
Collector-Emitter Breakdown Voltage (I_C = 100 μA; Base Open; Note 2)	–	BV_{CEO}	40	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA; Base Open; Note 2)	–	BV_{ECO}	6.0	–	–	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Units
Collector-Emitter Radiation Sensitivity (V_{CC} = 20 V; R_L = 100 ohms; Base Open) (Note 1)	1	S_{RCEO}	0.04	0.09	–	mA/mW/cm^2
Collector-Base Radiation Sensitivity (V_{CC} = 20 V; R_L = 100 ohms; Emitter Open) (Notes 1 and 4)	–	S_{RCBO}	0.3	0.4	–	μA/mW/cm^2
Photo Current Rise Time (Note 3)	2 and 3	t_r	–	–	2.5	μs
Photo Current Fall Time (Note 3)	2 and 3	t_f	–	–	4.0	μs
Wavelength of Maximum Sensitivity	9	$\lambda_{s(typ)}$	–	0.8	–	μm

NOTES:

1. Radiation Flux Density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870°K.
2. Measured under dark conditions. (H≈0).
3. For unsaturated rise time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode (λ = 0.9 μm) with a pulse width equal to or greater than 10 microseconds (see Figure 2 and Figure 3).
4. This characteristic applies only to the MRD100 since no base lead is available on the MRD150.

FIGURE 2 – PULSE RESPONSE TEST CIRCUIT

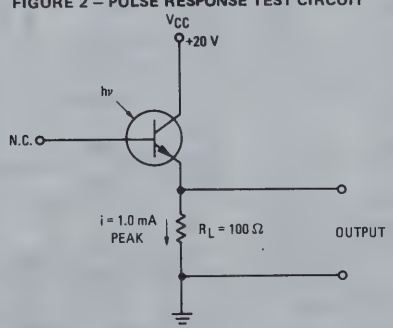
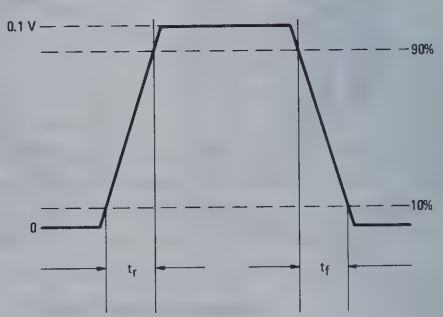


FIGURE 3 – PULSE RESPONSE TEST WAVEFORM



TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 4 – COLLECTOR-EMITTER CHARACTERISTICS

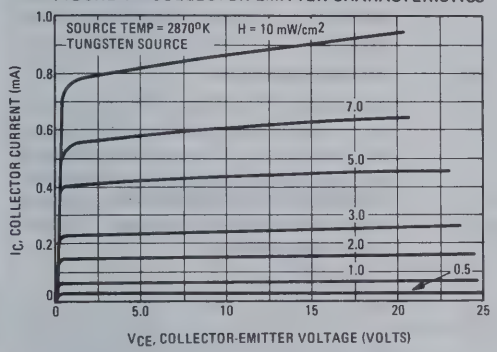


FIGURE 5 – COLLECTOR SATURATION CHARACTERISTICS

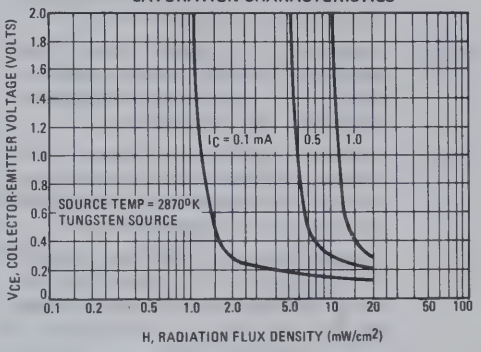


FIGURE 6 – DARK CURRENT versus TEMPERATURE

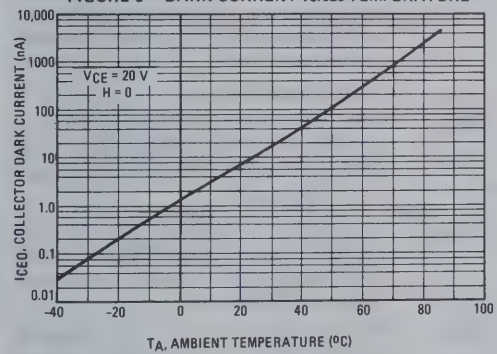


FIGURE 7 – DARK CURRENT versus VOLTAGE

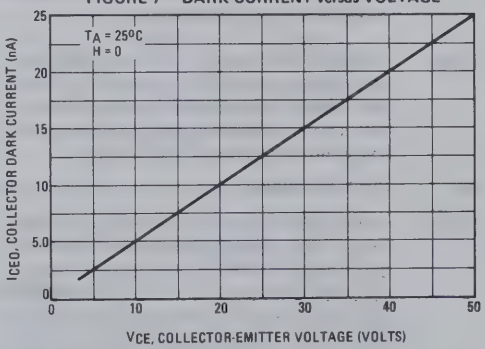


FIGURE 8 – ANGULAR RESPONSE

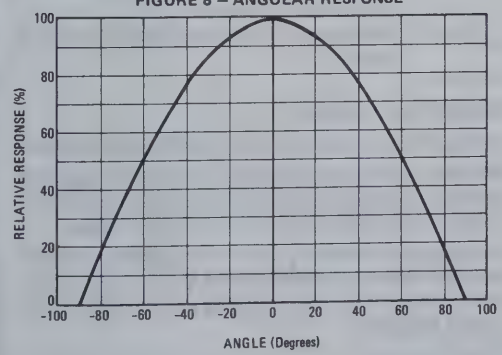
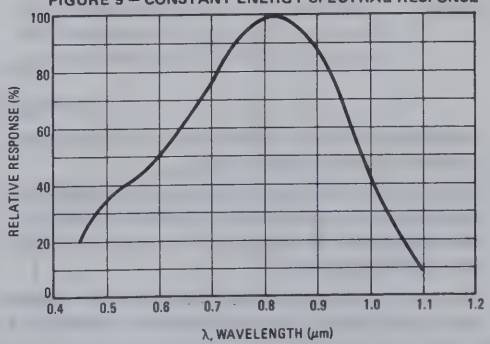


FIGURE 9 – CONSTANT ENERGY SPECTRAL RESPONSE



MRD100 AND MRD150

OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_{CBO} Collector-Base Breakdown Voltage — The minimum dc breakdown voltage, collector to base, at stated collector current and ambient temperature. (Emitter open and $H \approx 0$)

BV_{CEO} Collector-Emitter Breakdown Voltage — The minimum dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open and $H \approx 0$)

BV_{ECO} Emitter-Collector Breakdown Voltage — The minimum dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open and $H \approx 0$)

E Luminous Flux Density (Illuminance) [lumens/ft.^{2} = ft. candles] — The radiation flux density of wavelength within the band of visible light.

H Radiation Flux Density (Irradiance) [mW/cm^2] — The total incident radiation energy measured in power per unit area.

I_{CEO} Collector Dark Current — The maximum current through the collector terminal of the device measured under dark conditions, ($H \approx 0$), with a stated collector voltage, load resistance, and ambient temperature. (Base open)

P_D Power Dissipation

S_{RCBO} Collector-Base Radiation Sensitivity (μA/mW/cm^2) — The ratio of photo-induced collector-base current to the incident radiant energy measured at the plane of the lens of the photo device under stated conditions of radiation flux density (H), collector voltage, base load resistance, and ambient temperature. (Emitter open)

S_{RCEO} Collector-Emitter Radiation Sensitivity (mA/mW/cm^2) — The ratio of photo-induced, collector-emitter current to the incident radiant energy measured at the plane of the lens of the photodevice under stated conditions of radiation flux density (H), collector voltage, load resistance, and ambient temperature. (Base open)

T_A Ambient Temperature

t_f Photo Current Fall Time — The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the GaAs (gallium-arsenide) source pulse under stated conditions of collector voltage, load resistance and ambient temperature. (See Note 3 and Figures 2 and 3)

T_J Junction Temperature

t_r Photo Current Rise Time — The response time for the photo-induced current to rise from the 10% point to the 90% point when pulsed with the stated GaAs (gallium-arsenide) source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 3 and Figures 2 and 3)

T_{stg} Storage Temperature

V_{CBO} Collector-Base Voltage — The maximum allowable value of the collector-base voltage which can be applied to the device at the rated temperature. (Base open)

V_{CEO} Collector-Emitter Voltage — The maximum allowable value of collector-emitter voltage which can be applied to the device at the rated temperature. (Base open)

V_{ECO} Emitter-Collector Voltage — The maximum allowable value of emitter-collector voltage which can be applied to the device at the rated temperature. (Base open)

$\lambda_s(\mu m)$ Wavelength of maximum sensitivity in micrometers.

CUSTOM OPTOELECTRONIC ARRAYS

The MRD100/150 is also available in custom designed arrays or matrices as well as in discrete form.

These arrays can be designed to meet customer requirements for punched card and tape readers, position indicators, pattern and character recognition, shaft encoders, and many other special applications.

The arrays are pre-assembled and tested, ready for installation into the system eliminating the special handling and testing problems associated with the small photo detectors.

The custom arrays can be manufactured in almost any shape to allow maximum design flexibility; they can also be matched for sensitivity to assure more uniform output.

Specifying optoelectronic arrays is easy; all that is required is a print of the array and the desired specifications; or your representative will assist in developing specifications for your special applications.

MRD200 (SILICON)



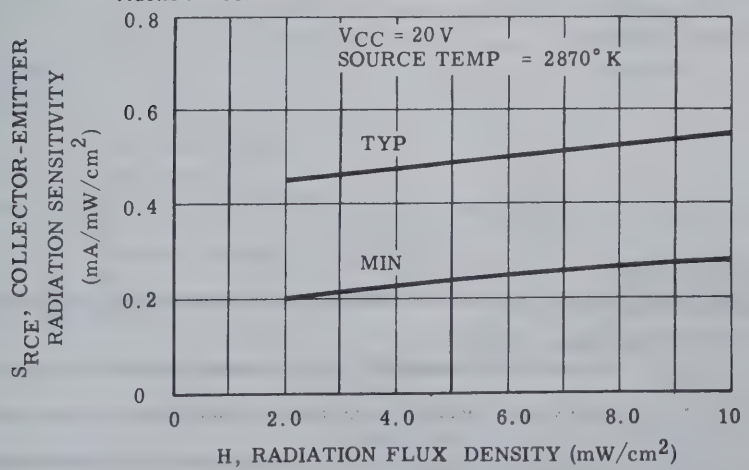
CASE 81
(DO-31)

NPN silicon high sensitivity photo detector designed for application in card and tape readers, pattern and character recognition, and shaft encoders, or any design requiring high radiation sensitivity, stable characteristics, and high-density mounting.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating (NOTE 1)	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Total Device Dissipation @ T_A = 25°C	P_D	50	mW
Derate above 25°C		0.5	mW/°C
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

FIGURE 1 — COLLECTOR-EMITTER SENSITIVITY



STATIC ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristics (NOTE 1)	Fig. No.	Symbol	Min	Typ	Max	Units
Collector Dark Current (V_{CC} = 20 V; R_L = 100 ohms) (Note 3) $T_A = 25°C$ $T_A = 100°C$	—	I_{CEO}	 — —	 — 10	 0.025 —	μA
Collector-Emitter Breakdown Voltage (I_C = 100 μA) (Note 3)	—	BV_{CEO}	50	—	—	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA) (Note 3)	—	BV_{ECO}	7.0	—	—	Volts

OPTICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristics (NOTE 1)	Fig. No.	Symbol	Min	Typ	Max	Units
Collector-Emitter Radiation Sensitivity (V_{CC} = 20 V; R_L = 100 ohms)(Note 2)	1	S_{RCE}	0.25	0.5	—	$mA/mW/cm^2$
Collector-Emitter Illumination Sensitivity (V_{CC} = 20 V; R_L = 100 ohms)(Note 4)	—	S_{ICE}	2.0	5.0		$\mu A/lum/ft^2$
Photo Current Saturated Rise Time (Note 5)	4	$t_{r(sat)}$	—	1.0	—	μs
Photo Current Saturated Fall Time (Note 5)	4	$t_{f(sat)}$	—	10	—	μs
Photo Current Rise Time (Note 6)	4	t_r	—	—	2.5	μs
Photo Current Fall Time (Note 6)	4	t_f	—	—	4.0	μs
Wavelength of Maximum Sensitivity	—	λS(typ)	—	0.8	—	Microns

NOTES:

1. No base terminal available.
2. Radiation flux density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of $2870°K$.
3. Measured under dark conditions. ($H \approx 0$)
4. Luminous flux density (E) equal to 100 lumens/ft^2. (100 ft. -candles) measured through two Corning CS1-69 filters.
5. For saturated rise time measurements, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 microsecond (see Figure 4).
6. For unsaturated rise time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode ($\lambda \approx 0.9$ microns) with a pulse width equal or greater than 10 microseconds (see Figure 4).

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 — COLLECTOR-EMITTER CHARACTERISTICS

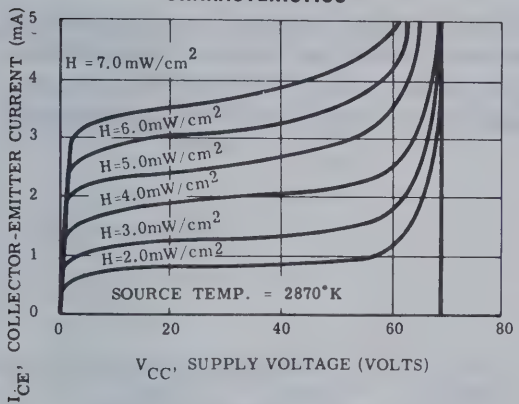


FIGURE 3 — PHOTO CURRENT vs TEMPERATURE

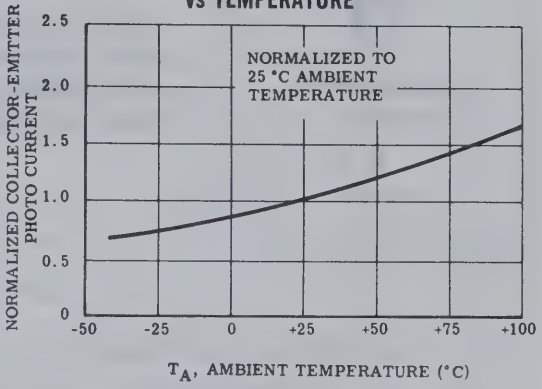
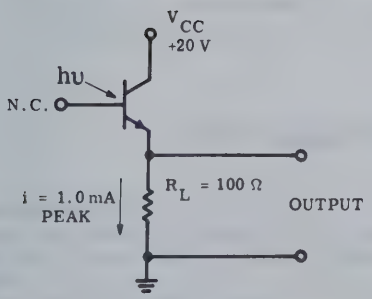
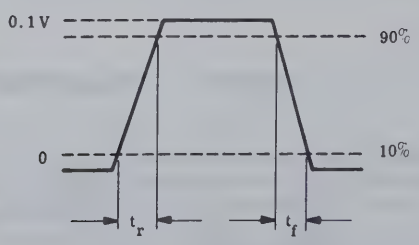


FIGURE 4 — PULSE RESPONSE TEST CIRCUIT



TEST CIRCUIT



OUTPUT VOLTAGE WAVEFORM

MRD210 (SILICON)



CASE 81
(DO-31)



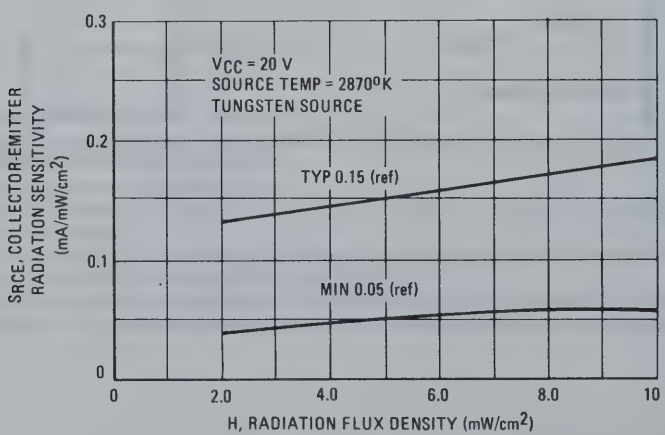
Actual Size

NPN silicon photo detector designed for application in card and tape readers, pattern and character recognition, and shaft encoders, or any design requiring radiation sensitivity, stable characteristics, and high-density mounting.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating (Note 1)	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Total Device Dissipation @ T_A = 25°C	P_D	50	mW
Derate above 25°C		0.5	mW/°C
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY



STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic (Note 1)	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 20 V, R_L = 100 ohms, Note 3)	I_{CEO}				μA
T_A = 25°C		-	-	0.025	
T_A = 100°C		-	10	-	
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	BV_{CEO}	50	-	-	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA)	BV_{ECO}	7.0	-	-	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic (Note 1)	Fig. No.	Symbol	Min	Typ	Max	Unit
Collector-Emitter Radiation Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 2)	1	S_{RCE}	0.05	0.15	-	mA/mW/cm^2
Collector-Emitter Illumination Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 4)	-	S_{ICE}	0.4	1.2	-	μA/lum/ft^2
Photo Current Saturated Rise Time (Note 5)	4	$t_{r(sat)}$	-	1.0	-	μs
Photo Current Saturated Fall Time (Note 5)	4	$t_{f(sat)}$	-	10	-	μs
Photo Current Rise Time (Note 6)	4	t_r	-	-	2.5	μs
Photo Current Fall Time (Note 6)	4	t_f	-	-	4.0	μs
Wavelength of Maximum Sensitivity	-	λ_s	-	0.8	-	μm

NOTES:

1. No base terminal available.
2. Radiation flux density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870°K.
3. Measured under dark conditions. (H≈0).
4. Luminous flux density (E) equal to 100 lumens/ft^2 (100 ft-candles) measured through two Corning CS1-69 filters.
5. For saturated rise time measurements, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 microsecond (see Figure 4).
6. For unsaturated rise time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode ($\lambda \approx 0.9$ μm) with a pulse width equal to or greater than 10 microseconds (see Figure 4).

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – COLLECTOR-EMITTER CHARACTERISTICS

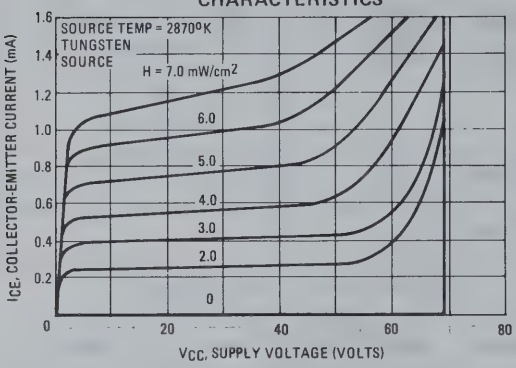


FIGURE 3 – PHOTO CURRENT versus TEMPERATURE

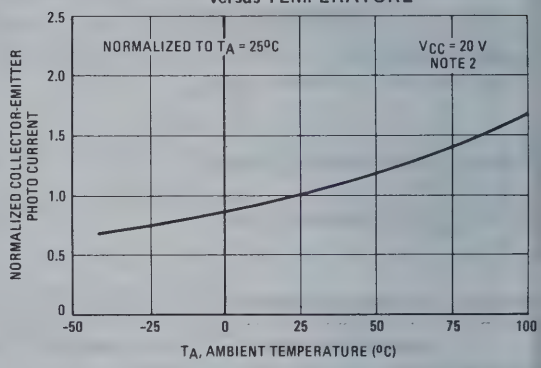
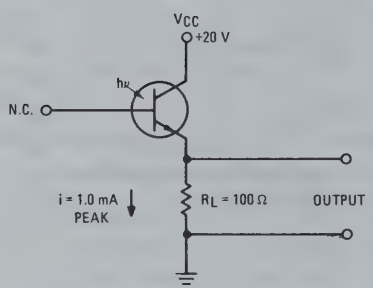
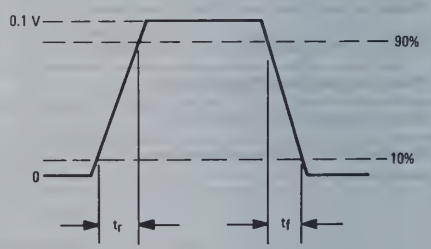


FIGURE 4 – PULSE RESPONSE TEST CIRCUIT AND WAVEFORM





CUSTOM OPTOELECTRONIC ARRAYS

The MRD 210 is also available in custom designed arrays or matrices as well as in discrete form.

These arrays can be designed to meet customer requirements for punched card and tape readers, position indicators, pattern and character recognition, shaft encoders, and many other special applications.

The arrays are pre-assembled and tested, ready for installation into the system eliminating the special handling and testing problems associated with the small photo detectors.

The custom arrays can be manufactured in almost any shape to allow maximum design flexibility; they can also be matched for sensitivity to assure more uniform output.

Specifying optoelectronic arrays is easy; all that is required is a print of the array and the desired specifications; or our representative will assist in developing specifications for your special application.

MRD210

OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_{CEO} Collector-Emitter Breakdown Voltage – The minimum dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open and $H \approx 0$)

BV_{ECO} Emitter-Collector Breakdown Voltage – The minimum dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open and $H \approx 0$)

E Luminous Flux Density (Illuminance) [lumens/ft.^{2} = ft. candles] – The radiation flux density of wavelength within the band of visible light.

H Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.

I_{CEO} Collector Dark Current – The maximum current through the collector terminal of the device measured under dark conditions, ($H \approx 0$), with a stated collector voltage, load resistance, and ambient temperature. (Base open)

P_D Power Dissipation

S_{ICEO} Collector-Emitter Illumination Sensitivity (μA/lumen/ft.^{2} = μA/ft. candle) – The ratio of photo-induced, collector-emitter current to the incident luminous energy measured at the plane of the lens of the photodevice under stated conditions of luminous flux density (E), collector voltage, load resistance, and ambient temperature. (Base open)

S_{RCEO} Collector-Emitter Radiation Sensitivity (mA/mW/cm^2) – The ratio of photo-induced, collector-emitter current to the incident radiant energy measured at the plane of the lens of the photodevice under stated conditions of radiation flux density (H), collector voltage, load resistance, and ambient temperature. (Base open)

T_A Ambient Temperature

t_f Photo Current Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the GaAs (gallium-arsenide) source pulse under stated conditions of collector voltage, load resistance and ambient temperature. (See Note 6 and Figure 4)

$t_{f(sat)}$ Photo Current Saturated Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the saturating xenon light source pulse under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 5 and Figure 4)

T_J Junction Temperature

t_r Photo Current Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when pulsed with the stated GaAs (gallium-arsenide) source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 6 and Figure 4)

$t_{r(sat)}$ Photo Current Saturated Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when driven into saturation by the stated xenon source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 5 and Figure 4)

T_{stg} Storage Temperature

V_{CEO} Collector-Emitter Voltage – The maximum allowable value of collector-emitter voltage which can be applied to the device at the rated temperature. (Base open)

V_{ECO} Emitter-Collector Voltage – The maximum allowable value of emitter-collector voltage which can be applied to the device at the rated temperature. (Base open)

$\lambda_s(\mu m)$ Wavelength of maximum sensitivity in micro meters.

MRD250 (SILICON)



CASE 81A-01



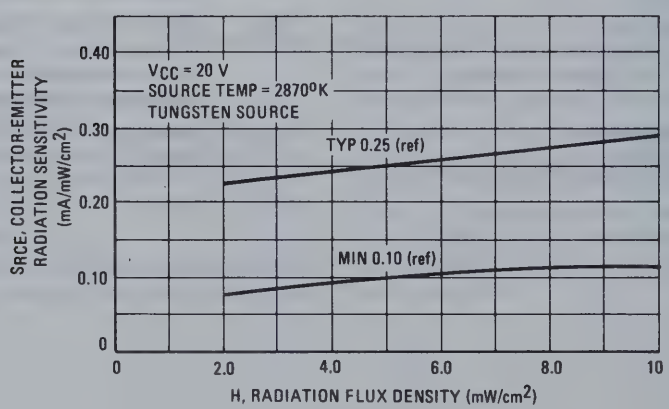
Actual Size

NPN silicon photo detector designed for application in card and tape readers, pattern and character recognition, and shaft encoders, or any design requiring radiation sensitivity, stable characteristics, and high-density mounting.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating (Note 1)	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Total Device Dissipation @ T_A = 25°C	P_D	50	mW
Derate above 25°C		0.5	mW/°C
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY



STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic (Note 1)	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 20 V, R_L = 100 ohms, Note 3)	I_{CEO}				μA
T_A = 25°C		-	-	0.025	
T_A = 100°C		-	10	-	
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	BV_{CEO}	50	-	-	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA)	BV_{ECO}	7.0	-	-	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic (Note 1)	Fig. No.	Symbol	Min	Typ	Max	Unit
Collector-Emitter Radiation Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 2)	1	S_{RCE}	0.10	0.25	-	mA/mW/cm^2
Collector-Emitter Illumination Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 4)	-	S_{ICE}	0.8	2.5	-	μA/lum/ft^2
Photo Current Saturated Rise Time (Note 5)	4	$t_{r(sat)}$	-	1.0	-	μs
Photo Current Saturated Fall Time (Note 5)	4	$t_{f(sat)}$	-	10	-	μs
Photo Current Rise Time (Note 6)	4	t_r	-	-	2.5	μs
Photo Current Fall Time (Note 6)	4	t_f	-	-	4.0	μs
Wavelength of Maximum Sensitivity	-	λ_s	-	0.8	-	μm

NOTES:

1. No base terminal available.
2. Radiation flux density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870°K.
3. Measured under dark conditions. (H≈0).
4. Luminous flux density (E) equal to 100 lumens/ft^2 (100 ft-candles) measured through two Corning CS1-69 filters.
5. For saturated rise time measurements, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 microsecond (see Figure 4).
6. For unsaturated rise time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode ($\lambda \approx 0.9$ μm) with a pulse width equal to or greater than 10 microseconds (see Figure 4).

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – COLLECTOR-EMITTER CHARACTERISTICS

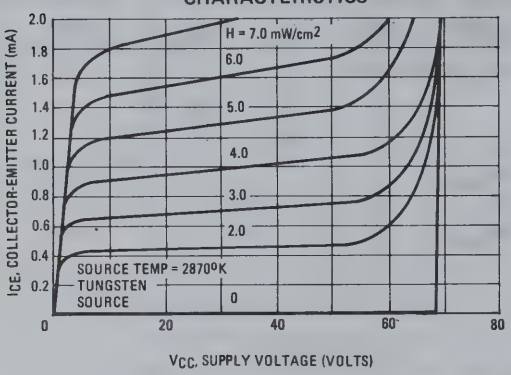


FIGURE 3 – PHOTO CURRENT versus TEMPERATURE

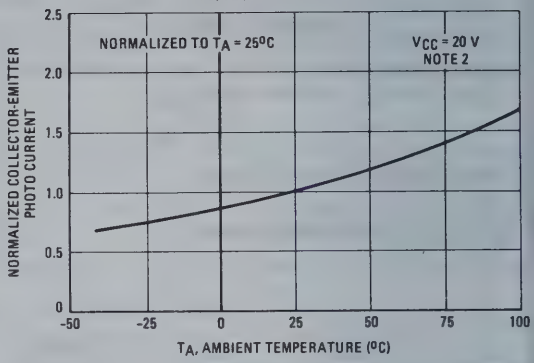
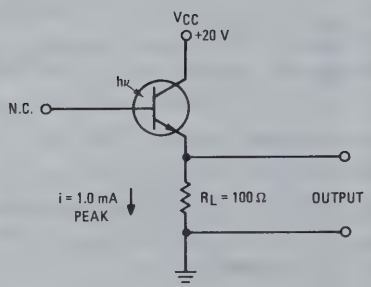
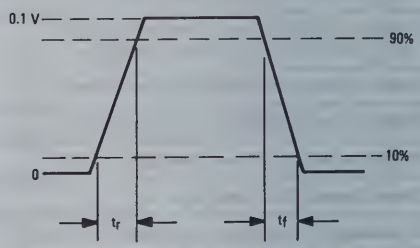


FIGURE 4 – PULSE RESPONSE TEST CIRCUIT AND WAVEFORM





CUSTOM OPTOELECTRONIC ARRAYS

The MRD 250 is also available in custom designed arrays or matrices as well as in discrete form.

These arrays can be designed to meet customer requirements for punched card and tape readers, position indicators, pattern and character recognition, shaft encoders, and many other special applications.

The arrays are pre-assembled and tested, ready for installation into the system eliminating the special handling and testing problems associated with the small photo detectors.

The custom arrays can be manufactured in almost any shape to allow maximum design flexibility; they can also be matched for sensitivity to assure more uniform output.

Specifying optoelectronic arrays is easy; all that is required is a print of the array and the desired specifications; or our representative will assist in developing specifications for your special application.

MRD250

OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_{CEO} Collector-Emitter Breakdown Voltage – The minimum dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open and $H \approx 0$)

BV_{ECO} Emitter-Collector Breakdown Voltage – The minimum dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open and $H \approx 0$)

E Luminous Flux Density (Illuminance) [lumens/ft.^{2} = ft. candles] – The radiation flux density of wavelength within the band of visible light.

H Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.

I_{CEO} Collector Dark Current – The maximum current through the collector terminal of the device measured under dark conditions, ($H \approx 0$), with a stated collector voltage, load resistance, and ambient temperature. (Base open)

P_D Power Dissipation

S_{ICEO} Collector-Emitter Illumination Sensitivity (μA/lumen/ft.^{2} = μA/ft. candle) – The ratio of photo-induced, collector-emitter current to the incident luminous energy measured at the plane of the lens of the photodevice under stated conditions of luminous flux density (E), collector voltage, load resistance, and ambient temperature. (Base open)

S_{RCEO} Collector-Emitter Radiation Sensitivity (mA/mW/cm^2) The ratio of photo-induced, collector-emitter current to the incident radiant energy measured at the plane of the lens of the photodevice under stated conditions of radiation flux density (H), collector voltage, load resistance, and ambient temperature. (Base open)

T_A Ambient Temperature

t_f Photo Current Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the GaAs (gallium-arsenide) source pulse under stated conditions of collector voltage, load resistance and ambient temperature. (See Note 6 and Figure 4)

$t_{f(sat)}$ Photo Current Saturated Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the saturating xenon light source pulse under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 5 and Figure 4)

T_J Junction Temperature

t_r Photo Current Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when pulsed with the stated GaAs (gallium-arsenide) source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 6 and Figure 4)

$t_{r(sat)}$ Photo Current Saturated Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when driven into saturation by the stated xenon source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 5 and Figure 4)

T_{stg} Storage Temperature

V_{CEO} Collector-Emitter Voltage – The maximum allowable value of collector-emitter voltage which can be applied to the device at the rated temperature. (Base open)

V_{ECO} Emitter-Collector Voltage – The maximum allowable value of emitter-collector voltage which can be applied to the device at the rated temperature. (Base open)

$\lambda_{s(\mu m)}$ Wavelength of maximum sensitivity in micro meters.

MRD300 (SILICON)



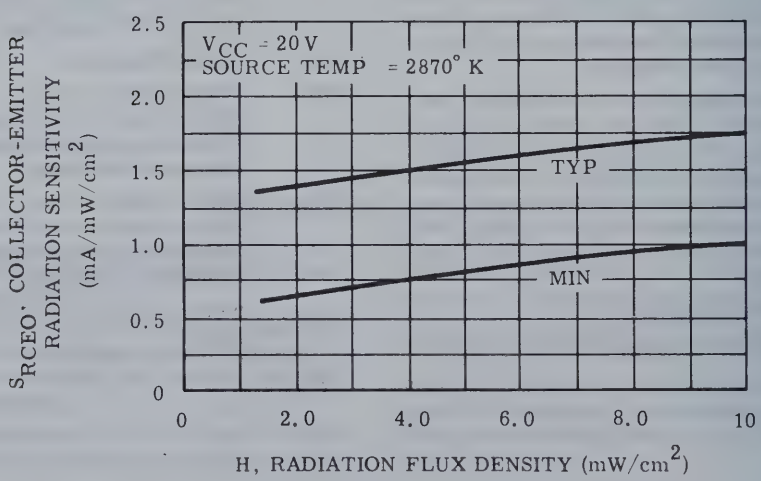
CASE 82

NPN silicon high sensitivity photo transistor designed for application in industrial inspection, processing and control, counters, sorters, switching and logic circuits or any design requiring high radiation sensitivity, and stable characteristics.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating (NOTE 2)	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Collector-Base Voltage	V_{CB}	80	Volts
Total Device Dissipation @ T_A = 25 °C	P_D	0.25	Watt
Derate above 25 °C		1.43	mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 — COLLECTOR-EMITTER SENSITIVITY



STATIC ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Units
Collector Dark Current (V_{CC} = 20 V; R_L = 100 ohms; Base Open) (Note 2) T_A = 25°C	—	I_{CEO}	—	—	0.025	μA
T_A = 100°C			—	10	—	
Collector-Base Breakdown Voltage (I_C = 100μA; Emitter Open) (Note 2)	—	BV_{CBO}	80	—	—	Volts
Collector-Emitter Breakdown Voltage (I_C = 100μA; Base Open) (Note 2)	—	BV_{CEO}	50	—	—	Volts
Emitter-Collector Breakdown Voltage (I_E = 100μA; Base Open) (Note 2)	—	BV_{ECO}	7.0	—	—	Volts

OPTICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Units
Collector-Emitter Radiation Sensitivity (V_{CC} = 20V; R_L = 100 ohms; Base Open) (Note 1)	—	S_{RCEO}	0.8	1.6	—	$mA/mW/cm^2$
Collector-Base Radiation Sensitivity (V_{CC} = 20V; R_L = 100 ohms; Emitter Open) (Note 1)	—	S_{RCBO}	1.4	—	—	$\mu A/mW/cm^2$
Collector-Emitter Illumination Sensitivity (V_{CC} = 20V; R_L = 100 ohms; Base Open) (Note 3)	—	S_{ICEO}	4.0	10	—	$\mu A/lum/ft^2$
Collector-Base Illumination Sensitivity (V_{CC} = 20V; R_L = 100 ohms; Emitter Open) (Note 3)	—	S_{ICBO}	0.01	—	—	$\mu A/lum/ft^2$
Photo Current Saturated Rise Time (Note 4)	4	$t_{r(sat)}$	—	1.0	—	μs
Photo Current Saturated Fall Time (Note 4)	4	$t_{f(sat)}$	—	10	—	μs
Photo Current Rise Time (Note 5)	4	t_r	—	—	2.5	μs
Photo Current Fall Time (Note 5)	4	t_f	—	—	4.0	μs
Angular Alignment (Note 6)	6	θ	—	—	10	Degrees
Wavelength of Maximum Sensitivity	—	$\lambda S(typ)$	—	0.8	—	Microns

NOTES:

1. Radiation Flux Density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870°K.
2. Measured under dark conditions. ($H \approx 0$)
3. Luminous flux density (E) equal to 100 lumens/ft^2. (100 ft.-candles)
4. For saturated rise time measurements, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 microsecond (see Figure 4).
5. For unsaturated rise time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode ($\lambda \simeq 0.9$ microns) with a pulse width equal or greater than 10 microseconds (see Figure 4).
6. Angular deviation from central axis of device within which the photo current will reach a maximum value.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 — COLLECTOR-EMITTER CHARACTERISTICS

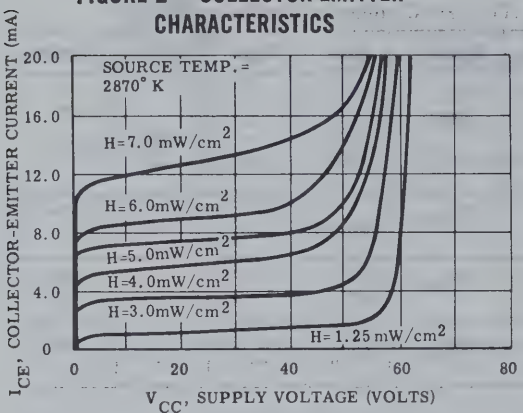


FIGURE 3 — PHOTO CURRENT vs TEMPERATURE

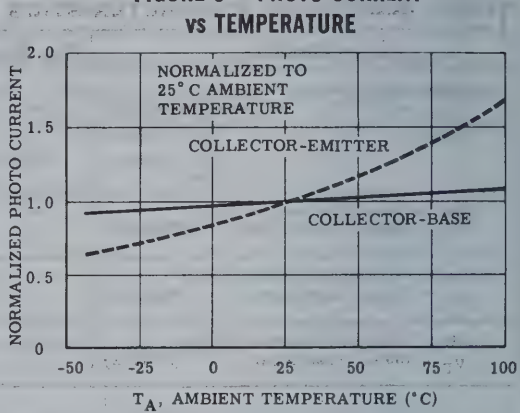
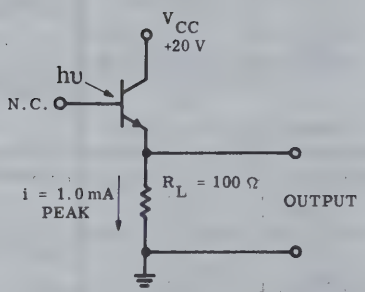
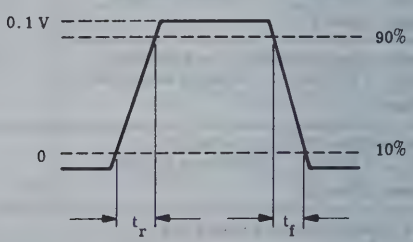


FIGURE 4 — PULSE RESPONSE TEST CIRCUIT



TEST CIRCUIT



OUTPUT VOLTAGE WAVEFORM

FIGURE 5 — BASE CURRENT vs RADIATION EQUIVALENT

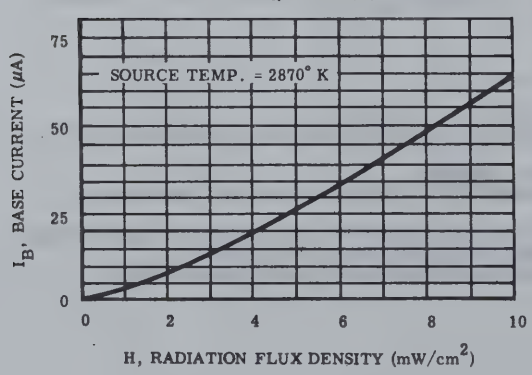


FIGURE 6 — ANGULAR ALIGNMENT



MRD310 (SILICON)



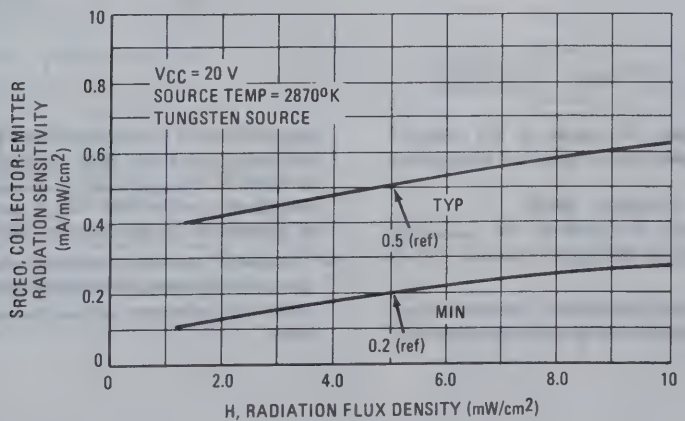
CASE 82

NPN silicon photo transistor designed for application in industrial inspection, processing and control, counters, sorters, switching and logic circuits or any design requiring radiation sensitivity, and stable characteristics.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating (Note 1)	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Collector-Base Voltage	V_{CB}	80	Volts
Total Device Dissipation @ T_A = 25 °C	P_D	250	mW
Derate above 25 °C		1.43	mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY



STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 20 V, R_L = 100 ohms, Note 2)	I_{CEO}				μA
T_A = 25°C		-	-	0.025	
T_A = 100°C		-	10	-	
Collector-Base Breakdown Voltage (I_C = 100 μA)	BV_{CBO}	80	-	-	Volts
Collector-Emitter Breakdown Voltage (I_C = 100 μA)	BV_{CEO}	50	-	-	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA)	BV_{ECO}	7.0	-	-	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Collector-Emitter Radiation Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 1)	1	S_{RCEO}	0.2	0.5	-	mA/mW/cm^2
Collector-Base Radiation Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 1)	-	S_{RCBO}	1.4	-	-	μA/mW/cm^2
Collector-Emitter Illumination Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 3)	-	S_{ICEO}	1.0	2.5	-	μA/lum/ft^2
Collector-Base Illumination Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 3)	-	S_{ICBO}	0.01	-	-	μA/lum/ft^2
Photo Current Saturated Rise Time (Note 4)	4	$t_{r(sat)}$	-	1.0	-	μs
Photo Current Saturated Fall Time (Note 4)	4	$t_{f(sat)}$	-	10	-	μs
Photo Current Rise Time (Note 5)	4	t_r	-	-	2.5	μs
Photo Current Fall Time (Note 5)	4	t_f	-	-	4.0	μs
Angular Alignment (Note 6)	6	θ	-	-	10	Degrees
Wavelength of Maximum Sensitivity	-	λ_s	-	0.8	-	μm

NOTES:

1. Radiation flux density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870°K.
2. Measured under dark conditions. (H≈0).
3. Luminous flux density (E) equal to 100 lumens/ft^2 (100 ft-candles) measured through two Corning CS1-69 filters.
4. For saturated rise time measurements, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 microsecond (see Figure 4).
5. For unsaturated rise time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode (λ≈ 0.9 μm) with a pulse width equal to or greater than 10 microseconds (see Figure 4).
6. The axis of maximum sensitivity shall be within a 10° cone with reference to the central axis of the device. The photo-induced current will reach a maximum within this cone.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – COLLECTOR-EMITTER CHARACTERISTICS

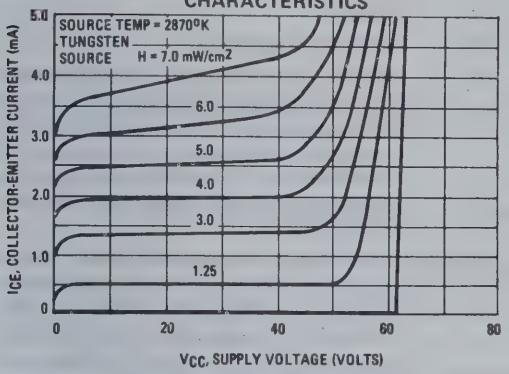


FIGURE 3 – PHOTO CURRENT versus TEMPERATURE

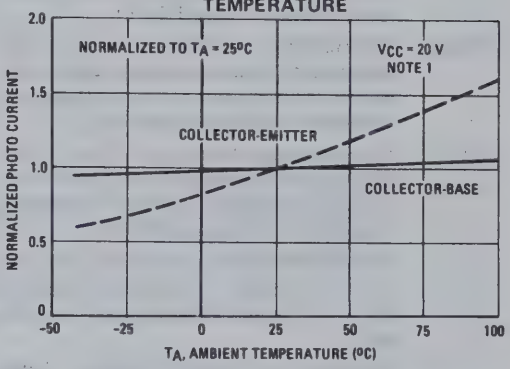
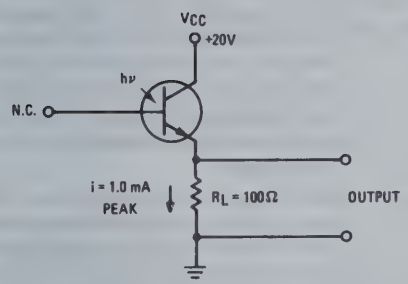


FIGURE 4 – PULSE RESPONSE TEST CIRCUIT AND WAVEFORM



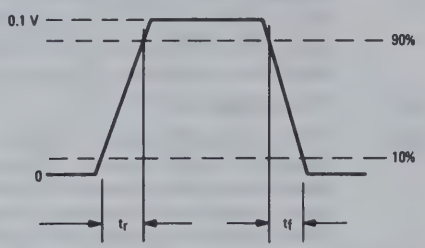


FIGURE 5 – BASE CURRENT versus RADIATION EQUIVALENCE

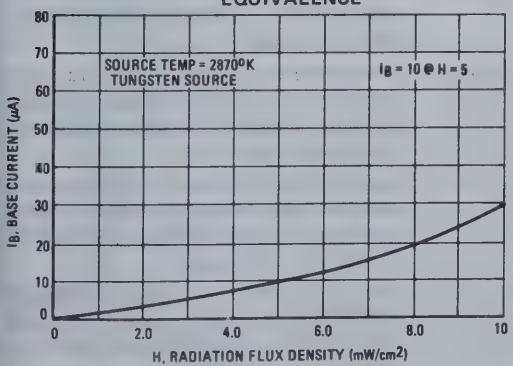
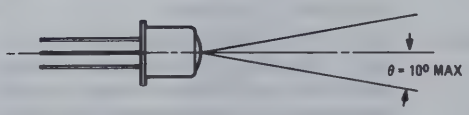


FIGURE 6 – ANGULAR ALIGNMENT



MRD310

OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_{CBO} Collector-Base Breakdown Voltage – The minimum dc breakdown voltage, collector to base, at stated collector current and ambient temperature. (Emitter open and $H \approx 0$)

BV_{CEO} Collector-Emitter Breakdown Voltage – The minimum dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open and $H \approx 0$)

BV_{ECO} Emitter-Collector Breakdown Voltage – The minimum dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open and $H \approx 0$)

E Luminous Flux Density (Illuminance) [lumens/ft.^{2} = ft. candles] – The radiation flux density of wavelength within the band of visible light.

H Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.

I_{CEO} Collector Dark Current – The maximum current through the collector terminal of the device measured under dark conditions, ($H \approx 0$), with a stated collector voltage, load resistance, and ambient temperature. (Base open)

P_D Power Dissipation

S_{ICBO} Collector-Base Illumination Sensitivity (μA/lumen/ft.^{2} = μA/ft. candle) – The ratio of photo-induced collector-base current to the incident luminous energy measured at the plane of the lens of the photo device under stated conditions of luminous flux density (E), collector voltage, base load resistance, and ambient temperature. (Emitter open)

S_{ICEO} Collector-Emitter Illumination Sensitivity (μA/lumen/ft.^{2} = μA/ft. candle) – The ratio of photo-induced, collector-emitter current to the incident luminous energy measured at the plane of the lens of the photodevice under stated conditions of luminous flux density (E), collector voltage, load resistance, and ambient temperature. (Base open)

S_{RCBO} Collector-Base Radiation Sensitivity (μA/mW/cm^2) – The ratio of photo-induced collector-base current to the incident radiant energy measured at the plane of the lens of the photo device under stated conditions of radiation flux density (H), collector voltage, base load resistance, and ambient temperature. (Emitter open)

S_{RCEO} Collector-Emitter Radiation Sensitivity (mA/mW/cm^2) – The ratio of photo-induced, collector-emitter current to the incident radiant energy measured at the plane of the lens of the photodevice under stated conditions of radiation flux density (H), collector voltage, load resistance, and ambient temperature. (Base open)

T_A Ambient Temperature

t_f Photo Current Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the GaAs (gallium-arsenide) source pulse under stated conditions of collector voltage, load resistance and ambient temperature. (See Note 5 and Figure 4)

$t_{f(sat)}$ Photo Current Saturated Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the saturating xenon light source pulse under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 4 and Figure 4)

T_J Junction Temperature

t_r Photo Current Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when pulsed with the stated GaAs (gallium-arsenide) source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 5 and Figure 4)

$t_{r(sat)}$ Photo Current Saturated Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when driven into saturation by the stated xenon source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 4 and Figure 4)

T_{stg} Storage Temperature

V_{CBO} Collector-Base Voltage – The maximum allowable value of the collector-base voltage which can be applied to the device at the rated temperature. (Base open)

V_{CEO} Collector-Emitter Voltage – The maximum allowable value of collector-emitter voltage which can be applied to the device at the rated temperature. (Base open)

V_{ECO} Emitter-Collector Voltage – The maximum allowable value of emitter-collector voltage which can be applied to the device at the rated temperature. (Base open)

θ Angular Alignment – The axis of maximum sensitivity shall lie within a cone of this angle with reference to the central axis of the device. (See Note 6 and Figure 6)

$\lambda_s(\mu m)$ Wavelength of maximum sensitivity in micro meters.

MRD450 (SILICON)

PLASTIC NPN SILICON PHOTO TRANSISTOR

. . . designed for application in industrial inspection, processing and control, counters, sorters, switching and logic circuits or any design requiring radiation sensitivity, and stable characteristics.

- Economical Plastic Package
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wide Application
- Minimum Sensitivity (0.2 mA/mW/cm^2) for Design Flexibility
- Unique Molded Lens for High, Uniform Sensitivity
- Annulart Passivated Structure for Stability and Reliability

40 VOLT
PHOTO TRANSISTOR
NPN SILICON

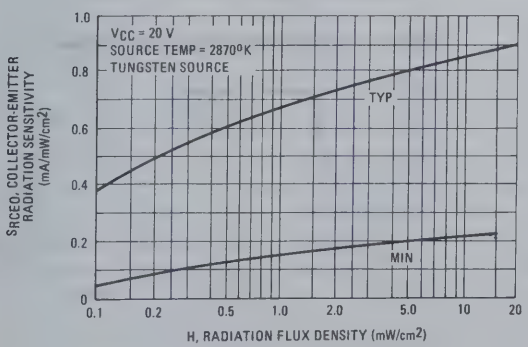
100 MILLIWATTS

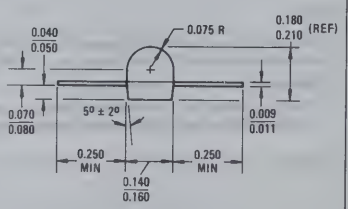


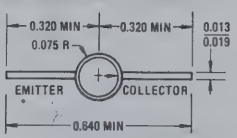
MAXIMUM RATINGS

Rating (Note 1)	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Volts
Emitter-Collector Voltage	V_{ECO}	6.0	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	100 1.3	mW mW/°C
Operating Junction Temperature Range Storage Temperature Range	T_J T_{stg}	−40 to +85 −40 to +100	°C °C

FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY







CASE 171

Collector indicated by arrow on bottom of device.

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 20 V, R_L = 100 ohms, Note 2)	I_{CEO}				μA
T_A = 25°C		–	–	0.10	
T_A = 85°C		–	5.0	–	
Collector-Emitter Breakdown Voltage (I_C = 100 μA; Note 2)	BV_{CEO}	40	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA; Note 2)	BV_{ECO}	6.0	–	–	Volts

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Collector-Emitter Radiation Sensitivity (V_{CC} = 20 V, R_L = 100 ohms, Note 1)	1	S_{RCEO}	0.2	0.8	–	mA/mW/cm^2
Photo Current Rise Time (Note 3)	2 and 3	t_r	–	–	2.5	μs
Photo Current Fall Time (Note 3)	2 and 3	t_f	–	–	4.0	μs
Angular Alignment (Note 4)	8	θ	–	–	10	Degrees
Wavelength of Maximum Sensitivity	9	λ_s	–	0.8	–	μm

NOTES:

1. Radiation Flux Density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870°K.
2. Measured under dark conditions. (H≈0).
3. For unsaturated rise time measurements, radiation is provided by a pulsed GaAs (gallium-arsenide) light-emitting diode ($\lambda \approx 0.9$ μm) with a pulse width equal to or greater than 10 microseconds (see Figures 2 and 3).
4. The axis of maximum sensitivity shall be within a 10° cone with reference to the central axis of the device. The photo-induced current will reach a maximum within this cone.

FIGURE 2 – PULSE RESPONSE TEST CIRCUIT

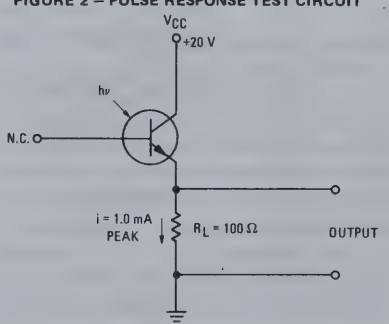
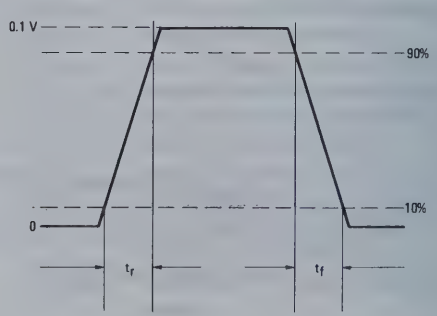


FIGURE 3 – PULSE RESPONSE TEST WAVEFORM



TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 4 – COLLECTOR-EMITTER CHARACTERISTICS

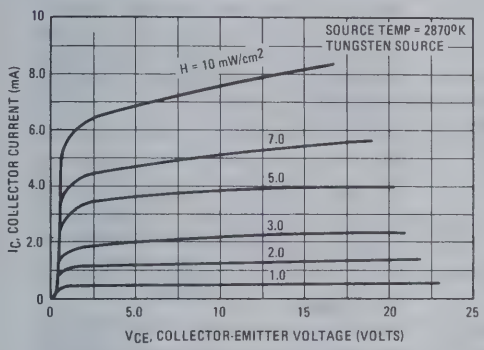


FIGURE 5 – COLLECTOR SATURATION CHARACTERISTICS

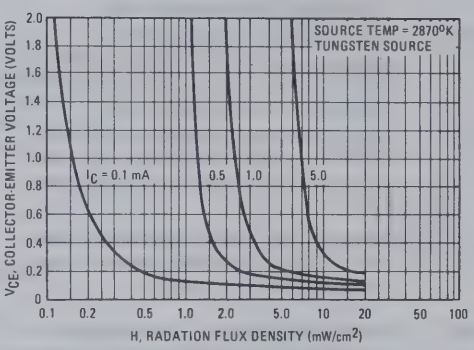


FIGURE 6 – DARK CURRENT versus TEMPERATURE

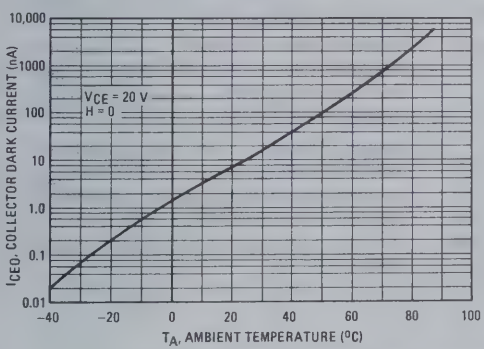


FIGURE 7 – DARK CURRENT versus VOLTAGE

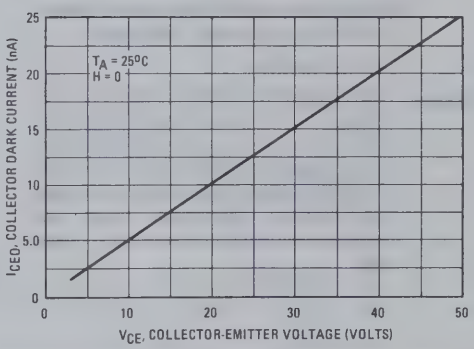


FIGURE 8 – ANGULAR RESPONSE

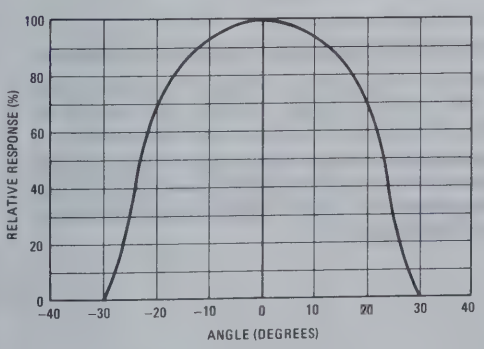
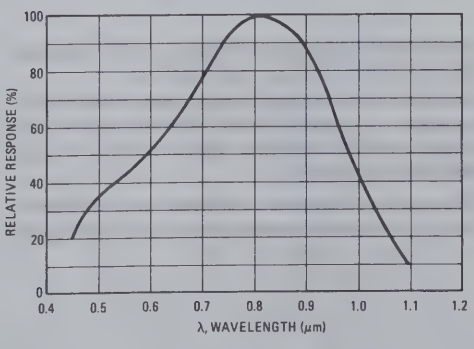


FIGURE 9 – CONSTANT ENERGY SPECTRAL RESPONSE



MRD450

OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_{CEO} Collector-Emitter Breakdown Voltage – The minimum dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open and H ≈0)

BV_{ECO} Emitter-Collector Breakdown Voltage – The minimum dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open and H ≈ 0)

E Luminous Flux Density (Illuminance) [lumens/ft.^{2} = ft. candles] – The radiation flux density of wavelength within the band of visible light.

H Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.

I_{CEO} Collector Dark Current – The maximum current through the collector terminal of the device measured under dark conditions, (H ≈ 0), with a stated collector voltage, load resistance, and ambient temperature. (Base open)

P_D Power Dissipation

S_{RCEO} Collector-Emitter Radiation Sensitivity (mA/mW/cm^2) – The ratio of photo-induced, collector-emitter current to the incident radiant energy measured at the plane of the lens of the photodevice under stated conditions of radiation flux density (H), collector voltage, load resistance, and ambient temperature. (Base open)

T_A Ambient Temperature

t_f Photo Current Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the GaAs (gallium-arsenide) source pulse under stated conditions of collector voltage, load resistance and ambient temperature. (See Note 3 and Figures 2 and 3)

T_J Junction Temperature

t_r Photo Current Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when pulsed with the stated GaAs (gallium-arsenide) source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 3 and Figures 2 and 3)

V_{CEO} Collector-Emitter Voltage – The maximum allowable value of collector-emitter voltage which can be applied to the device at the rated temperature. (Base open)

V_{ECO} Emitter-Collector Voltage – The maximum allowable value of emitter-collector voltage which can be applied to the device at the rated temperature. (Base open)

θ Angular Alignment – The axis of maximum sensitivity shall lie within a cone of this angle with reference to the central axis of the device. (See Note 4 and Figure 8)

$\lambda_s(\mu m)$ Wavelength of maximum sensitivity in micro meters.

CUSTOM OPTOELECTRONIC ARRAYS

Optoelectronic devices are also available in custom designed arrays or matrices as well as in discrete form.

These arrays can be designed to meet customer requirements for punched card and tape readers, position indicators, pattern and character recognition, shaft encoders, and many other special applications.

The arrays are pre-assembled and tested, ready for installation into the system eliminating the special handling and testing problems associated with the small photo detectors.

The custom arrays can be manufactured in almost any shape to allow maximum design flexibility; they can also be matched for sensitivity to assure more uniform output.

Specifying optoelectronic arrays is easy; all that is required is a print of the array and the desired specifications; or your representative will assist in developing specifications for your special application.

MRD500 (SILICON)
MRD510

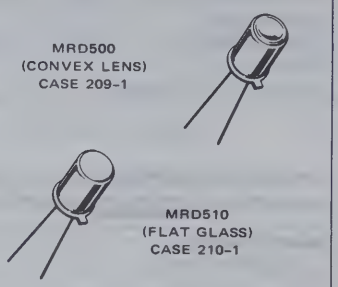
PIN SILICON PHOTO DIODE

. . . designed for application in laser detection, light demodulation, detection of visible and near infrared light-emitting diodes, shaft or position encoders, switching and logic circuits, or any design requiring radiation sensitivity, ultra high-speed, and stable characteristics.

- Ultra Fast Response – (<1.0 ns Typ)
- High Sensitivity – MRD500 (1.2 μA/mW/cm^2 Min)
  MRD510 (0.3 μA/mW/cm^2 Min)
- Available With Convex Lens (MRD500) or Flat Glass (MRD510) for Design Flexibility
- Popular TO-18 Type Package for Easy Handling and Mounting
- Sensitive Throughout Visible and Near Infrared Spectral Range for Wide Application
- Annular Passivated Structure for Stability and Reliability

100 VOLT
PHOTO DIODE
PIN SILICON

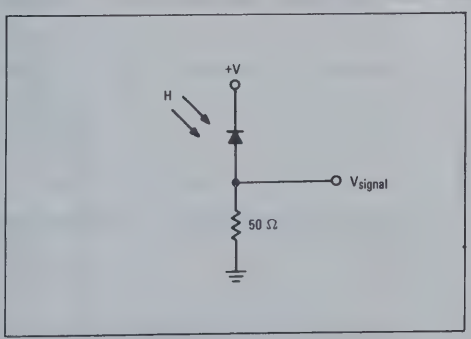
100 MILLIWATTS

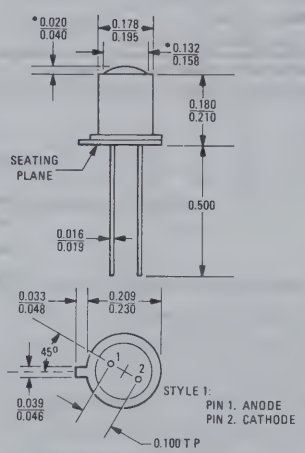


MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	100 0.57	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 – TYPICAL OPERATING CIRCUIT





CASE 209-1 CASE 210-1

NOTES: All dimensions in inches
Leads are gold-plated kovar
Cathode internally connected to case
Package weight ≈0.45 grams

*Does not apply to MRD510, Case 210-1 MRD510 is a flat top package.

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Dark Current (V_R = 20 V, R_L = 1.0 megohm; Note 2)		I_D				nA
T_A = 25°C	4 and 5		–	–	2.0	
T_A = 100°C			–	14	–	
Reverse Breakdown Voltage (I_R = 10 μA)	–	BV_R	100	200	–	Volts
Forward Voltage (I_F = 50 mA)	–	V_F	–	–	1.1	Volts
Series Resistance (I_F = 50 mA)	–	R_s	–	–	10	ohms
Total Capacitance (V_R = 20 V; f = 1.0 MHz)	6	C_T	–	–	4	pF

OPTICAL CHARACTERISTICS (T_A = 25°C)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
Radiation Sensitivity (V_R = 20 V, Note 1)			S_R				μA/mW/cm²
	MRD500	2 and 3		1.2	1.8	–	
	MRD510			0.3	0.42	–	
Sensitivity at 0.8 μm (V_R = 20 V, Note 3)			$S_{(\lambda = 0.8\ \mu m)}$				μA/mW/cm²
	MRD500	–		–	6.6	–	
	MRD510	–			1.5	–	
Response Time (V_R = 20 V, R_L = 50 ohms)		–	$t_{(resp)}$		1.0		ns
		–					
Wavelength of Peak Spectral Response		7	λ_s	–	0.8	–	μm

NOTES:

1. Radiation Flux Density (H) equal to 5.0 mW/cm² emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. (H≈0).
3. Radiation Flux Density (H) equal to 0.5 mW/cm² at 0.8 μm.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – IRRADIATED VOLTAGE – CURRENT CHARACTERISTIC FOR MRD500

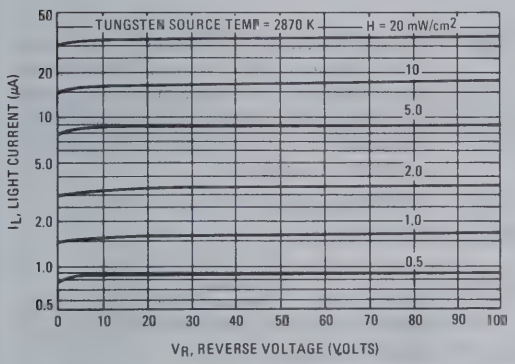


FIGURE 3 – IRRADIATED VOLTAGE – CURRENT CHARACTERISTIC FOR MRD 510

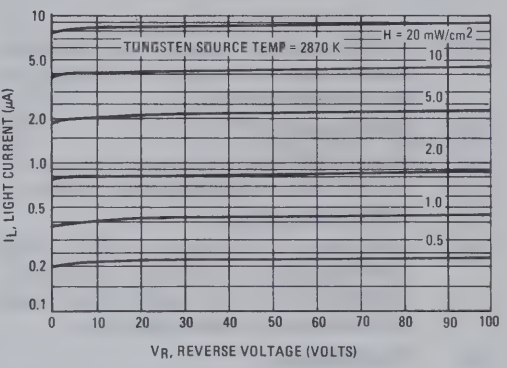


FIGURE 4 – DARK CURRENT versus TEMPERATURE

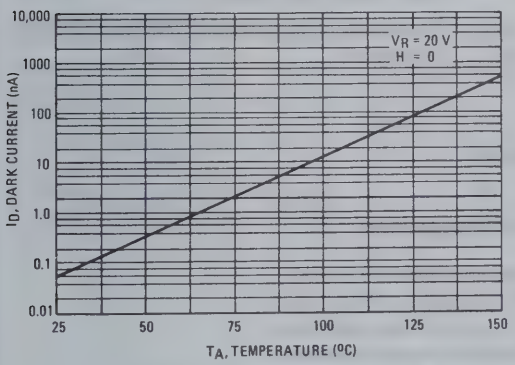


FIGURE 5 – DARK CURRENT versus REVERSE VOLTAGE

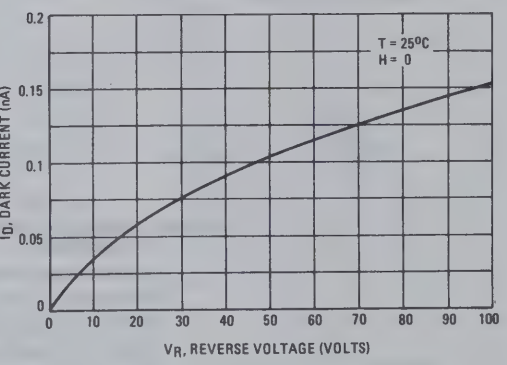


FIGURE 6 – CAPACITANCE versus VOLTAGE

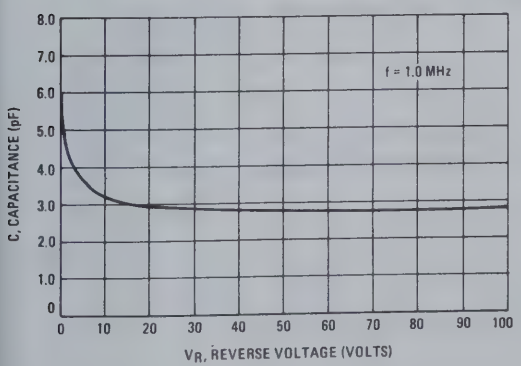
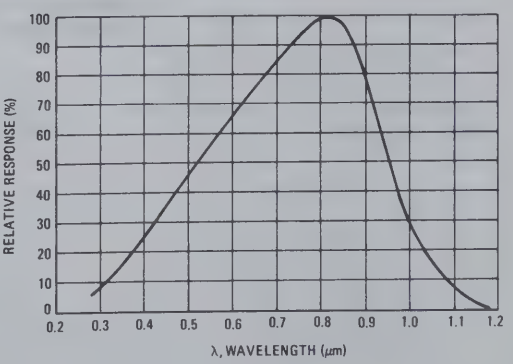


FIGURE 7 – RELATIVE SPECTRAL RESPONSE



MRD500 AND MRD510
OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_R Reverse Breakdown Voltage – The minimum dc reverse breakdown voltage at stated diode current and ambient temperature.

C_T Total Capacitance

H Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.

I_D Dark Current – The maximum reverse leakage current through the device measured under dark conditions, ($H \approx 0$), with a stated reverse voltage, load resistance, and ambient temperature.

P_D Power Dissipation

R_S Series Resistance – The maximum dynamic series resistance measured at stated forward current and ambient temperature.

S_R Radiation Sensitivity ($\mu A/mW/cm^2$) – The ratio of photo-induced current to the incident radiant energy measured at the plane of the lens of the photo device under stated conditions of radiation flux density (H), reverse voltage, load resistance, and ambient temperature.

T_A Ambient Temperature

T_J Junction Temperature

T_{stg} Storage Temperature

V_F Forward Voltage – The maximum forward voltage drop across the diode at stated diode current and ambient temperature.

V_R Reverse Voltage – The maximum allowable value of dc reverse voltage which can be applied to the device at the rated temperature.

$\lambda_s(\mu m)$ Wavelength of peak spectral response in micrometers.

OPTO DEVICES

AN-440 – THEORY AND CHARACTERISTICS OF PHOTO TRANSISTORS

A brief history of the photoelectric effect is discussed, followed by a comprehensive analysis of the effect in bulk semiconductors, pn junctions and phototransistors. A model is presented for the phototransistor. Static and transient data for the MRD300 provide typical phototransistor characteristics. Appendices provide a discussion of the relationship of irradiation and illumination and define terms specifically related to phototransistors.

MRD600 (SILICON)

NPN SILICON PHOTO DETECTOR

. . . designed for application in card and tape readers, pattern and character recognition, equipment, and shaft encoders, or any design requiring radiation sensitivity, stable characteristics, and high-density mounting.

- Small Size for High Density Mounting
- Sensitive Throughout Visible and Near Infra-Red Spectral Range for Wide Application
- Minimum Sensitivity (0.04 mA/mW/cm^2) for Design Flexibility
- Pill Package Allows Printed Circuit Board Assembly
- Annular Passivated Structure for Stability and Reliability

50 VOLT
PHOTO DETECTOR
NPN SILICON

50 MILLIWATTS

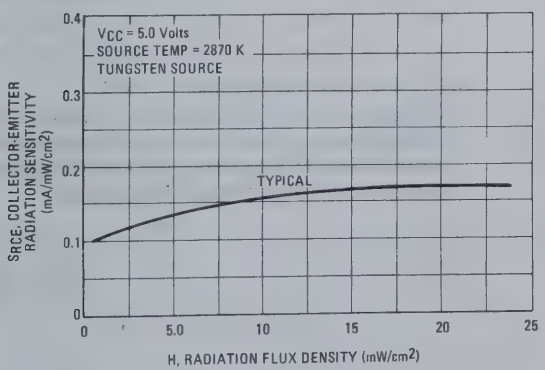
MAXIMUM RATINGS

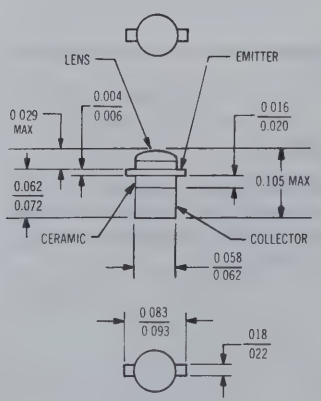
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Volts
Emitter-Collector Voltage	V_{ECO}	7.0	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	50 0.5	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

Actual Size



FIGURE 1 – COLLECTOR-EMITTER SENSITIVITY





CASE 81A - 02

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic (Note 1)	Symbol	Min	Typ	Max	Unit
Collector Dark Current (V_{CC} = 30 V, R_L = 1.0 megohm, Note 3) T_A = 25°C T_A = 100°C	I_{CEO}	 – –	 0.010 10	 0.025 –	μA
Collector-Emitter Breakdown Voltage (I_C = 100 μA, Note 3)	BV_{CEO}	50	–	–	Volts
Emitter-Collector Breakdown Voltage (I_E = 100 μA, Note 3)	BV_{ECO}	7.0	–	–	Volts
Collector-Emitter Saturation Voltage (I_C = 0.4 mA, Note 2)	$V_{CE(sat)}$	–	0.3	–	Volt

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic (Note 1)	Fig. No.	Symbol	Min	Typ	Max	Unit
Collector-Emitter Radiation Sensitivity (V_{CC} = 5.0 V, R_L = 100 ohms, Note 2)	1	S_{RCE}	0.04	0.17	–	mA/mW/cm^2
Collector Light Current (V_{CC} = 5.0 V, R_L = 100 ohms, Note 2)	–	I_L	0.8	3.4	–	mA
Photo Current Saturated Rise Time (Note 4)	4	$t_{r(sat)}$	–	1.5	–	μs
Photo Current Saturated Fall Time (Note 4)	4	$t_{f(sat)}$	–	15	–	μs
Wavelength of Maximum Sensitivity	6	λ_s	–	0.8	–	μm

NOTES:

1. No base terminal available.
2. Radiation flux density (H) equal to 20 mW/cm^2 emitted from a tungsten source at a color temperature of 2870K.
3. Measured under dark conditions. (H≈0).
4. For saturated rise time measurements, radiation is provided by a pulsed xenon arc lamp with a pulse width of approximately 1.0 microsecond (see Figure 4). Radiation flux density is adjusted for I_L = 800 μA peak.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – COLLECTOR-EMITTER CHARACTERISTICS

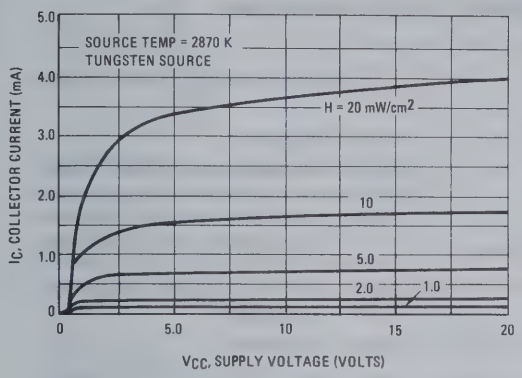


FIGURE 3 – PHOTO CURRENT versus TEMPERATURE

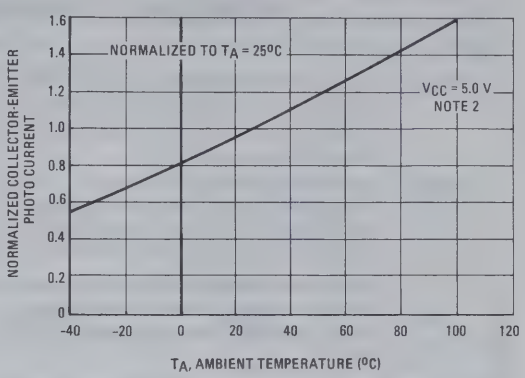


FIGURE 4 – PULSE RESPONSE TEST CIRCUIT AND WAVEFORM

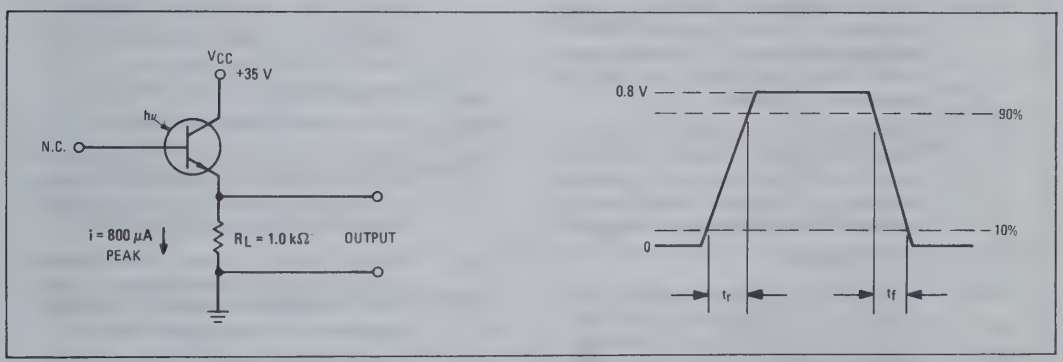


FIGURE 5 – DARK CURRENT versus VOLTAGE

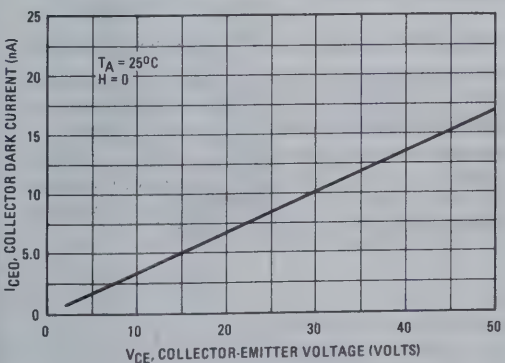
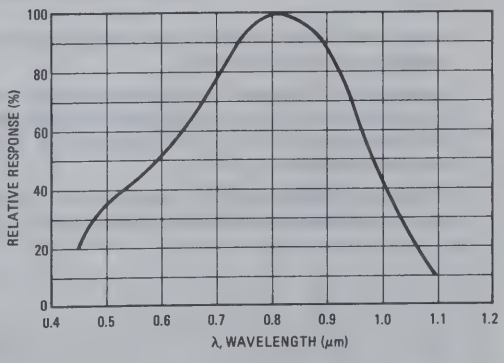


FIGURE 6 – CONSTANT ENERGY SPECTRAL RESPONSE



OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_{CEO} Collector-Emitter Breakdown Voltage – The dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open and $H \approx 0$)

BV_{CEO} Emitter-Collector Breakdown Voltage – The dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open and $H \approx 0$)

E Luminous Flux Density (Illuminance) [lumens/ft.^{2} = ft. candles] – The radiation flux density of wavelength within the band of visible light.

H Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.

I_{CEO} Collector Dark Current – The current through the collector terminal of the device measured under dark conditions, ($H \approx 0$), with a stated collector voltage, load resistance, and ambient temperature. (Base open)

I_L Collector Light Current (mA) – The current through the collector terminal of the device measured under stated conditions of radiation flux density (H), collector voltage, load resistance, and ambient temperature. (Base open)

P_D Power Dissipation

S_{RCEO} Collector-Emitter Radiation Sensitivity (mA/mW/cm^2) – The ratio of photo-induced, collector-emitter current to the incident radiant energy measured at the plane of the lens of the photodevice under stated conditions of radiation flux density (H), collector voltage, load resistance, and ambient temperature. (Base open)

T_A Ambient Temperature

$t_{f(sat)}$ Photo Current Saturated Fall Time – The response time for the photo-induced current to fall from the 90% point to the 10% point after removal of the saturating xenon light source pulse under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 4 and Figure 4)

T_J Junction Temperature

$t_{r(sat)}$ Photo Current Saturated Rise Time – The response time for the photo-induced current to rise from the 10% point to the 90% point when driven into saturation by the stated xenon source under stated conditions of collector voltage, load resistance, and ambient temperature. (See Note 4 and Figure 4)

T_{stg} Storage Temperature

$V_{CE(sat)}$ Collector-Emitter Saturation Voltage

V_{CEO} Collector-Emitter Voltage – The maximum allowable value of collector-emitter voltage which can be applied to the device at the rated temperature. (Base open and $H \approx 0$)

V_{ECO} Emitter-Collector Voltage – The maximum allowable value of emitter-collector voltage which can be applied to the device at the rated temperature. (Base open and $H \approx 0$)

$\lambda_s(\mu m)$ Wavelength of maximum sensitivity in micro meters.

MOTOROLA CUSTOM OPTOELECTRONIC ARRAYS

The MRD 600 is also available in custom designed arrays or matrices as well as in discrete form.

These arrays can be designed to meet customer requirements for punched card and tape readers, position indicators, pattern and character recognition, shaft encoders, and many other special applications.

The arrays are pre-assembled and tested, ready for installation into the system eliminating the special handling and testing problems associated with the small photo detectors.

The custom arrays can be manufactured in almost any shape to allow maximum design flexibility; they can also be matched for sensitivity to assure more uniform output.

Specifying Motorola optoelectronic arrays is easy; all that is required is a print of the array and the desired specifications; or your Motorola representative will assist in developing specifications for your special application.

MSD6100 (SILICON)



Silicon epitaxial dual switching diode, designed for use in high speed switching applications, features high breakdown voltage, low capacitance, one-piece injection-molded unibloc package, and space saving common-cathode configuration.

CASE 29(3)
(TO-92)



PIN 1. ANODE
2. ANODE
3. CATHODE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μsec)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating Junction Temperature	T_J	135	°C
Storage Temperature Range	T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	—	$V_{(BR)}$	100	—	Vdc
Reverse Current (V_R = 100 Vdc) (V_R = 50 Vdc) (V_R = 50 Vdc, T_A = 125°C)	2	I_R	 — — —	 5 0.1 20	μAdc
Forward Voltage (I_F = 1 mAdc) (I_F = 10 mAdc) (I_F = 100 mAdc)	1	V_F	 0.55 0.67 0.75	 0.7 0.82 1.1	Vdc
Capacitance (V_R = 0)	3	C	—	1.5	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5 Vdc, i_{rr} = 1.0 mAdc)	4,5	t_{rr}	—	4.0	ns

FIGURE 1 — FORWARD CHARACTERISTICS

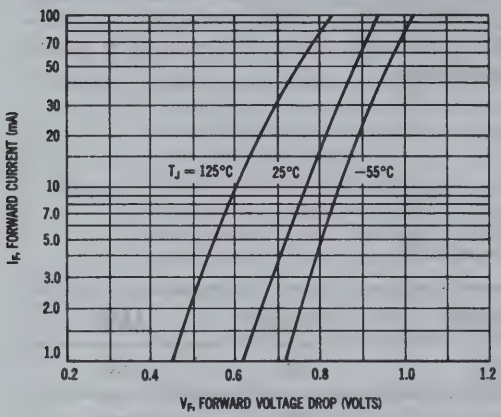


FIGURE 2 — REVERSE LEAKAGE CURRENT

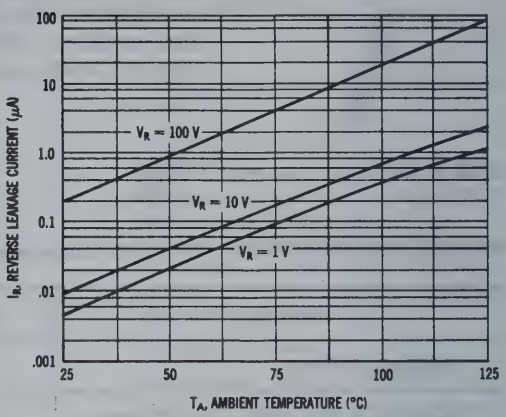


FIGURE 3 — CAPACITANCE

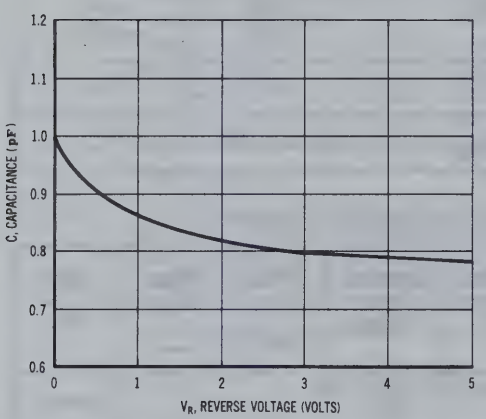


FIGURE 4 — REVERSE RECOVERY TIME

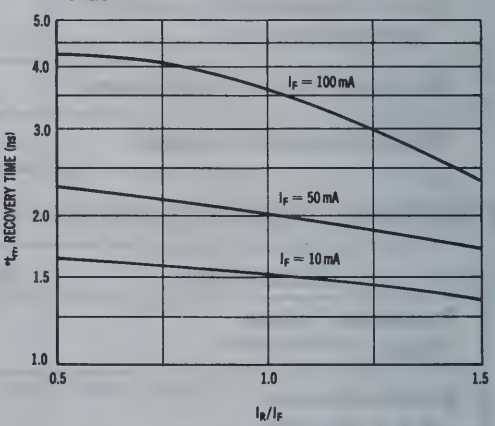
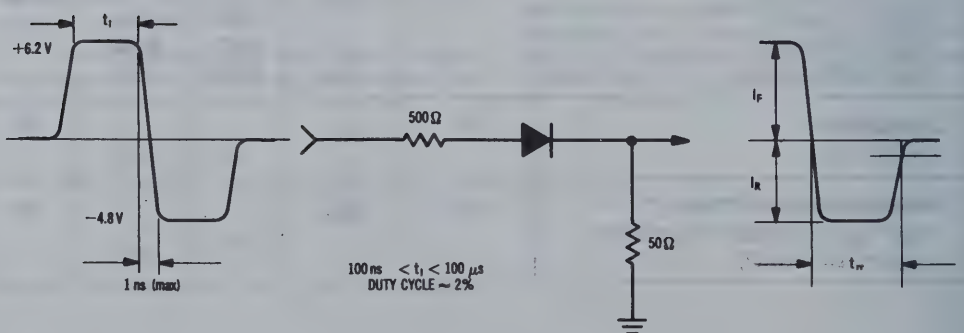
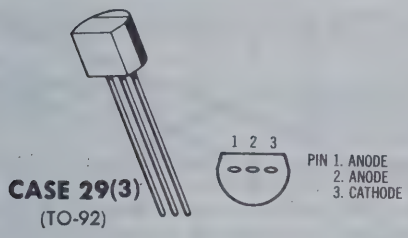


FIGURE 5 — RECOVERY TIME EQUIVALENT TEST CIRCUIT



MSD6101 (SILICON)



CASE 29(3)
(TO-92)

Silicon epitaxial dual discriminator diode designed for use in FM discriminator applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	50	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	-	$V_{(BR)}$	50	-	Vdc
Reverse Current (V_R = 40 Vdc) (V_R = 40 Vdc, T_A = 125°C)	2	I_R	- -	0.1 100	μAdc
Forward Voltage (I_F = 0.1 mAdc) (I_F = 10 mAdc)	1	V_F	 0.43 0.67	 0.57 0.82	Vdc
Capacitance (V_R = 0)	3	C	-	2.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5 Vdc, i_{rr} = 1.0 mAdc)	4, 5	t_{rr}	-	10	ns
Forward Voltage Matching $\lvert V_{F1} - V_{F2} \rvert$ (I_{F1} = I_{F2} = 0.1 mAdc)	-	ΔV_F	-	0.003	Vdc

FIGURE 1 — FORWARD CHARACTERISTICS

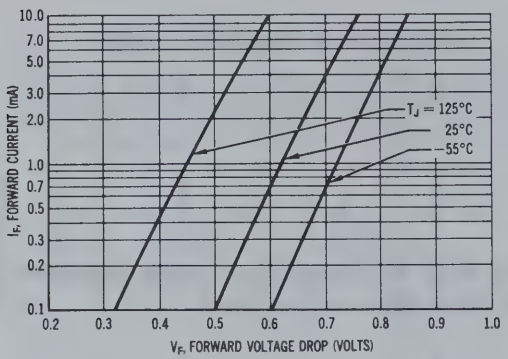


FIGURE 2 — REVERSE LEAKAGE CURRENT

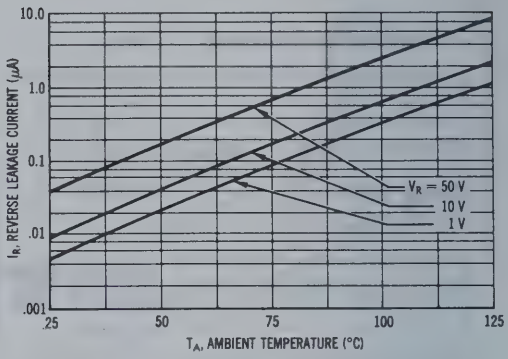


FIGURE 3 — CAPACITANCE

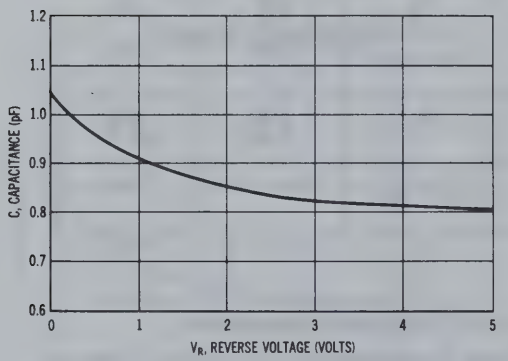


FIGURE 4 — REVERSE RECOVERY TIME

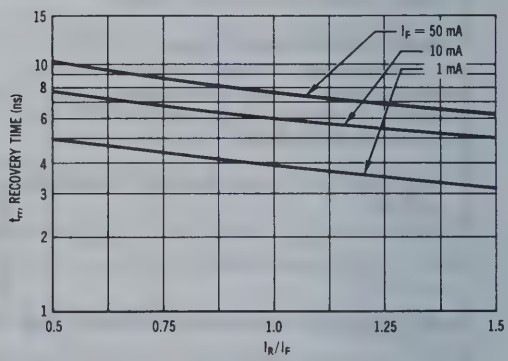
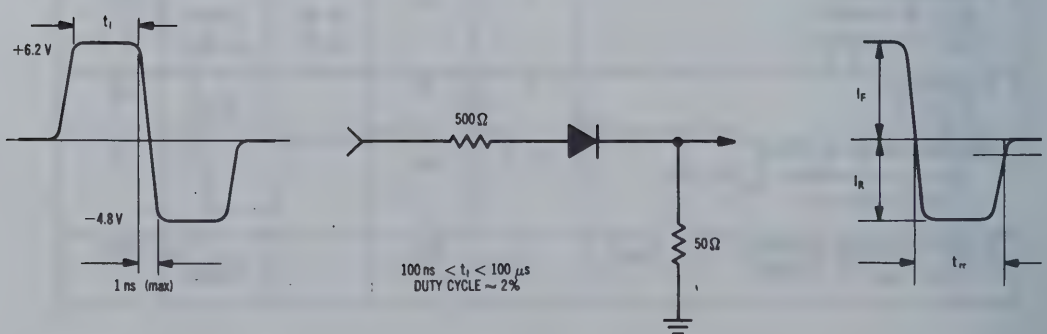


FIGURE 5 — RECOVERY TIME EQUIVALENT TEST CIRCUIT



MSD6102 (SILICON)

Silicon epitaxial dual diode designed for use as a horizontal phase detector for television receivers, and for similar applications.



CASE 29(3)
(TO-92)



PIN 1. ANODE
2. ANODE
3. CATHODE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating Junction Temperature	T_J	135	°C
Storage Temperature Range	T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	—	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	—	0.1	μAdc
Forward Voltage (I_F = 10 mAdc)	V_F	0.67	1.0	Vdc
Capacitance (V_R = 0)	C	—	3.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	—	100	ns

FIGURE 1 — FORWARD CHARACTERISTICS

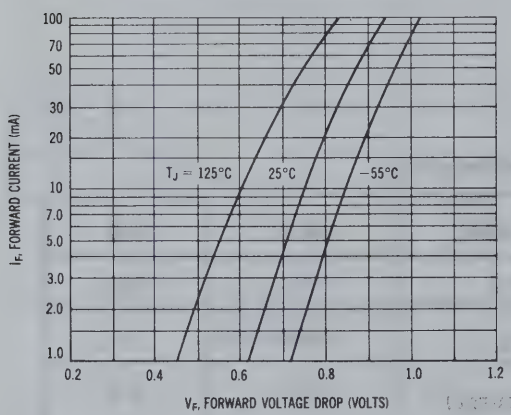


FIGURE 2 — REVERSE LEAKAGE CURRENT versus TEMPERATURE

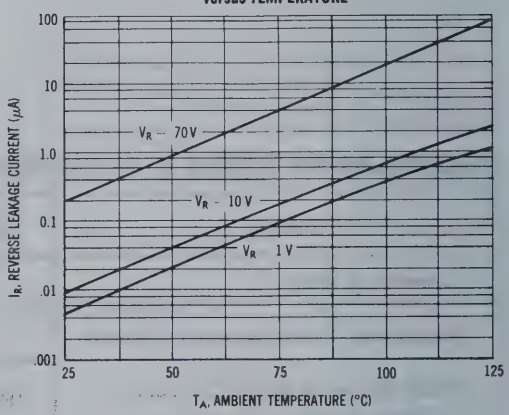
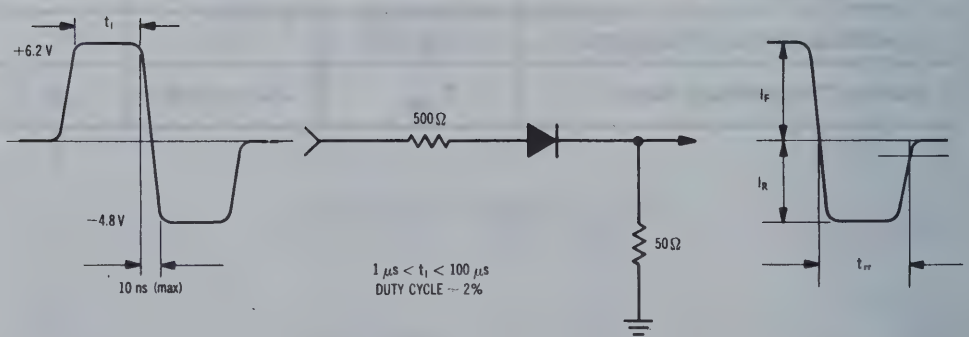


FIGURE 3 — RECOVERY TIME EQUIVALENT TEST CIRCUIT



MSD6150 (SILICON)

SILICON EPITAXIAL DUAL DIODE

. . . designed for general-purpose consumer applications.

- High Breakdown Voltage –
  $V_{(BR)}$ = 70 Vdc (Min) @ $I_{(BR)}$ = 100 μAdc
- Space-Saving Package with Common Anode Configuration
- One-Piece, Injection-Molded Unibloc Package

SILICON EPITAXIAL DUAL DIODE

COMMON ANODE



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	70	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	$V_{(BR)}$	70	–	–	Vdc
Reverse Current (V_R = 50 Vdc)	I_R	–	–	0.1	μAdc
Forward Voltage (I_F = 10 mAdc)	V_F	–	0.80	1.0	Vdc
Capacitance (V_R = 0)	C		5.0	8.0	pF
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5.0 Vdc, i_{rr} = 1.0 mAdc)	t_{rr}	–	–	100	ns

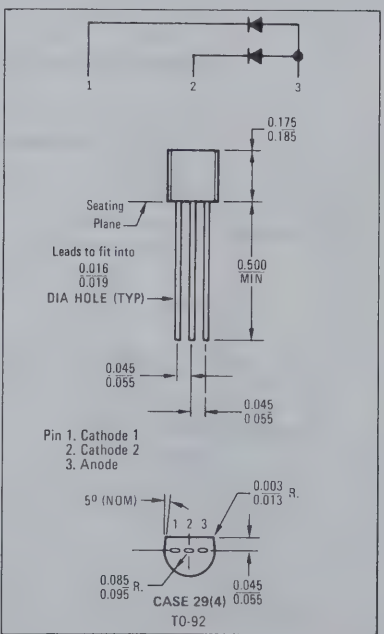


FIGURE 1 – FORWARD CHARACTERISTICS

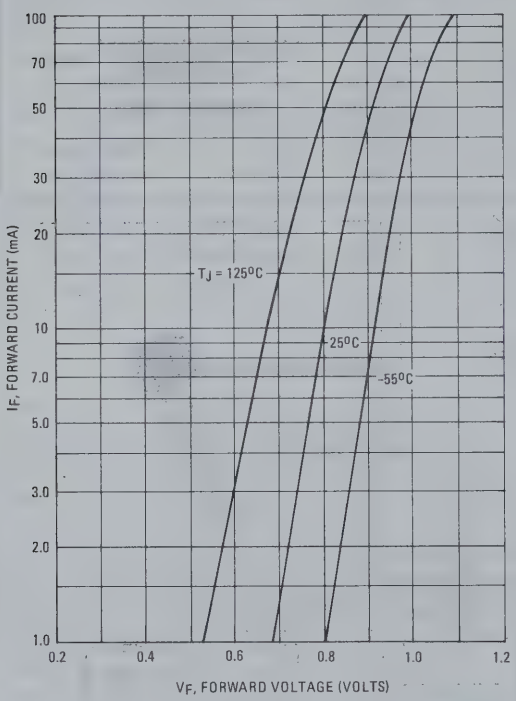


FIGURE 2 – REVERSE LEAKAGE CURRENT

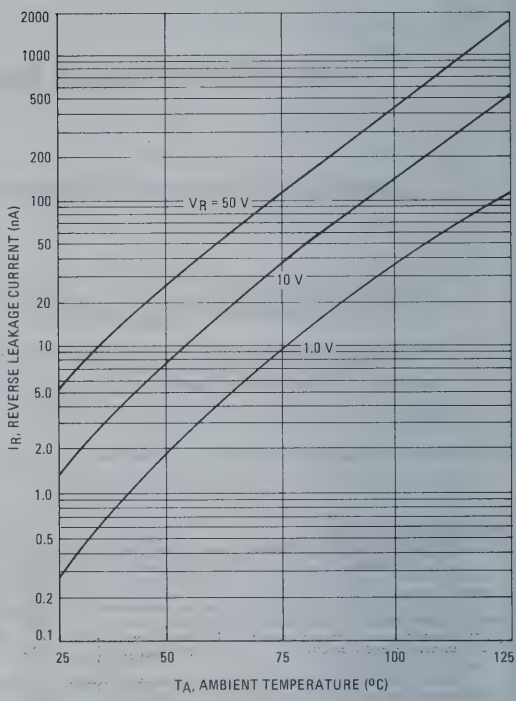
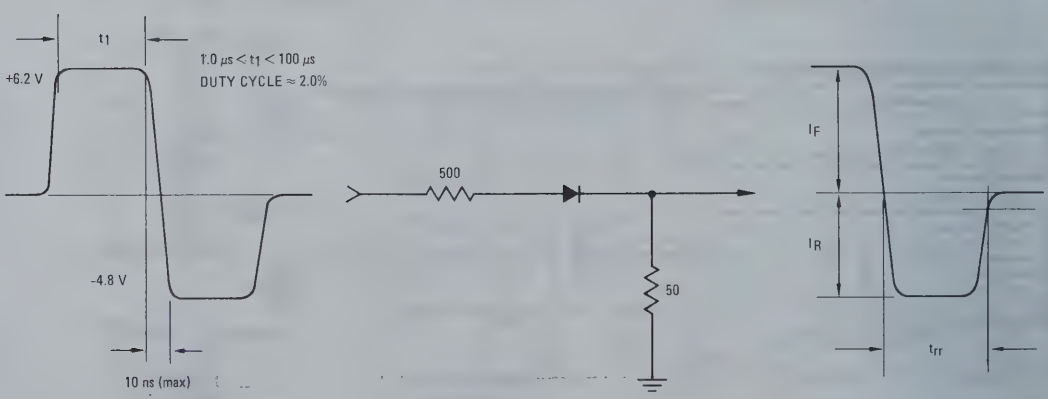


FIGURE 3 – RECOVERY TIME EQUIVALENT TEST CIRCUIT



MU851 (SILICON)
thru
MU853

SILICON ANNULAR UNIJUNCTION TRANSISTORS

. . . designed for computer and industrial applications requiring high-density mounting. These devices are used in pulse, timing, triggering, sensing and oscillator circuits. The annular process provides low leakage current, fast switching and low peak-point currents, as well as outstanding reliability and uniformity.

- Low Peak-Point Current — I_P = 0.4 μA Max (MU853)
- Low Emitter Reverse Current — I_{EO} = 50 nA Max (MU853)
- Fast Switching — 1.0 MHz Min Oscillation Frequency
- Electrically Similar to The 2N4851 Thru 2N4853 Devices

MICRO-T UNIJUNCTION TRANSISTORS



UNIT IDENTITY COLOR CODING
MU851 — Red Plastic
MU852 — Black on Red Plastic
MU853 — Yellow on Red Plastic

For Handling Convenience, All Devices are Painted White on the Bottom.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage (1)	V_{B2B1}	28	Volts
RMS Emitter Current	I_e	50	mA
Peak-Pulse Emitter Current (2)	i_e	1.5	Amp
RMS Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

(1) Based Upon Power Dissipation at T_A = 25°C
(2) Duty Cycle ≦ 1.0%, PRR = 10 pps (See Figure 6)

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

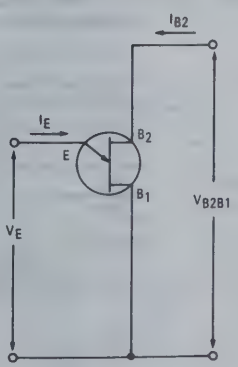
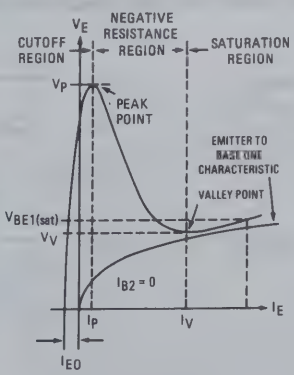
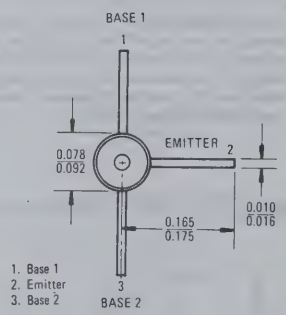


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES





CASE 28 (7)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Rating		Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (1), Figure 3 (V_{B2B1} = 10 V)		η				–
	MU851		0.56	–	0.75	
	MU852, MU853		0.70	–	0.85	
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)		R_{BB}	4.7	–	9.1	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = –65 to +125°C)		αR_{BB}	0.2	–	0.8	%/°C
Emitter Saturation Voltage (2) (V_{B2B1} = 10 V, I_E = 50 mA)		$V_{EB1(sat)}$	–	2.5	–	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	–	20	–	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)		I_{EB2O}				μA
	MU851, MU852		–	–	0.1	
	MU853		–	–	0.05	
Peak-Point Emitter Current (V_{B2B1} = 25 V)		I_P				μA
	MU851, MU852		–	–	2.0	
	MU853		–	–	0.4	
Valley-Point Current (2) (V_{B2B1} = 20 V, R_{B2} = 100 ohms)		I_V				mA
	MU851		2.0	–	–	
	MU852, MU853		4.0	–	–	
Base-One Peak Pulse Voltage, Figure 4		V_{OB1}				Volts
	MU851		3.0	–	–	
	MU852		5.0	–	–	
	MU853		6.0	–	–	
Maximum Frequency of Oscillation, Figure 5		$f_{(max)}$	1.0	1.25	–	MHz

(1) η, intrinsic standoff ratio, is defined in terms of the peak-point voltage, V_P, by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is about 0.49 volt at 25°C @ I_F = 10 μA and decreases with temperature at about 2.5 mV/°C. The test circuit is shown in Figure 3. Components R1, C1, and the UJT form a relaxation oscillator; the remaining circuitry serves as a peak-voltage detector. The forward drop of Diode D1 compensates for V_F. To use, the "cal" button is pushed, and R3 is adjusted to make the current meter, M1, read full scale. When the "Cal" bottom is released, the value of η is read directly from the meter, if full scale on the meter reads 1.0.

(2) Use pulse techniques: PW ≈ 300 μs, duty cycle ≦ 2.0% to avoid internal heating, which may result in erroneous readings.

FIGURE 3 – η TEST CIRCUIT

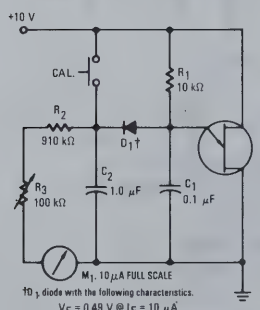


FIGURE 4 – V_{OB1} TEST CIRCUIT

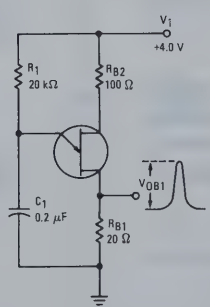


FIGURE 5 – $f_{(max)}$ TEST CIRCUIT

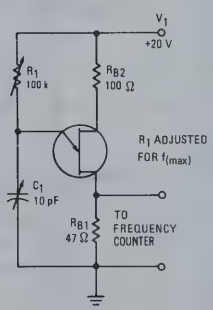
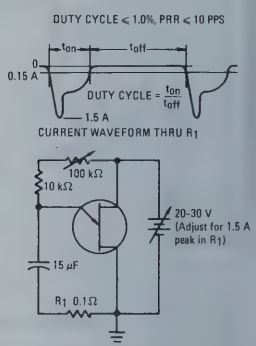


FIGURE 6 – PRR TEST CIRCUIT AND WAVEFORM



MU4891 (SILICON)
thru
MU4894

Silicon annular plastic unijunction transistors designed for military and industrial use in pulse, timing, triggering, sensing, and oscillator circuits. The annular process provides low leakage current, fast switching and low peak-point currents as well as outstanding reliability and uniformity.



CASE 29 (9)
(TO-92)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D	300	mW
RMS Emitter Current	I_e	50	mA
Peak Pulse Emitter Current**	i_e	1.0**	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Storage Temperature Range	T_{stg}	-65 to +150	°C

* Derate 3.0 mW/°C increase in ambient temperature. Total power dissipation (available power to Emitter and Base-Two) must be limited by external circuitry. Interbase voltage (V_{B2B1}) limited by power dissipation,

$$V_{B2B1} = \sqrt{R_{BB} \cdot P_D}$$

** Capacitance discharge current must fall to 0.37 Amp within 3.0 ms and PRR ≤ 10 PPS.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

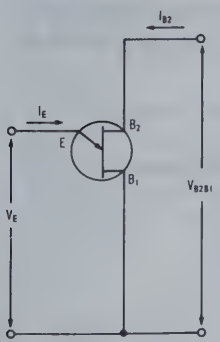


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES

(Exaggerated to Show Details)

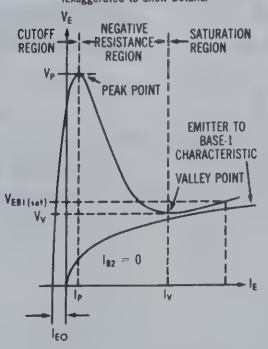
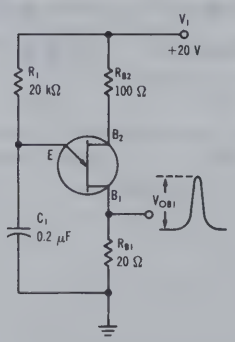


FIGURE 3 — V_{OB1} TEST CIRCUIT

(Typical Relaxation Oscillator)



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (V_{B2B1} = 10 V) Note 1	MU4892	η	0.51	-	0.69	-
	MU4891, MU4893		0.55	-	0.82	
	MU4894		0.74	-	0.86	
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)	MU4891, MU4892	R_{BB}	4.0	7.0	9.1	k ohms
	MU4893, MU4894		4.0	7.0	12.0	
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65°C to + 100°C)		αR_{BB}	0.1	-	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA) Note 2		$V_{EB1(sat)}$	-	2.5	4.0	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	10	15	-	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)		I_{EB2O}	-	5.0	10	nA
Peak Point Emitter Current (V_{B2B1} = 25 V)	MU4891	I_P		0.6	5.0	μA
	MU4892, MU4893		-	0.6	2.0	
	MU4894		-	0.6	1.0	
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms) Note 2	MU4891, MU4893, MU4894	I_V	2.0	4.0	-	mA
	MU4892		2.0	3.0	-	
Base-One Peak Pulse Voltage (Note 3, Figure 3)	MU4891, MU4892, MU4894	V_{OB1}	3.0	5.0	-	Volts
	MU4893		6.0	8.0	-	

NOTES

1. Intrinsic standoff ratio.
   η, is defined by equation:

$$\eta = \frac{V_P - V_{(EB1)}}{V_{B2B1}}$$

   Where V_P = Peak Point Emitter Voltage
   V_{B2B1} = Interbase Voltage
   $V_{(EB1)}$ = Emitter to Base-One Junction Diode Drop (≈0.5 V @ 10 μA)

2. Use pulse techniques: PW ≈ 300 μs duty cycle ≤2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

3. Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

MV830 thru MV840 (SILICON)



CASE 51
(DO-7)

Polarity band on cathode end

Silicon voltage-variable capacitance diodes, designed for electronic-tuning applications from 15 to 100 pF.

MAXIMUM RATINGS (Tc = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Vdc
Forward Current	I_F	250	mAdc
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2 13.3	W mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) See Notes

Characteristic — All Types	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	I_R = 10 μAdc	30	—	—	Vdc
Reverse Voltage Leakage Current	I_R	V_R = 25 Vdc	—	—	0.2	μAdc
Series Inductance	L_S	f = 250 MHz, L ≈ 1/16"	—	5	10	nH
Case Capacitance	C_C	f = 1 MHz, L = 0	—	0.25	0.3	pF

	C_T, Diode Capacitance V_R = 4 Vdc, f = 1 MHz pF			TR, Tuning Ratio f = 1 MHz C_4/C_{25}		Q, Figure of Merit V_R = 4 Vdc, f = 50 MHz		α	
Device	Min	Typ	Max	Min	Typ	Min	Typ	Min	Typ
MV830	13.5	15.0	16.5	1.8	2.00	30	35	0.32	0.375
MV831	16.2	18.0	19.8	1.8	2.00	25	30	0.32	0.375
MV832	19.8	22.0	24.2	1.8	2.10	25	30	0.32	0.40
MV833	24.3	27.0	29.7	1.8	2.10	25	30	0.32	0.40
MV834	29.7	33.0	36.3	1.9	2.12	20	25	0.35	0.41
MV835	35.1	39.0	42.9	1.9	2.12	20	25	0.35	0.41
MV836	42.3	47.0	51.7	1.9	2.15	15	20	0.35	0.415
MV837	50.4	56.0	61.6	1.9	2.15	15	20	0.35	0.415
MV838	61.2	68.0	74.8	2.0	2.18	15	20	0.375	0.425
MV839	73.8	82.0	90.2	2.0	2.18	10	15	0.375	0.425
MV840	90.0	100.0	110.0	2.0	2.18	10	15	0.375	0.425

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE
L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter). L = lead length.

2. C_C, CASE CAPACITANCE
C_C is measured on an open package at 1 MHz using a capacitance bridge (Boonton Electronics Model 75A).

3. C_T, DIODE CAPACITANCE
($C_T = C_C + C_J$). C_T is measured at 1 MHz using a capacitance bridge (Boonton Electronics Model 33AS8).

4. TR, TUNING RATIO
TR is the ratio of C_T measured at 4 Vdc divided by C_T measured at 25 Vdc.

5. Q, FIGURE OF MERIT
Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8).

6. α, DIODE CAPACITANCE REVERSE VOLTAGE SLOPE
The diode capacitance, C_T (as measured at V_R = 4 Vdc, f = 1 MHz) is compared to C_T (as measured at V_R = 30 Vdc, f = 1 MHz) by the following equation which defines α.

$$\alpha = \frac{\log C_T(4) - \log C_T(30)}{\log 30 - \log 4}$$

Note that a C_T versus V_R law is assumed as shown in the following equation where C_C is included.

$$C_T = \frac{K}{V^{\alpha}}$$

MV1401, MV1403 (SILICON)
MV1404, MV1405

VVC

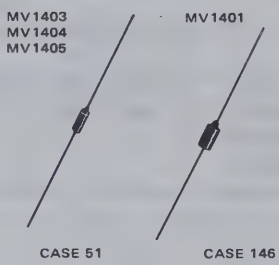
SILICON HYPER-ABRUPT JUNCTION TUNING DIODES

. . . designed with a capacitance change of greater than TEN TIMES for a bias change ranging from 2 to 10 volts. Provides tuning over broad frequency ranges, tuning AM radio broadcast band, general AFC and tuning applications in lower RF frequencies.

- High Q with Guaranteed Minimum Values
- Broad Capacitance Selection from 120–550 pF (Nominal Values)
- Available in Two Standard Glass Packages

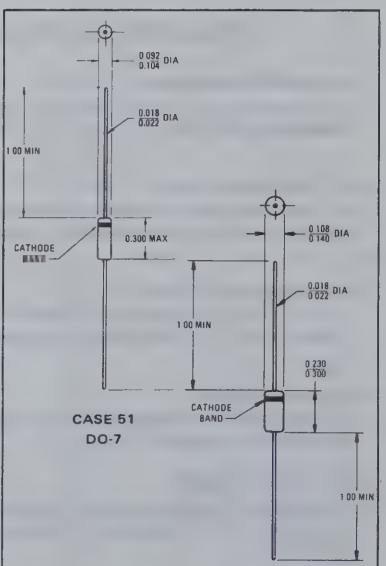
HIGH TUNING RATIO VOLTAGE – VARIABLE CAPACITANCE DIODES

120-550 pF
12 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	12	Volts
Forward Current	I_F	250	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	12	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 10 Vdc, T_A = 25°C)	I_R	–	–	0.10	μAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	5.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.25	–	pF

	C_T, Diode Capacitance						Q, Figure of Merit	TR, Tuning Ratio	
	V_R = 1.0 Vdc, f = 1.0 MHz pF			V_R = 2.0 Vdc, f = 1.0 MHz pF			V_R = 2.0 Vdc, f = 1.0 MHz	C_1/C_{10} f = 1.0 MHz	C_2/C_{10} f = 1.0 MHz
Device	Min	Nom	Max	Min	Nom	Max	Min	Min	Min
MV1401	468	550	633	–	–	–	200	14	–
MV1403	–	–	–	140	175	210	200	–	10
MV1404	–	–	–	96	120	144	200	–	10
MV1405	–	–	–	200	250	300	200	–	10

PARAMETER TEST METHODS

1. **L_S, SERIES INDUCTANCE**
   L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter).

2. **C_C, CASE CAPACITANCE**
   C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. **C_T, DIODE CAPACITANCE**
   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

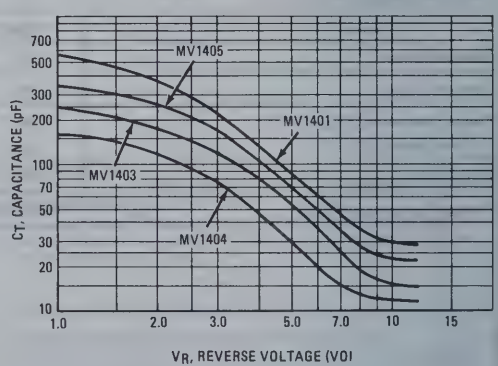
4. **TR, TUNING RATIO**
   TR is the ratio of C_T measured at 2.0 Vdc (1.0 Vdc for MV1401) divided by C_T measured at 10 Vdc.

5. **Q, FIGURE OF MERIT**
   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equation:

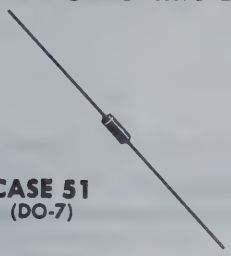
$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8). Use Lead Length ≈1/16".

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE



MV1620 thru MV1650 (SILICON)



CASE 51
(DO-7)

Silicon Epicap diodes, epitaxial passivated tuning diodes designed for AFC applications in radio, TV, and general electronic-tuning.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	20	Volts
Forward Current	I_F	250	mAdc
Device Dissipation @ T_A = 25°C	P_D	400	mW
Derate above 25°C		2.67	mW/°C
Device Dissipation @ T_C = 25°C	P_D	2	Watts
Derate above 25°C		13.3	mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic – All Types	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	BV_R	20	–	–	Vdc
Reverse Voltage Leakage Current	V_R = 15 Vdc	I_R	–	–	0.1	μAdc
Series Inductance	f = 250 MHz, lead length ≈ 1/16"	L_S	–	5.0	10	nH
Case Capacitance	f = 1 MHz, lead length ≈ 1/16"	C_C	–	0.25	0.3	pF

Device	C_T, Diode Capacitance V_R = 4 Vdc, f = 1 MHz pF			Q, Figure of Merit V_R = 4 Vdc, f = 50 MHz	TR, Tuning Ratio * C_2/C_{20} f = 1 MHz	
	Min	Nom	Max	Min	Min	Max
MV1620	6.1	6.8	7.5	300	2.0	3.2
MV1622	7.4	8.2	9.0	300	2.0	3.2
MV1624	9.0	10.0	11.0	300	2.0	3.2
MV1626	10.8	12.0	13.2	300	2.0	3.2
MV1628	13.5	15.0	16.5	250	2.0	3.2
MV1630	16.2	18.0	19.8	250	2.0	3.2
MV1632	18.0	20.0	22.0	250	2.0	3.2
MV1634	19.8	22.0	24.2	250	2.0	3.2
MV1636	24.3	27.0	29.7	200	2.0	3.2
MV1638	29.7	33.0	36.3	200	2.0	3.2
MV1640	35.1	39.0	42.9	200	2.0	3.2
MV1642	42.3	47.0	51.7	200	2.0	3.2
MV1644	50.4	56.0	61.6	150	2.0	3.2
MV1646	61.2	68.0	74.8	150	2.0	3.2
MV1648	73.8	82.0	90.2	150	2.0	3.2
MV1650	90.0	100.0	110.0	150	2.0	3.2

* TR, Tuning Ratio, is the ratio of C_T measured at 2 Vdc divided by C_T measured at 20 Vdc.

MV1652 (SILICON)
MV1654
MV1656
MV1658
MV1660
MV1662
MV1664
MV1666



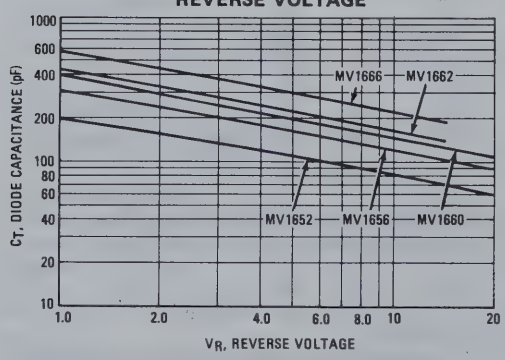
Silicon epicap epitaxial passivated tuning diodes designed for general tuning, trimming and AFC applications at low radio frequencies.

CASE 146

MAXIMUM RATINGS

Rating	Symbol	MV1652/ MV1660	MV1662/ MV1666	Unit
Reverse Voltage	V_R	20	15	Vdc
Forward Current	I_F	400		mAdc
Total Device Dissipation @ T_A = 25°C	P_D	400		mW
Derate above 25°C		2.67		mW/°C
Junction Temperature	T_J	175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

FIGURE 1 - DIODE CAPACITANCE versus REVERSE VOLTAGE



PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE
   L_S, is determined from the self resonant frequency and the junction capacity of the device.

$$L_S = \frac{1}{\omega^2_{res} C_J}$$

2. C_T, DIODE CAPACITANCE
   ($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).
3. TR, TUNING RATIO
   TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 20 Vdc or at 15 Vdc.
4. Q, FIGURE OF MERIT
   Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS9 with range extender or equivalent).

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	MV1652 thru MV1660	BV_R	20	-	-	Vdc
	MV1662 thru MV1666		15	-	-	
Reverse Current (V_R = 15 Vdc)	MV1652 thru MV1660	I_R	-	-	0.1	μAdc
(V_R = 10 Vdc)	MV1662 thru MV1666		-	-	0.1	
Series Inductance	MV1652 thru MV1666	L_S	-	5.0	-	nH

Device	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz (pF)			Q, Figure of Merit V_R = 4.0 Vdc, f = 20 MHz	Capacitance Ratio C_2/C_{20}
	Min	Nom	Max		Typical
MV1652	108	120	135	250	2.6
MV1654	132	150	165	250	2.6
MV1656	162	180	198	200	2.6
MV1658	180	200	220	200	2.6
MV1660	198	220	242	150	2.6
					C_2/C_{15}
MV1662	225	250	275	150	2.3
MV1664	243	270	300	100	2.3
MV1666	297	330	363	100	2.3

MV1804 (SILICON)

For Specifications, See 1N4387 Data.

MV1805C (SILICON)



CASE 47

High-frequency step-recovery silicon power varactor for 100 MHz to 2.0 GHz harmonic-generation applications with output power up to 35 watts at 1.0 GHz.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	80	Volts
Forward Current	I_F	5	Amps
RF Power Input	P_{in}	50	Watts
Total Device Dissipation @ T_A = 75°C	P_D	18	Watts
Derate above 75°C		0.14	W/°C
Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	I_R = 10 μAdc	80	95	—	Vdc
Reverse Current	I_R	V_R = 70 Vdc	—	—	2	μAdc
		V_R = 70 Vdc, T_A = 150°C	—	—	100	
Diode Capacitance	C_T	V_R = 6 Vdc, f = 1.0 MHz	20	25	30	pF
Figure of Merit	Q	V_R = 6 Vdc, f = 50 MHz	—	500	—	—
Thermal Resistance	θ_{JC}		—	—	7	°C/W

FUNCTIONAL TEST

RF Power Output	P_{out}	Test Setup Figure 4 P_{in} = 40 Watts	26	—	—	Watts
Tripler Efficiency	η	f_{in} = 250 MHz f_{out} = 750 MHz	65	—	—	%

POWER OUTPUT versus OUTPUT FREQUENCY

FIGURE 1A — DOUBLING (X2)

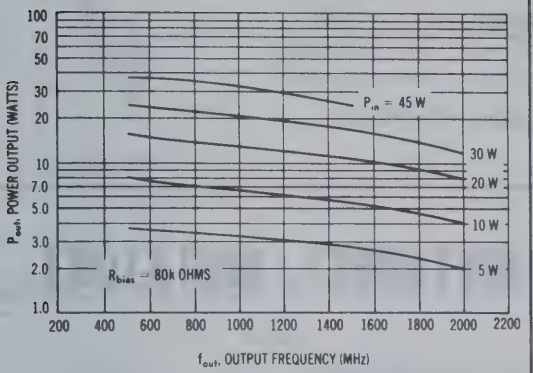


FIGURE 1B — TRIPLING (X3)

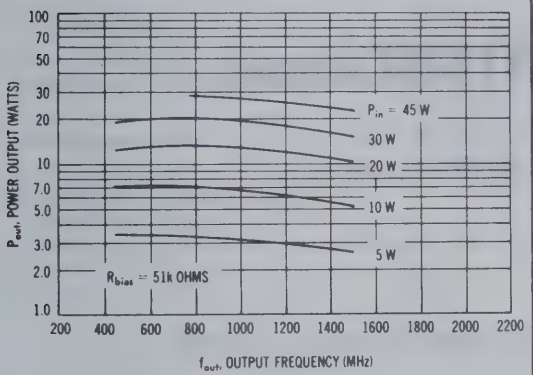


FIGURE 2 — TRIPLER LINEARITY CHARACTERISTICS

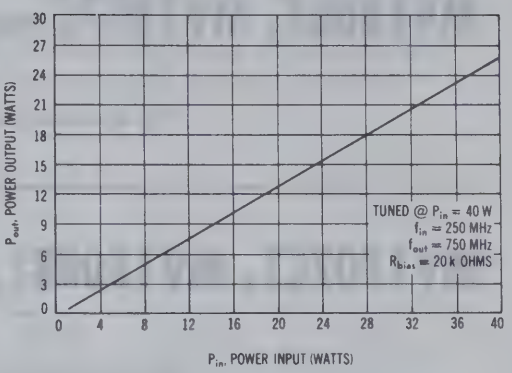


FIGURE 3 — CAPACITANCE versus REVERSE VOLTAGE

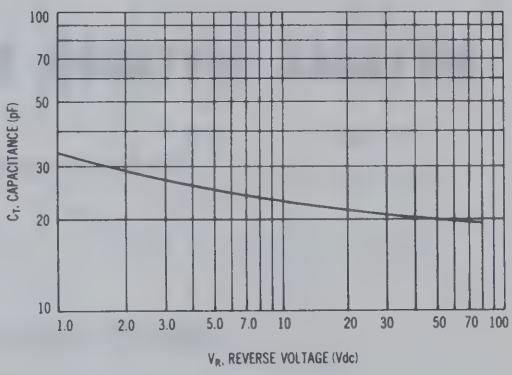


TABLE 1 — TYPICAL QUADRUPLING (X4)

f_{in} = 275 MHz, f_{out} = 1100 MHz, R_{bias} = 100k OHMS

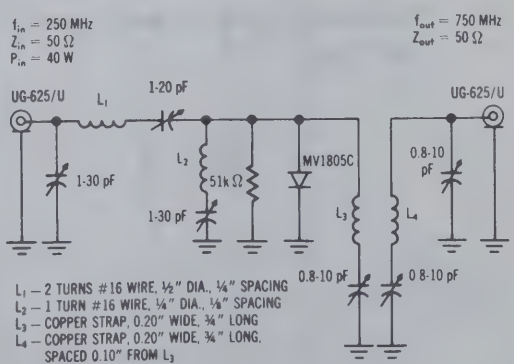
INPUT POWER Watts	OUTPUT POWER Watts	EFFICIENCY %
5	2.6	52
10	5.4	54
20	10.6	53
30	14.4	48
40	19.0	47.5
45	20.6	45.8

TABLE 2 — TYPICAL ONE-STEP (X9)

f_{in} = 50 MHz, f_{out} = 450 MHz, R_{bias} = 5k OHMS

INPUT POWER Watts	OUTPUT POWER Watts	EFFICIENCY %
5	1.4	28
10	2.7	27

FIGURE 4 — HARMONIC TRIPLER — 250 MHz to 750 MHz



MV1806 (SILICON)

For Specifications, See 1N4388 Data.

MV1806C, MV1807C (SILICON)

For Specifications, See 1N5149 Data.

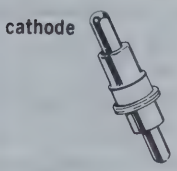
MV1807C1, MV1808B1, MV1808C1, MV1810B1

For Specifications, See 1N5150A Data.

MV1808A, MV1808B, MV1808C (SILICON)

For Specifications, See 1N5151 Data.

MV1809C (SILICON)
MV1809C1



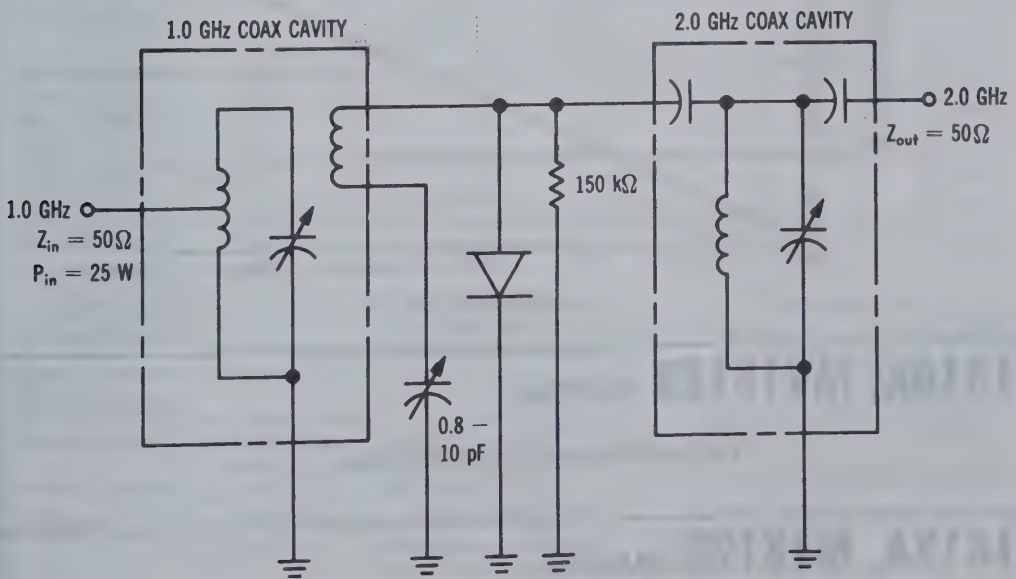
CASE 47

Silicon high-frequency step-recovery power varactors for 300 MHz to 3.0 GHz harmonic-generation applications with output power to 17 watts at 2.0 GHz.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating		Symbol	Value	Unit
Reverse Voltage		V_R	75	Vdc
Forward Current		I_F	5.0	Adc
RF Power Input	MV1809C MV1809C1	P_{in}	25 30	Watts
Total Device Dissipation @ T_C = 75°C	MV1809C MV1809C1	P_D	9.0 14	Watts
Derate above 75°C	MV1809C MV1809C1		0.07 0.11	mW/°C
Operating and Storage Junction Temperature Range		T_J, T_{stg}	-65 to +200	°C

FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT



MV1809C, MV1809C1 (continued)

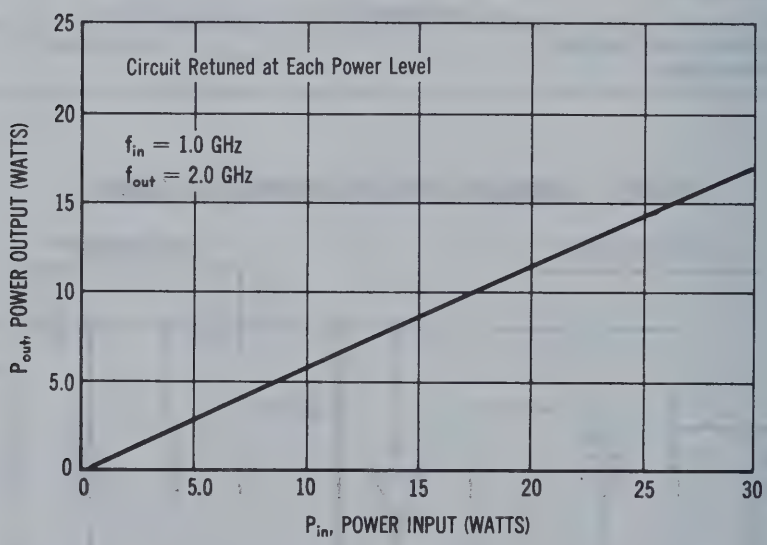
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)		BV_R	75	-	-	Vdc
Reverse Current (V_R = 70 Vdc)		I_R	-	-	2.0	μAdc
(V_R = 70 Vdc, T_A = 150°C)			-	-	100	
Diode Capacitance ($C_J + C_C$)	MV1809C	C_T				pF
(V_R = 6.0 Vdc, f = 1.0 MHz)	MV1809C		9.6	-	14.4	
	MV1809C1		10.8	-	13.2	
Case Capacitance		C_C	-	0.47	-	pF
Series Inductance		L_S	-	2.2	-	nH
Series Resistance (V_R = 6.0 Vdc)		R_S	-	0.35	0.5	Ohm
Thermal Resistance	MV1809C	θ_{JC}	-	-	14	°C/W
	MV1809C1		-	-	9.0	

FUNCTIONAL TESTS

MV1809C1 Power Output	Doubler Test Circuit (Figure 1) P_{in} = 25 W, f_{in} = 1.0 GHz, f_{out} = 2.0 GHz	P_{out}	14.5	-	-	Watt
Efficiency		η	58	-	-	%
MV1809C Power Output	Doubler Test Circuit (Figure 1) P_{in} = 20 W, f_{in} = 1.0 GHz, f_{out} = 2.0 GHz	P_{out}	10.4	-	-	Watt
Efficiency		η	52	-	-	%

FIGURE 2 — POWER OUTPUT versus POWER INPUT



MV1810A, MV1810B (SILICON)

For Specifications, See 1N5154 Data.

MV1812A, M1812B (SILICON)

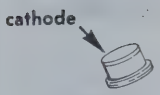
For Specifications, See 1N5156 Data.

MV1816A, B (SILICON)
MV1816A1, B1



CASE 46

MV1816B
MV1816B1



CASE 48

MV1816A
MV1816A1

Silicon high-frequency power varactors designed for high efficiency in frequency multiplier applications. Permits ONE-STEP multiplication to frequencies as high as 3.0 GHz.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	75	Vdc
Forward Current	I_F	2.5	Adc
RF Power Input	P_{in}	10	Watts
Total Device Dissipation @ T_C = 25°C	P_D		
MV1816A, MV1816B		7.5	Watts
Derate above 25°C		43	mW/°C
MV1816A1, MV1816B1		11.5	Watts
Derate above 25°C		66	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)		BV_R	75	103	-	Vdc
Reverse Current		I_R				μAdc
(V_R = 60 Vdc)			-	-	1.0	
(V_R = 60 Vdc, T_A = 150°C)			-	-	100	
Diode Capacitance (C_J + C_C)		C_T				pF
(V_R = 6.0 Vdc, f = 1.0 MHz)	MV1816A		2.5	-	3.7	
	MV1816A1		2.8	-	3.4	
	MV1816B		2.4	-	3.6	
	MV1816B1		2.7	-	3.3	
Case Capacitance	MV1816A, MV1816A1	C_C	-	0.25	-	pF
	MV1816B, MV1816B1		-	0.15	-	
Series Inductance		L_S	-	0.85	-	nH
Series Resistance (V_R = 6.0 Vdc)		R_S	-	0.57	-	Ohm
Minority Carrier Lifetime (I_F = 1.7 I_R, when I_F = 10 mA)	MV1816B1	τ	-	580	-	ns
Transition Time (I_F = 10 mA, Z_L = 50 ohms; measured between the 20% and 80% points)		t_t	-	1.25	-	ns
Thermal Resistance	MV1816A, MV1816B	θ_{JC}	-	-	23	°C/W
	MV1816A1, MV1816B1		-	8.5	15	

FUNCTIONAL TEST

Power Output	X 8 Test Circuit (Figure 1) P_{in} = 3.0 W, f_{in} = 300 MHz, f_{out} = 2.4 GHz	MV1816A, MV1816B	P_{out}	0.6	-	-	Watt
		MV1816A1, MV1816B1		0.75	-	-	
Efficiency		MV1816A, MV1816B	η	20	-	-	%
		MV1816A1, MV1816B1		25	-	-	

FIGURE 1 — OCTUPLER TEST CIRCUIT

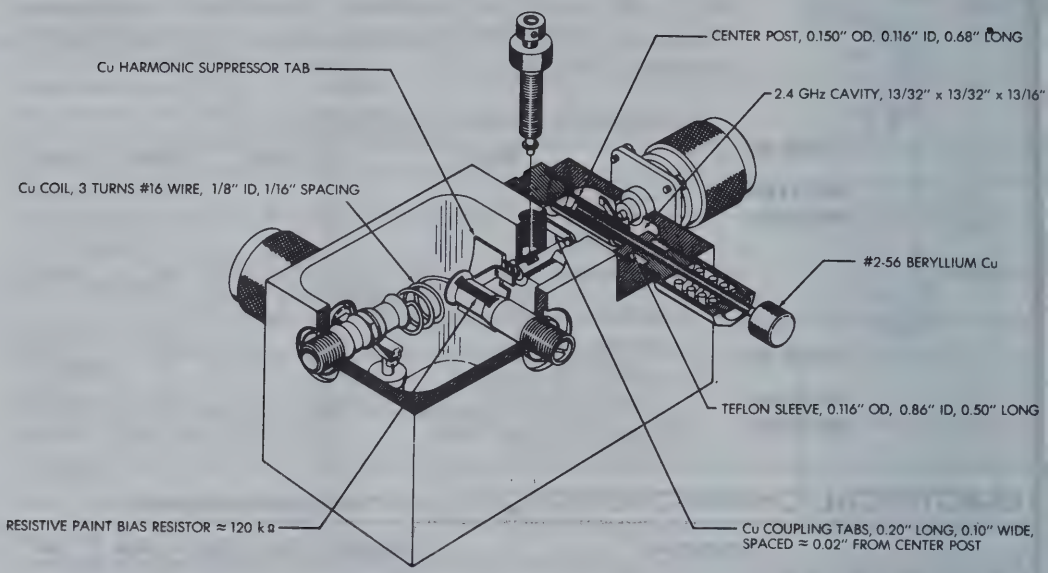


FIGURE 2 — CAPACITANCE versus REVERSE VOLTAGE

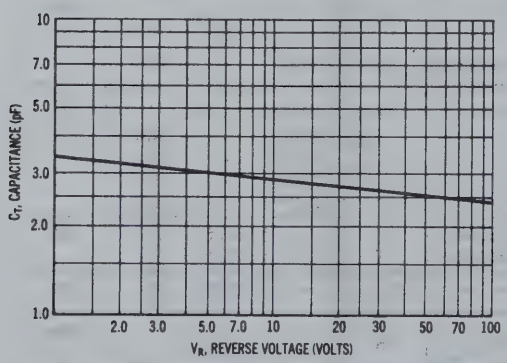


FIGURE 3 — OUTPUT POWER versus INPUT POWER

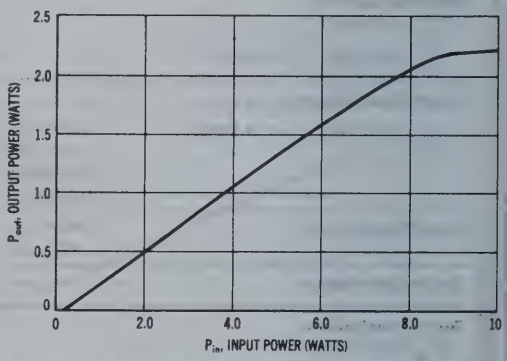
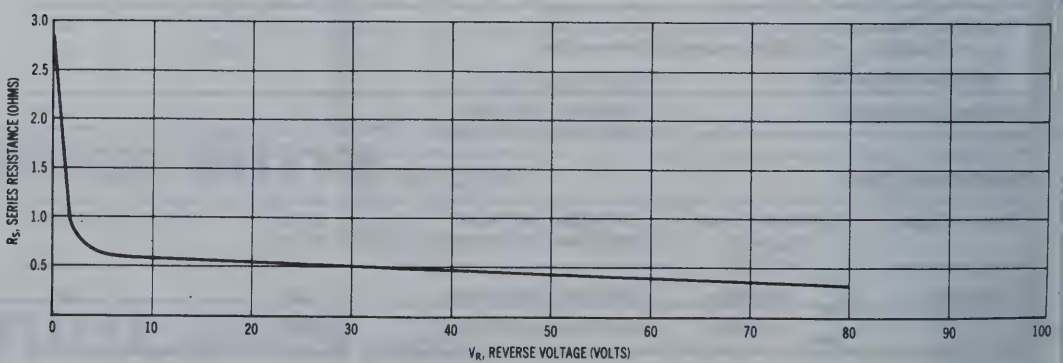
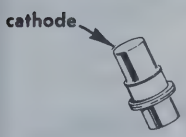


FIGURE 4 — SERIES RESISTANCE versus REVERSE VOLTAGE



MV1817A, B (SILICON)
MV1817A1, B1



Silicon high-frequency step-recovery power varactors designed for high efficiency in frequency multiplier applications. Permits ONE-STEP multiplication to frequencies as high as 8.0 GHz.

CASE 46
MV1817B
MV1817B1



CASE 48
MV1817A
MV1817A1

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	35	Vdc
Forward Current	I_F	0.80	Adc
RF Power Input	P_{in}	2.0	Watts
Total Device Dissipation @ T_C = 25°C	P_D		
MV1817A, MV1817B		5.0	Watts
Derate above 25°C		28	mW/°C
MV1817A1, MV1817B1		7.0	Watts
Derate above 25°C		40	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)		BV_R	35	60	-	Vdc
Reverse Current		I_R				μAdc
(V_R = 60 Vdc)			-	-	1.0	
(V_R = 60 Vdc, T_A = 150°C)			-	-	100	
Diode Capacitance ($C_J + C_C$)		C_T				pF
(V_R = 6.0 Vdc, f = 1.0 MHz)	MV1817A		0.9	-	1.3	
	MV1817A1		1.0	-	1.2	
	MV1817B		0.8	-	1.2	
	MV1817B1		0.9	-	1.1	
Case Capacitance	MV1817A, MV1817A1	C_C	-	0.25	-	pF
	MV1817B, MV1817B1		-	0.15	-	
Series Inductance		L_S	-	0.85	-	nH
Series Resistance (V_R = 6.0 Vdc)		R_S	-	0.80	-	Ohm
Minority Carrier Lifetime (I_F = 1.7 I_R, when I_F = 10 mA)		τ	-	120	-	ns
Transition Time (I_F = 10 mA, Z_L = 50 ohms; measured between the 20% and 80% points)		t_t	-	0.4	-	ns
Thermal Resistance	MV1817A, MV1817B,	θ_{JC}	-	-	35	°C/W
	MV1817A1 MV1817B1		-	12.5	25	

FUNCTIONAL TESTS

Power Output	X 8 Test Circuit (Figure 1)	MV1817A, MV1817B	P_{out}	0.2	-	-	Watt
		MV1817A1, MV1817B1		0.25	-	-	
Efficiency	P_{in} = 1.0 W, f_{in} = 800 MHz, f_{out} = 6.4 GHz	MV1817A, MV1817B	η	20	-	-	%
		MV1817A1, MV1817B1		25	-	-	

FIGURE 1 — OCTUPLER TEST CIRCUIT

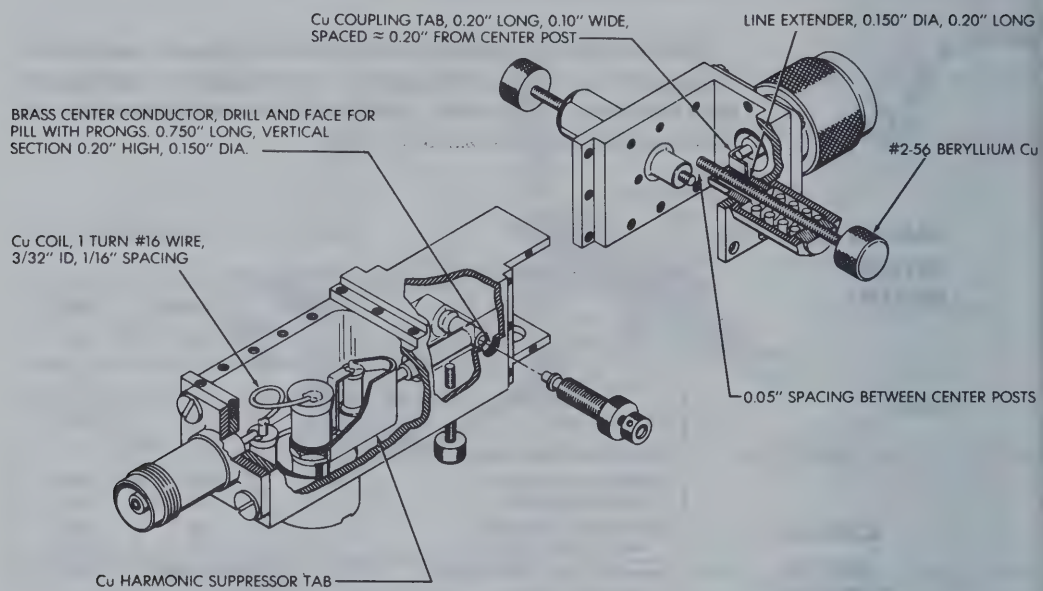


FIGURE 2 — CAPACITANCE versus REVERSE VOLTAGE

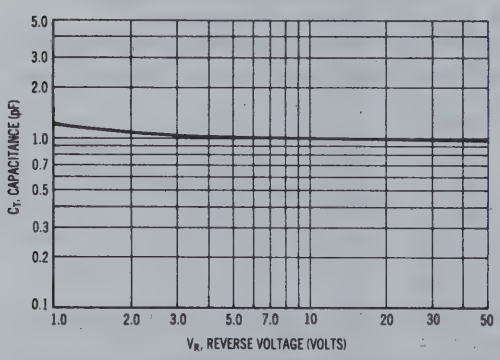


FIGURE 3 — OUTPUT POWER versus INPUT POWER

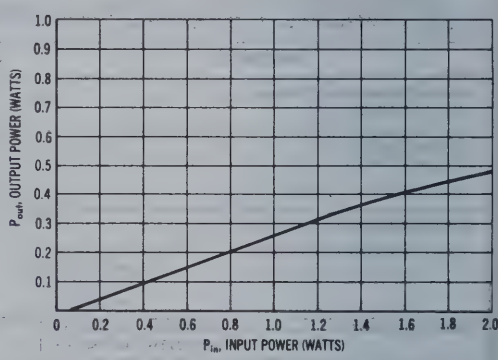
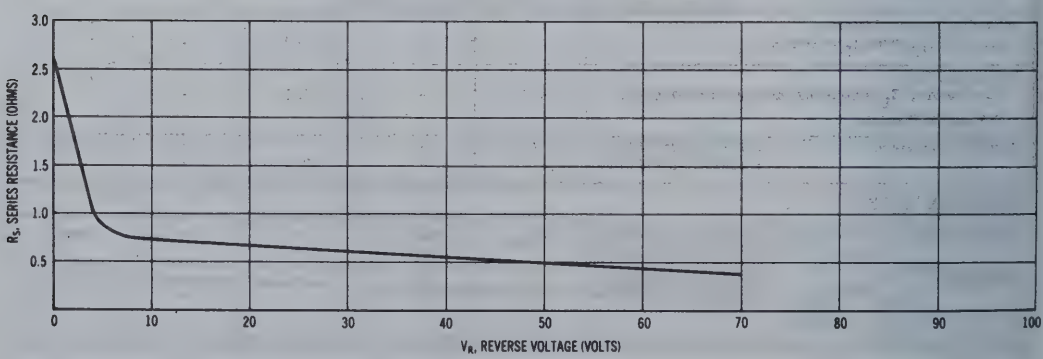


FIGURE 4 — SERIES RESISTANCE versus REVERSE VOLTAGE



MV1858D (SILICON)
thru
MV1870D

Silicon Epicap diodes designed for electronic tuning and control applications in the UHF and lower microwave frequency ranges, where extremely high Q and broad tuning ratio are required.



CASE 45



CASE 46
MV1858B thru MV1870B



CASE 48
MV1858A thru MV1870A

AVAILABLE ON SPECIAL REQUEST

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	60	Vdc
Forward Current	I_F	250	mAdc
Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic (all types)	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	I_R = 10 μAdc	B_{VR}	60	-	-	Vdc
Reverse Voltage Leakage Current	V_R = 55 Vdc V_R = 55 Vdc, T_A = 150°C	I_R	- -	- -	0.02 20	μAdc
Series Inductance	f = self-resonant frequency	L_S	-	0.8	-	nH
Case Capacitance	f = 1 MHz	C_C	-	0.15*	-	pF

Device	C_T, Diode Capacitance † V_R = 4 Vdc, f = 1.0 MHz pF			TR, Tuning Ratio C_4/C_{60} f = 1 MHz		R_s, Series Resistance V_R = 4 Vdc, OHMS
	Min	Nom	Max	Min	Max	Max
MV1858D	0.70	1.0	1.30	2.1	2.7	4.5
MV1860D	1.76	2.2	2.64	2.5	3.1	2.1
MV1862D	2.97	3.3	3.63	2.6	3.3	1.6
MV1863D	4.23	4.7	5.17	2.6	3.3	1.1
MV1864D	6.10	6.8	7.50	2.7	3.4	0.8
MV1865D	7.38	8.2	9.02	2.7	3.4	0.8
MV1866D	9.00	10.0	11.00	2.8	3.5	0.7
MV1868D	10.80	12.0	13.20	2.8	3.5	0.6
MV1870D	13.50	15.0	16.50	2.8	3.5	0.5

*Case Capacitance = 0.26 pF typical for types MV1858A thru MV1870A (case 48).
†All C_T values 0.11 pF higher for types MV1858A thru MV1870A (case 48). TR is reduced proportionately.

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE

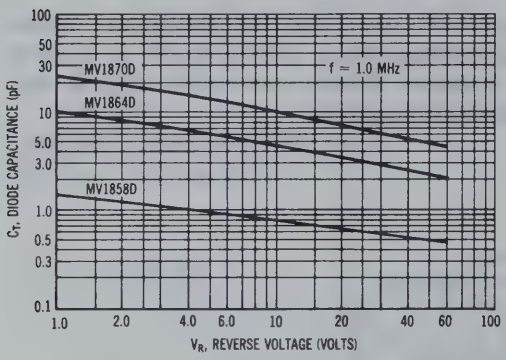


FIGURE 2 — NORMALIZED SERIES RESISTANCE versus REVERSE VOLTAGE

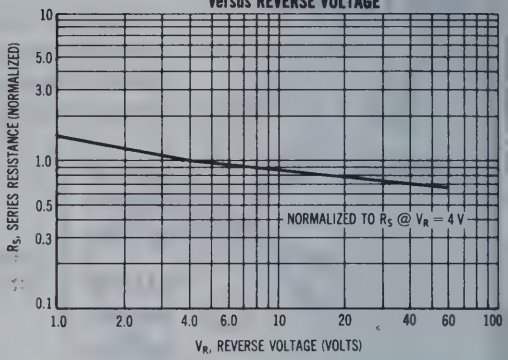


FIGURE 3 — CAPACITANCE VARIATION versus TEMPERATURE

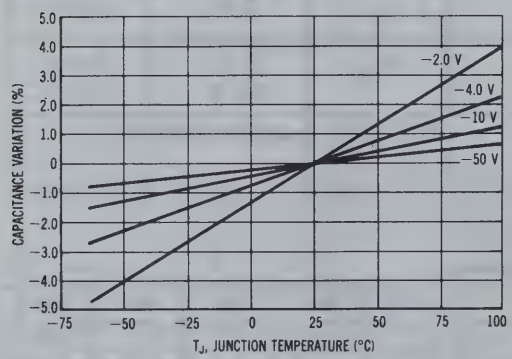


FIGURE 4 — NORMALIZED SERIES RESISTANCE versus TEMPERATURE

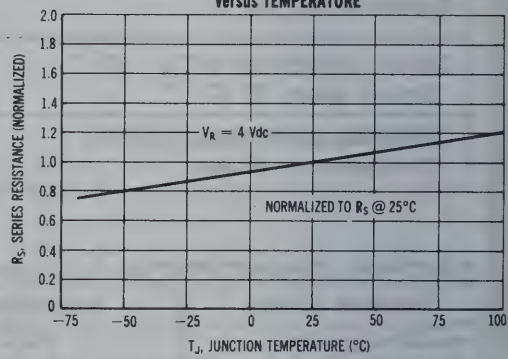


FIGURE 5 — REVERSE LEAKAGE CURRENT versus REVERSE VOLTAGE

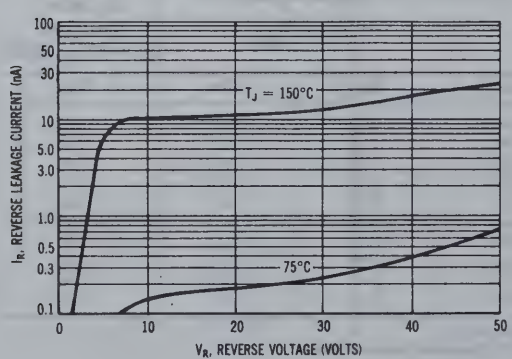
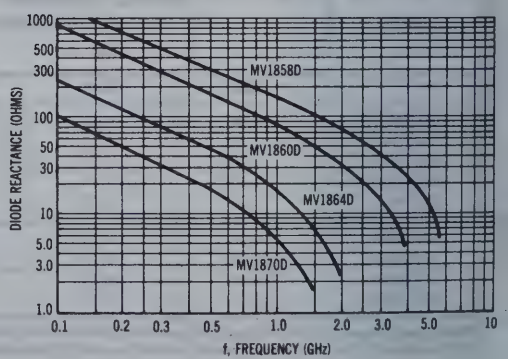


FIGURE 6 — DIODE REACTANCE versus FREQUENCY



EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. EPICAP NETWORK PRESENTATION

The equivalent circuit in Figure 7 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_s, R_j, and C_c can be neglected. The simplified equivalent circuit of Figure 8 represents the diode under these conditions.

FIGURE 7

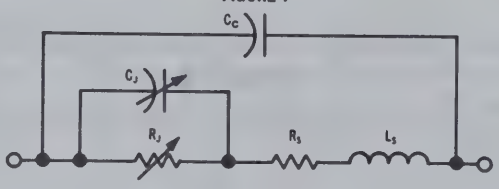
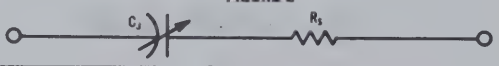


FIGURE 8



Definitions:

- C_j — Voltage-Variable Junction Capacitance
- R_s — Series Resistance (semiconductor bulk, contact, and lead resistance)
- C_c — Case Capacitance
- L_s — Series Inductance
- R_j — Voltage-Variable Junction Resistance (negligible above 100 kHz)

B. EPICAP CAPACITANCE vs REVERSE BIAS VOLTAGE

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Since the designer is primarily interested in the slope of C_T versus V_R, the C_c, C_o, ϕ, and γ characteristics have been encompassed by the simplified equation 3. Min/max limits on α can be guaranteed over a specified V_R range.

$$C_T = C_c + C_j \tag{1}$$

$$C_T = C_c + \frac{C_o}{(1 + \frac{V_R}{\phi})^\gamma} \tag{2}$$

$C_o = C_j$ at $V_R = 0$ $\quad$ V_R = Reverse Bias

ϕ = Contact Potential, $\phi \approx 0.6$ Volt $\quad$ $\gamma = C_j$ slope, $\gamma \approx 0.5$

$$C_T = \frac{K}{V_R^\alpha} \tag{3}$$

C. EPICAP CAPACITANCE vs FREQUENCY

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 7, but neglecting R_s and R_j. The admittance expression for such a circuit is given in equation 4. Examination of equation 4 yields the following information:

At low frequencies, $C_{eq} \approx C_j$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_c$.

As frequency is increased from 1 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_sC_j$; and as ω^2 is increased from $1/L_sC_j$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_c$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1 MHz. As ω approaches $\omega_o = 1/\sqrt{L_sC_j}$, small variations in L_s cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_c + \frac{j\omega C_j}{1 - \omega^2 L_s C_j} \tag{4}$$

D. EPICAP FIGURE OF MERIT (Q) AND CUTOFF FREQUENCY (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 5. For very low frequencies, equation 6 applies whereas at high frequencies, where R_j can be neglected, equation 5 may be rewritten into the familiar form of equation 7.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 8 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \tag{5}$$

$$Q_{LF} = \frac{\omega C_j R_j^2}{R_j + R_s(1 + \omega^2 C_j^2 R_j^2)} \tag{6}$$

$$Q_M = \frac{1}{\omega R_s C_{eq}} \tag{7}$$

$$f_{co} = Qf_{max} \approx \frac{1}{2\pi R_s C_{SVR}} \tag{8}$$

E. HARMONIC GENERATION USING EPICAPS

Efficient harmonic generation is possible with EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 9 gives the level of maximum input power for the EPICAP and equation 10 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_s} \frac{f_{in}}{f_{co}} \tag{9}$$

$M(x2) = 0.0285; M(x3) = 0.0241; M(x4) = 0.196$

$$Eff = 1 - N \frac{f_{out}}{f_{co}} \tag{10}$$

$N(x2) = 20.8;\ N(x3) = 34.8;\ N(x4) = 62.5$

M and N are Constants

MV2101 thru MV2115 (SILICON)

VVC

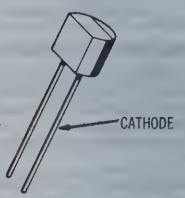
SILICON EPICAP DIODES

. . . designed in the popular PLASTIC PACKAGE for high volume requirements of FM Radio and TV tuning and AFC, general frequency control and tuning applications; providing solid-state reliability in replacement of mechanical tuning methods.

- High Q with Guaranteed Minimum Values
- Controlled and Uniform Tuning Ratio
- Standard Capacitance Tolerance—10%
- Complete Typical Design Curves
- Case TO-92 with Two Leads

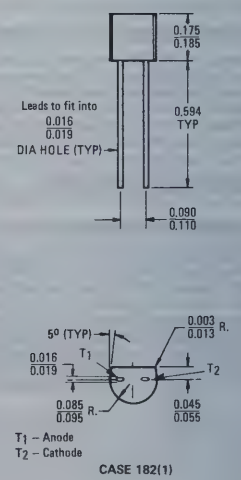
VOLTAGE-VARIABLE CAPACITANCE DIODES

6.8–100 pF
30 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



CASE 182(1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	30	–	–	Vdc
Reverse Voltage Leakage Current (V_R = 25 Vdc, T_A = 25°C)	I_R	–	–	0.10	μAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	6.0	–	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.18	–	pF
Diode Capacitance Temperature Coefficient (V_R = 4.0 Vdc, f = 1.0 MHz)	TC_C	–	280	400	ppm/°C

	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF			Q, Figure of Merit V_R = 4.0 Vdc, f = 50 MHz	TR, Tuning Ratio C_2/C_{30} f = 1.0 MHz		
Device	Min	Nom	Max	Min	Min	Typ	Max
MV2101	6.1	6.8	7.5	450	2.5	2.7	3.2
MV2102	7.4	8.2	9.0	450	2.5	2.8	3.2
MV2103	9.0	10.0	11.0	400	2.5	2.9	3.2
MV2104	10.8	12.0	13.2	400	2.5	2.9	3.2
MV2105	13.5	15.0	16.5	400	2.5	2.9	3.2
MV2106	16.2	18.0	19.8	350	2.5	2.9	3.2
MV2107	19.8	22.0	24.2	350	2.5	2.9	3.2
MV2108	24.3	27.0	29.7	300	2.5	3.0	3.2
MV2109	29.7	33.0	36.3	200	2.5	3.0	3.2
MV2110	35.1	39.0	42.9	150	2.5	3.0	3.2
MV2111	42.3	47.0	51.7	150	2.5	3.0	3.2
MV2112	50.4	56.0	61.6	150	2.6	3.0	3.3
MV2113	61.2	68.0	74.8	150	2.6	3.0	3.3
MV2114	73.8	82.0	90.2	100	2.6	3.0	3.3
MV2115	90.0	100.0	110.0	100	2.6	3.0	3.3

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE

L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter).

2. C_C, CASE CAPACITANCE

C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. C_T, DIODE CAPACITANCE

($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. TR, TUNING RATIO

TR is the ratio of C_T measured at 2.0 Vdc divided by C_T measured at 30 Vdc.

5. Q, FIGURE OF MERIT

Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8). Use Lead Length ≈1/16".

6. TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT

TC_C is guaranteed by comparing C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = -65°C with C_T at V_R = 4.0 Vdc, f = 1.0 MHz, T_A = +85°C in the following equation which defines TC_C:

$$TC_C = \frac{C_T(+85^\circ C) - C_T(-65^\circ C)}{85 + 65} \cdot \frac{10^6}{C_R(25^\circ C)}$$

Accuracy limited by measurement of C_T to ± 0.1 pF.

TYPICAL DEVICE PERFORMANCE

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE

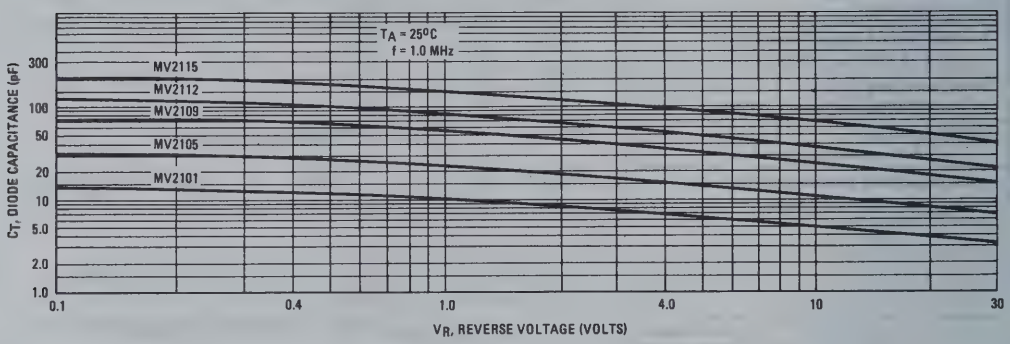


FIGURE 2 – NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

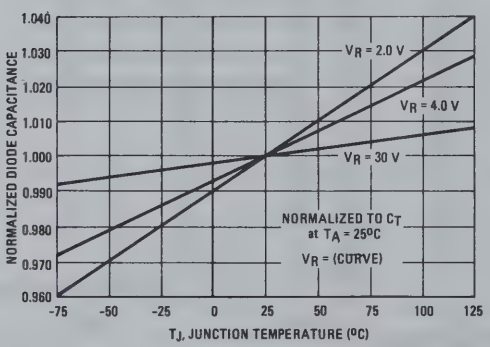


FIGURE 3 – REVERSE CURRENT versus REVERSE BIAS VOLTAGE

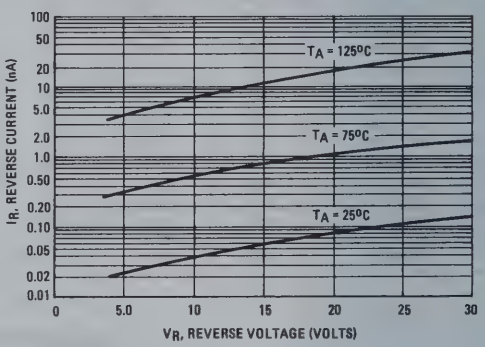


FIGURE 4 – FIGURE OF MERIT versus REVERSE VOLTAGE

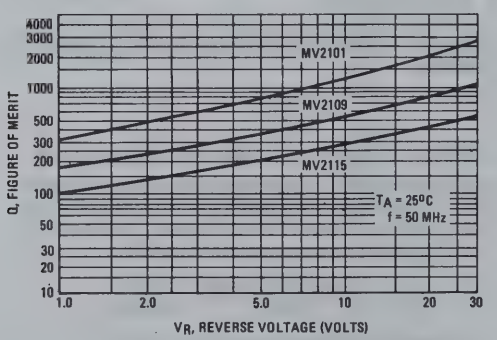
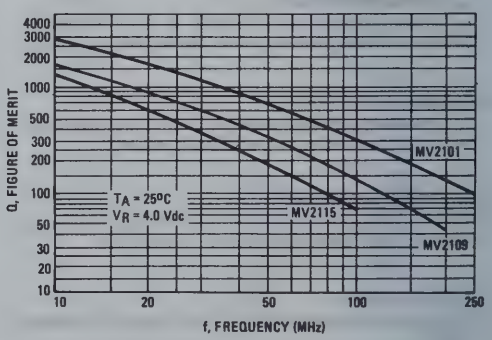


FIGURE 5 – FIGURE OF MERIT versus FREQUENCY



EPICAP VOLTAGE-VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. Epicap Network Presentation

The equivalent circuit in Figure 6 shows the voltage capacitance and parasitic elements of an EPICAP diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 7 represents the diode under these conditions.

Definitions:

- C_J – Voltage-Variable Junction Capacitance
- R_S – Series Resistance (semiconductor bulk, contact, and lead resistance)
- C_C – Case Capacitance
- L_S – Series Inductance
- R_J – Voltage-Variable Junction Resistance (negligible above 100 kHz)

FIGURE 6

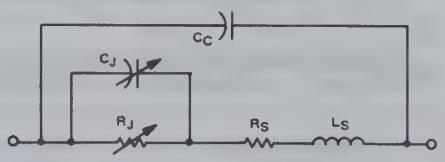


FIGURE 7



B. Epicap Capacitance versus Reverse Bias Voltage

The most important design characteristic of an EPICAP diode is the C_T versus V_R variation as shown in equations 1 and 2. Tuning Ratio, TR, between any two voltage points on curve of equation (2) is determined from equations (3) and (4).

$$C_T = C_C + C_J \tag{1}$$

$$C_T = C_C + \frac{C_o}{\left(1 + \frac{V_R}{\phi}\right)^{\gamma}} \tag{2}$$

$$\text{TR Junction} = \frac{C_{J1}}{C_{J2}} = \left(\frac{V_{R2} + \phi}{V_{R1} + \phi}\right)^{\gamma} \tag{3}$$

$$\text{TR Diode} = \frac{C_{T1}}{C_{T2}} = \frac{C_{J1} + C_C}{C_{J2} + C_C} \tag{4}$$

Conditions:

$C_o = C_J$ at $V_R = 0$
V_R = Reverse Bias (Volts)
γ, Diode Power Law, ≈ 0.44
ϕ, Contact Potential, ≈ 0.6 Volt
$C_c \approx 0.18$ pF

C. Epicap Capacitance versus Frequency

Variations in EPICAP effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 6, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 5. Examination of equation 5 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_C$.

As frequency is increased from 1.0 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_S C_J$; and as ω^2 is increased from $1/L_S C_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductance) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1.0 MHz. As ω approaches $\omega_o = 1/\sqrt{L_S C_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_C + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \tag{5}$$

D. EPICAP Figure of Merit (Q) and Cutoff Frequency (f_{co})

The efficiency of EPICAP response to an input frequency is related to the Figure of Merit of the device as defined in equation 6. For very low frequencies, equation 7 applies whereas at high frequencies, where R_J can be neglected, equation 6 may be rewritten into the familiar form of equation 8.

Another useful parameter for EPICAP devices is the cutoff frequency (f_{co}), and is the frequency point where Q is equal to 1. Equation 9 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \tag{6}$$

$$Q_{Lf} = \frac{\omega C_J R_J^2}{R_J + R_S(1 + \omega^2 C_J^2 R_J^2} \tag{7}$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \tag{8}$$

$$f_{co} = Qf_{meas} \approx \frac{1}{2\pi R_S C_{BVR}} \tag{9}$$

E. Harmonic Generation Using EPICAPS

Efficient harmonic generation is possible with EPICAPS because of their high cutoff frequency and breakdown voltage. Since EPICAP junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 10 gives the level of maximum input power for the EPICAP and equation 11 gives the relationships governing EPICAP circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \frac{f_{in}}{f_{co}} \tag{10}$$

M(x2) = 0.0285; M(x3) = 0.0241; M(x4) = 0.196

$$\text{Eff} = 1 - N\frac{f_{out}}{f_{co}} \tag{11}$$

N(x2) = 20.8; N(x3) = 34.8; N(x4) = 62.5

M and N are Constants

MV2201, MV2203 (SILICON)
MV2205, MV2209

VVC

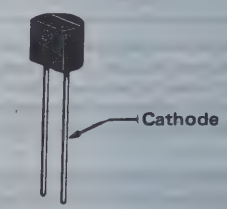
AFC SILICON EPICAP DIODES

. . . designed specifically for the high volume AFC applications of FM Radio and TV, utilizing the economical PLASTIC PACKAGE.

- Very High Q with Guaranteed Minimum Values
- Guaranteed Uniformity with Minimum and Maximum Tuning Ratio Limits, Assuring Fixed Design
- Nominal Capacitance Values — 6.8 pF Thru 33 pF — Providing Complete AFC Design Flexibility

VOLTAGE-VARIABLE CAPACITANCE DIODES

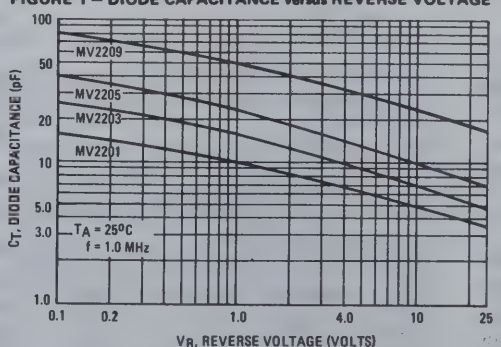
6.8–33 pF
25 VOLTS

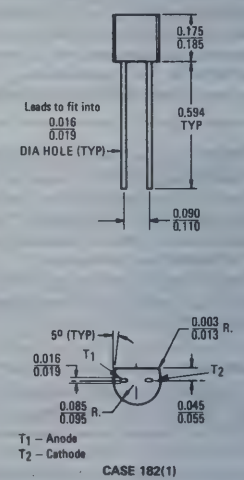


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	25	Volts
Forward Current	I_F	200	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE





CASE 182(1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	25		–	Vdc
Reverse Voltage Leakage Current (V_R = 10 Vdc, T_A = 25°C) (V_R = 10 Vdc, T_A = 85°C)	I_R	– –	– –	0.5 5.0	μAdc
Forward Voltage Drop (I_F = 250 μAdc)	V_F	–	0.65	–	Vdc
Series Inductance (f = 250 MHz, lead length ≈ 1/16")	L_S	–	6.0	–	nH
Case Capacitance (f = 1.0 MHz, lead length ≈ 1/16")	C_C	–	0.18	–	pF

	C_T, Diode Capacitance V_R = 4.0 Vdc, f = 1.0 MHz pF		Q, Figure of Merit V_R = 4.0 Vdc, f = 50 MHz	TR, Tuning Ratio C_1/C_{10} f = 1.0 MHz	
Device	Min	Max	Min	Min	Max
MV2201	5.5	8.0	300	1.9	2.3
MV2203	8.5	11.5	200	2.0	2.4
MV2205	13	17	200	2.1	2.5
MV2209	29	37	150	2.1	2.5

FIGURE 2 – FIGURE OF MERIT versus REVERSE VOLTAGE

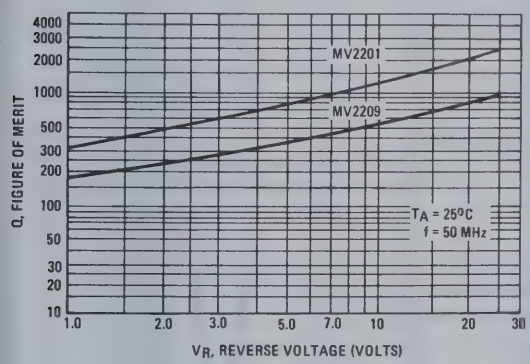


FIGURE 3 – FIGURE OF MERIT versus FREQUENCY

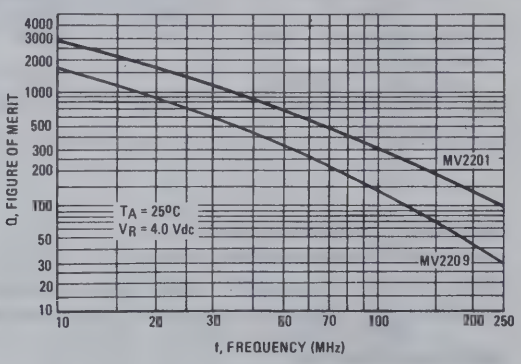
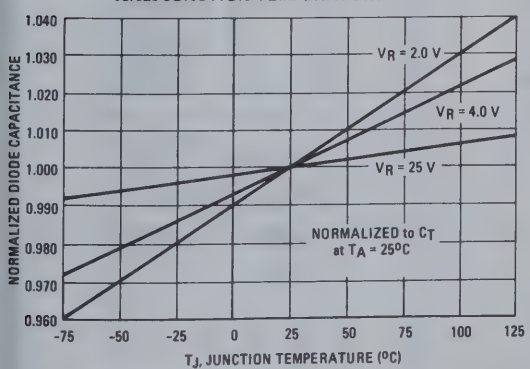


FIGURE 4 – NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE



NOTES ON TESTING AND SPECIFICATIONS

L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

C_C is measured on a package without a die, using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Q is calculated by taking the G and C readings of an admittance bridge, such as Boonton Electronics Model 33AS8, at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

MZ92-2.4, A, B (SILICON)
thru
MZ92-200, A, B

500 mW UNIBLOC SILICON OXIDE PASSIVATED ZENER REGULATOR DIODES

Highly reliable silicon regulators utilizing an oxide-passivated junction for long-term voltage stability. Supplied in the popular TO-92 plastic package for the high volume requirements of the consumer industry.

- In-Line Leads for Easy Insertion
- Lower Cost in High Volume
- Electrically Similar to Our Popular Surmetic 20 Series "1N5221 – 1N5281"
- Wide Voltage Selection – 2.4-200 V

UNIBLOC ZENER REGULATOR DIODES

500 MILLIWATTS
2.4 thru 200 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_L = 55^oC$ Lead Length = 1/4"	P_D	500	mW
Derate above 55^oC (Figure 1)		5.26	mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	^oC

MECHANICAL CHARACTERISTICS

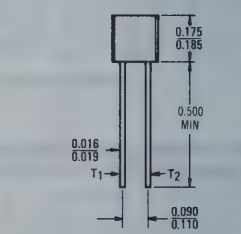
CASE: Void free, transfer molded, thermosetting plastic

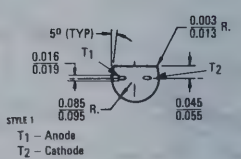
FINISH: All external surfaces are corrosion resistant. Leads are readily solderable and weldable

POLARITY: Cathode indicated by color dot. When operated in zener mode, cathode will be positive with respect to anode

MOUNTING POSITION: Any

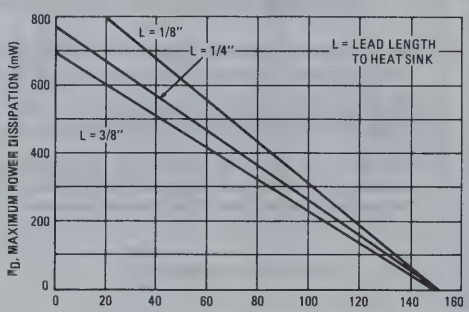
WEIGHT: 0.18 gram (approx)





CASE 182 (1)

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



MZ92-2.4,A,B thru MZ92-200,A,B (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted. Based on dc measurements at thermal equilibrium; lead length = 1/4"; thermal resistance of heat sink ≈ 30°C/W), V_F = 1.5 Max @ I_F = 200 mA for all types.)

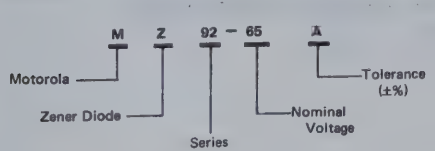
Motorola Type Number (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mA	Max Zener Impedance A & B Suffix Only		Max Reverse Leakage Current A & B Suffix Only			Non-Suffix	Typical Zener Voltage Temp. Coeff. θ_{VZ} (%/°C) (Note 3)
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} = 0.25 mA Ohms	I_R μA	@	V_R Volts	I_R @ V_R Used For Suffix A μA	
						A	B		
MZ92-2.4	2.4	20	50	2100	100	0.95	1.0	200	−1.03
MZ92-2.5	2.5	20	50	2100	100	0.95	1.0	200	−1.03
MZ92-2.7	2.7	20	50	2200	75	0.95	1.0	150	−1.01
MZ92-2.8	2.8	20	50	2200	75	0.95	1.0	150	−1.00
MZ92-3.0	3.0	20	50	2300	50	0.95	1.0	100	−0.09
MZ92-3.3	3.3	20	50	2500	25	0.95	1.0	100	−0.068
MZ92-3.6	3.6	20	48	2700	15	0.95	1.0	100	−0.051
MZ92-3.9	3.9	20	40	2800	10	0.95	1.0	75	−0.034
MZ92-4.3	4.3	20	25	2900	5.0	0.95	1.0	50	−0.010
MZ92-4.7	4.7	20	19	2600	5.0	1.9	2.0	50	+0.012
MZ92-5.1	5.1	20	17	2400	5.0	1.9	2.0	50	+0.025
MZ92-5.6	5.6	20	15	2100	5.0	2.9	3.0	50	+0.035
MZ92-6.0	6.0	20	13	1900	5.0	3.3	3.5	50	+0.041
MZ92-6.2	6.2	20	14	1500	5.0	3.8	4.0	50	+0.043
MZ92-6.8	6.8	20	17	780	3.0	4.8	5.0	30	+0.050
MZ92-7.5	7.5	20	23	700	3.0	5.7	6.0	30	+0.055
MZ92-8.2	8.2	20	34	700	3.0	6.2	6.5	30	+0.059
MZ92-8.7	8.7	20	44	700	3.0	6.2	6.5	30	+0.061
MZ92-9.1	9.1	20	50	700	3.0	6.7	7.0	30	+0.062
MZ92-10	10	20	62	700	3.0	7.6	8.0	30	+0.066
MZ92-11	11	20	68	700	2.0	8.0	8.4	30	+0.068
MZ92-12	12	20	70	700	1.0	8.7	9.1	10	+0.070
MZ92-13	13	9.5	70	700	0.5	9.4	9.9	10	+0.072
MZ92-14	14	9.0	70	700	0.1	9.5	10	10	+0.074
MZ92-15	15	8.5	34	700	0.1	10.5	11	10	+0.076
MZ92-16	16	7.8	38	700	0.1	11.4	12	10	+0.077
MZ92-17	17	7.4	42	700	0.1	12.4	13	10	+0.078
MZ92-18	18	7.0	48	700	0.1	13.3	14	10	+0.079
MZ92-19	19	6.6	52	700	0.1	13.3	14	10	+0.080
MZ92-20	20	6.2	57	700	0.1	14.3	15	10	+0.080
MZ92-22	22	5.6	68	700	0.1	16.2	17	10	+0.082
MZ92-24	24	5.2	78	700	0.1	17.1	18	10	+0.083
MZ92-25	25	5.0	85	700	0.1	18.1	19	10	+0.083
MZ92-27	27	4.6	98	700	0.1	20	21	10	+0.084
MZ92-28	28	4.5	105	700	0.1	20	21	10	+0.084
MZ92-30	30	4.2	117	700	0.1	22	23	10	+0.085
MZ92-33	33	3.8	140	700	0.1	24	25	10	+0.086
MZ92-36	36	3.4	160	700	0.1	26	27	10	+0.087
MZ92-39	39	3.2	190	800	0.1	29	30	10	+0.087
MZ92-43	43	3.0	225	900	0.1	31	33	10	+0.088
MZ92-47	47	2.7	260	1000	0.1	34	36	10	+0.088
MZ92-51	51	2.5	300	1100	0.1	37	39	10	+0.089
MZ92-56	56	2.2	360	1300	0.1	41	43	10	+0.089
MZ92-60	60	2.1	410	1500	0.1	44	46	10	+0.090
MZ92-62	62	2.0	430	1600	0.1	45	47	10	+0.090
MZ92-68	68	1.8	520	1900	0.1	49	52	10	+0.090
MZ92-75	75	1.7	600	2300	0.1	53	56	10	+0.090
MZ92-82	82	1.5	700	2700	0.1	59	62	10	+0.090
MZ92-87	87	1.4	780	3100	0.1	65	68	10	+0.091
MZ92-91	91	1.4	840	3400	0.1	66	69	10	+0.091
MZ92-100	100	1.3	1000	4000	0.1	72	76	10	+0.091
MZ92-110	110	1.1	1200	5000	0.1	80	84	10	+0.091
MZ92-120	120	1.0	1400	5100	0.1	86	91	10	+0.092
MZ92-130	130	0.95	1600	5200	0.1	94	99	10	+0.092
MZ92-140	140	0.90	1800	5300	0.1	101	106	10	+0.092
MZ92-150	150	0.85	2100	5400	0.1	108	114	10	+0.092
MZ92-160	160	0.80	2300	5500	0.1	116	122	10	+0.092
MZ92-170	170	0.74	2600	5600	0.1	123	129	10	+0.092
MZ92-180	180	0.68	2900	6000	0.1	130	137	10	+0.092
MZ92-190	190	0.66	3200	6500	0.1	137	144	10	+0.093
MZ92-200	200	0.65	3500	7000	0.1	144	152	10	+0.093

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

Tolerance designation – The type numbers listed indicate a tolerance of ±20% with guaranteed limits on V_Z, I_R and V_F. In addition, zener impedance (Z_{ZT}, Z_{ZK}) limits are guaranteed on devices indicated by suffix "A" for ±10% tolerance, "B" for ±5.0%, "C" for ±2.0% and "D" for ±1.0% tolerance.

Non-Standard voltage designation – To designate units with zener voltages other than those assigned the Motorola type number should be used.

EXAMPLE:



NOTE 2 – SPECIAL SELECTIONS AVAILABLE INCLUDE:

(a) Nominal zener voltages between those shown.

(b) Matched sets: (Standard Tolerances are ±5.0%, ±2.0%, ±1.0%)

a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.

b. Two or more units matched to one another with any specified tolerance.

(c) Tight voltage tolerances: 1.0%, 2.0%

NOTE 3 – TYPICAL TEMPERATURE COEFFICIENT (θ_{VZ})

Test conditions for temperature coefficient are as follows:

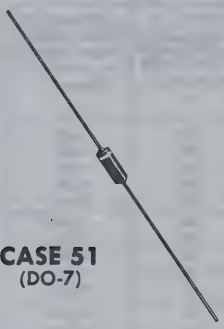
a. I_{ZT} = 7.5 mA, T_1 = 25°C.
T_2 = 125°C (MZ92-2.4A,B thru MZ92-12A,B).

b. I_{ZT} = Rated I_{ZT}, T_1 = 25°C.
T_2 = 125°C (MZ92-13A,B thru MZ92-200A,B).

Device to be temperature stabilized with current applied prior to reading breakdown voltage at the specified ambient temperature.

MZ500-1 thru MZ500-40 (SILICON)

400 mW
2.4-100 V



CASE 51
(DO-7)

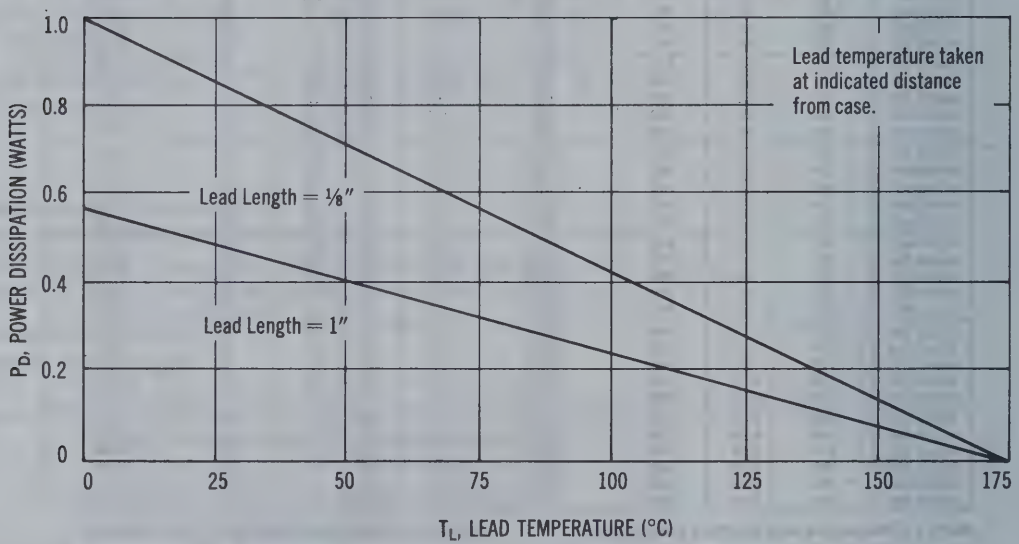
Miniature plastic encapsulated zener diodes for regulated power supply circuits, surge protection, arc suppression and other functions in television, automotive and other consumer product applications.

MAXIMUM RATINGS

Rating	Value	Unit
DC Power Dissipation @ T_L = 50°C	400	mW
Derate above 50°C	3.2	mW/°C
Junction Temperature*	-65 to +175	°C

*Maximum lead temperature for 10 seconds at 1/16'' from case = 230°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



MECHANICAL CHARACTERISTICS

CASE: Void free, transfer molded.

FINISH: All external surfaces are corrosion resistant. Leads are readily solderable.

POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.

MOUNTING POSITION: Any.

WEIGHT: 0.42 gram (approximately).

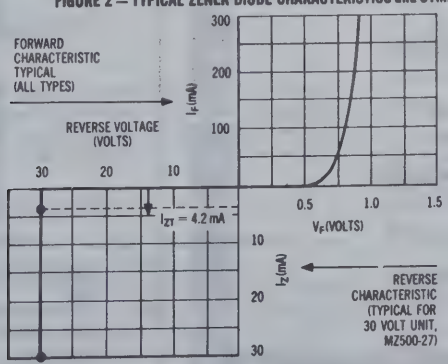
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted) V_F = 1.5 V max @ 200 mA on all types

Type No.	Zener Voltage V_Z @ I_{ZT} Volts*			Test Current I_{ZT} mA	Typical Z_{ZT} @ I_{ZT} Ohms	Max DC Zener Current I_{ZM} mA	Maximum Reverse Leakage Current I_R @ V_R		Typical Temperature Coefficient %/°C
	Min	Nom	Max				μA Max	Volts	
MZ500-1	2.16	2.4	2.64	20	35	150	—	—	-.085
MZ500-2	2.43	2.7	2.94	20	30	135	—	—	-.080
MZ500-3	2.7	3.0	3.3	20	30	120	—	—	-.075
MZ500-4	2.97	3.3	3.63	20	30	110	20	1	-.070
MZ500-5	3.24	3.6	3.96	20	25	100	20	1	-.065
MZ500-6	3.51	3.9	4.29	20	25	95	20	1	-.060
MZ500-7	3.87	4.3	4.73	20	25	85	5	1	-.050
MZ500-8	4.23	4.7	5.17	20	20	80	5	1	-.043
MZ500-9	4.59	5.1	5.61	20	20	70	5	1	±.030
MZ500-10	5.04	5.6	6.16	20	15	65	5	1	±.028
MZ500-11	5.58	6.2	6.82	20	10	60	5	1	+.045
MZ500-12	6.12	6.8	7.48	20	5	55	5	1	.050
MZ500-13	6.75	7.5	8.25	20	10	50	5	1	.058
MZ500-14	7.38	8.2	9.02	20	10	45	5	1	.062
MZ500-15	8.19	9.1	10.02	20	10	40	5	1	.068
MZ500-16	9.0	10	11.0	20	20	36	5	1	.075
MZ500-17	9.9	11	12.1	20	20	35	5	1	.076
MZ500-18	10.8	12	13.2	20	30	32	5	1	.077
MZ500-19	11.7	13	14.3	9.5	15	30	10	9.4	.079
MZ500-20	13.5	15	16.5	8.5	20	26	10	10.8	.082
MZ500-21	14.4	16	17.6	7.8	20	25	10	11.5	.083
MZ500-22	16.2	18	19.8	7.0	25	21	10	13.0	.085
MZ500-23	18.0	20	22.0	6.2	30	19	10	14.4	.086
MZ500-24	19.8	22	24.2	5.6	30	17	10	15.8	.087
MZ500-25	21.6	24	26.4	5.2	35	16	10	17.3	.088
MZ500-26	24.3	27	29.7	4.6	45	14	10	19.4	.090
MZ500-27	27.0	30	33.0	4.2	50	13	10	21.6	.091
MZ500-28	29.7	33	36.3	3.8	60	12	10	23.8	.092
MZ500-29	32.4	36	39.6	3.4	70	11	10	25.9	.093
MZ500-30	35.1	39	42.9	3.2	80	9.1	10	28.1	.094
MZ500-31	38.7	43	47.3	3.0	95	8.8	10	31.0	.095
MZ500-32	42.3	47	51.7	2.7	110	7.9	10	33.8	.095
MZ500-33	45.9	51	56.1	2.5	130	7.4	10	36.7	.096
MZ500-34	50.4	56	61.6	2.2	150	6.9	10	40.3	.096
MZ500-35	55.8	62	68.2	2.0	190	6.0	10	44.6	.097
MZ500-36	61.2	68	74.8	1.8	240	5.5	10	49.0	.097
MZ500-37	67.5	75	82.5	1.7	280	5.1	10	54.0	.098
MZ500-38	73.8	82	90.2	1.5	340	4.6	10	59.0	.098
MZ500-39	81.9	91	100.1	1.4	400	4.2	10	65.5	.099
MZ500-40	90.0	100	110.0	1.3	500	3.7	10	72.0	.100

*1. Nominal voltages other than those stated above, matched sets of tight voltage tolerance devices, tighter voltage tolerances and double anode clippers, are available from the .4M3.3Z35 series on special request.

2. Voltages to 200 volts are available.

FIGURE 2 — TYPICAL ZENER DIODE CHARACTERISTICS and SYMBOL IDENTIFICATION



- I_F — Forward Current
- I_Z — Zener Current
- I_{ZM} — Maximum DC Zener Current (Limited by Power Dissipation)
- I_{ZT} — Zener Test Current
- V_F — Forward Voltage
- V_Z — Nominal Zener Voltage
- Z_Z — Zener Impedance
- Z_{ZT} — Zener Impedance at Test Current (I_{ZT})

MZ600 SERIES (SILICON)
6.2 Volts
MZ800 SERIES
8.4 Volts

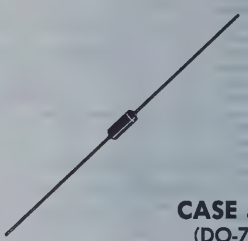
PRECISION REFERENCE DIODES

. . . designed, manufactured and tested for applications requiring a precision voltage reference with ultra-high stability of voltage with time and temperature change.

Special test laboratory uses precision measurement equipment, four-terminal (separate contacts for current and voltage) measurement techniques and voltage standards to provide calibration directly traceable to the National Bureau of Standards.

PRECISION REFERENCE DIODES

with CERTIFIED ZENER VOLTAGE-TIME STABILITY

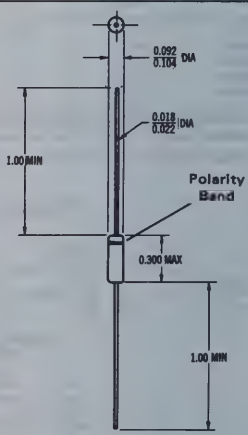


CASE 51
(DO-7)

Certified TEST DATA

Every Precision Reference Diode is individually serialized and its test data recorded on a Certificate of Precision that accompanies the device when shipped. This data shows:

- Device voltages at each test temperature (+25, +75 and +100°C)
- Voltage stability within the measuring temperature range
- Actual device voltage at 168 hour intervals during verification test
- Voltage stability throughout the entire 1000 hour test period
- Certification of Precision
- All diodes are marked with the device type number and polarity band



DO-7 GLASS PACKAGE

MECHANICAL CHARACTERISTICS:

Case:
Glass, Hermetically Sealed

Leads: Dumet

Lead Finish:
Nickel 50-100 μin. then gold plated 50-200 μin.

Weight:
0.2 grams (approx)

OPERATING TEMPERATURE RANGE:* 25 to 100°C.

MZ600 SERIES (Voltage 6.2V ± 5%, I_{ZT} = 7.5 mAdc †, ΔV_z = 2.5 mVdc)**

Type No.	Voltage-Time Stability (μV/1000 Hours)	Parts Per Million Change (ppm/1000 Hours)
MZ605	30 Maximum	< 5
MZ610	60 Maximum	<10
MZ620	120 Maximum	<20
MZ640	240 Maximum	<40

DYNAMIC IMPEDANCE: 10 ohms at I_{ZT} = 7.5 mAdc, I_{ac} = 0.75 mA.

MZ800 SERIES (Voltage 8.4V ± 5%, I_{ZT} = 10 mAdc†, ΔV_z = 3.5 mVdc)**

Type No.	Voltage-Time Stability (μV/1000 Hours)	Parts Per Million Change (ppm/1000 Hours)
MZ805	45 Maximum	< 5
MZ810	90 Maximum	<10
MZ820	180 Maximum	<20
MZ840	360 Maximum	<40

DYNAMIC IMPEDANCE: 15 ohms at I_{ZT} = 10 mAdc, I_{ac} = 1.0 mA.

NOTES

†TEST CURRENT
For certification testing of time stability, Motorola maintains I_{ZT} constant and repeatable to ±0.05 μA tolerance. For voltage tolerance, impedance and voltage temperature stability I_{ZT} needs to be held to 0.01 mA tolerance only.

*Maximum limits for use as a precision reference device. Limits are well below the maximum thermal limits.

**VOLTAGE-TEMPERATURE STABILITY: Maximum allowable voltage change between voltages recorded at 25, 75 and 100° C ambient.

VOLTAGE-TIME STABILITY (ΔV_Z/1000 Hours).

The device voltage is read and recorded initially and at 168 hour intervals through 1000 hours. The maximum change of voltage between readings, taken at any of the seven points, must be less than the maximum voltage change per 1000 hours specified as Voltage-Time Stability.

TURN-ON CHARACTERISTICS

Precision Reference Diodes have been tested to determine the behavior of the device under interrupted power operation.

To insure specified performance, adequate time must be allowed for the device and its environment to reach thermal equilibrium. "Warm-up" time may range from 10 to 30 minutes. Thermal equilibrium is reached when the chamber is cycling at the required temperature with the device energized.

After this "warm-up" period, the device voltage will be between the minimum and the maximum voltage of those recorded at the seven points of the Voltage-Time Stability certification.

MOUNTING

Excellent results have been obtained by using a mechanical mounting. If necessary, the device may be soldered into a circuit using a heat sink between the heat source and the body of the diode. A low thermal EMF solder is recommended.

SPECIAL NOTE

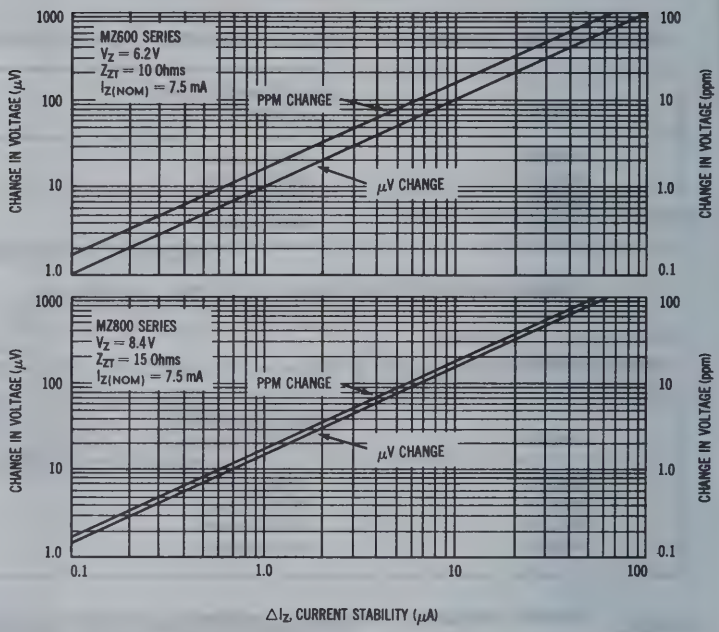
Voltage tolerance less than 5.0% is available upon special request.

Precision Reference Diodes capable of meeting special requirements for standard voltages regardless of required test current, temperature range, or test temperatures are available. Custom requirements of particular devices for specific applications are also available.

VOLTAGE-CURRENT STABILITY CHARACTERISTICS

For verification of time stability, and for repeatable operation, I_{ZT} should be maintained with a tolerance of ±0.1 μA. Figure 1 will assist in design where the supply current stability cannot be maintained to better than 0.2 μA deviation.

FIGURE 1 – MAXIMUM VOLTAGE CHANGE, IN μV AND PPM, DUE TO CURRENT SUPPLY STABILITY



VOLTAGE-TEMPERATURE CHARACTERISTICS

CHOICE OF OPERATING TEMPERATURE

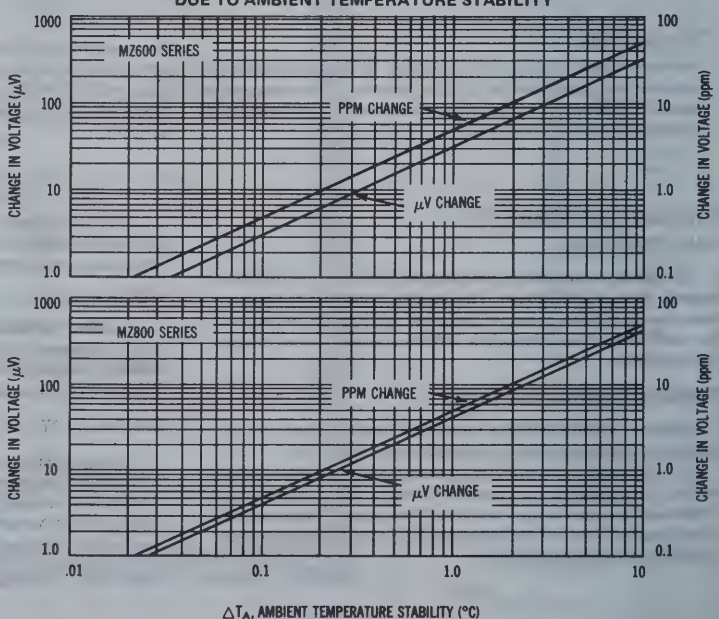
The stability certification is performed at 65°C ± 0.02°C. The operating temperature can be selected within the operating temperature range. If the desired temperature is not 65°C, the precise voltage of the device will be different but the certified stability will still be observed.

VOLTAGE TEMPERATURE STABILITY

For verification of time stability and/or repeatable operation, the ambient temperature should be controlled to ±0.1°C.

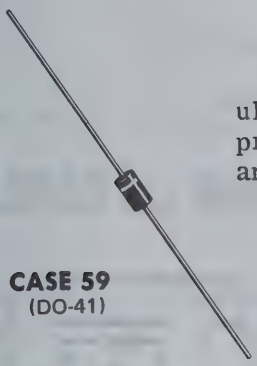
Figure 2 will assist in designs where ambient temperature cannot be controlled to better than 0.2°C deviation.

FIGURE 2 – TYPICAL VOLTAGE CHANGE, IN μV AND PPM, DUE TO AMBIENT TEMPERATURE STABILITY



MZ1000-1 thru MZ1000-37 (SILICON)

1 W
3.3-100 V



CASE 59
(DO-41)

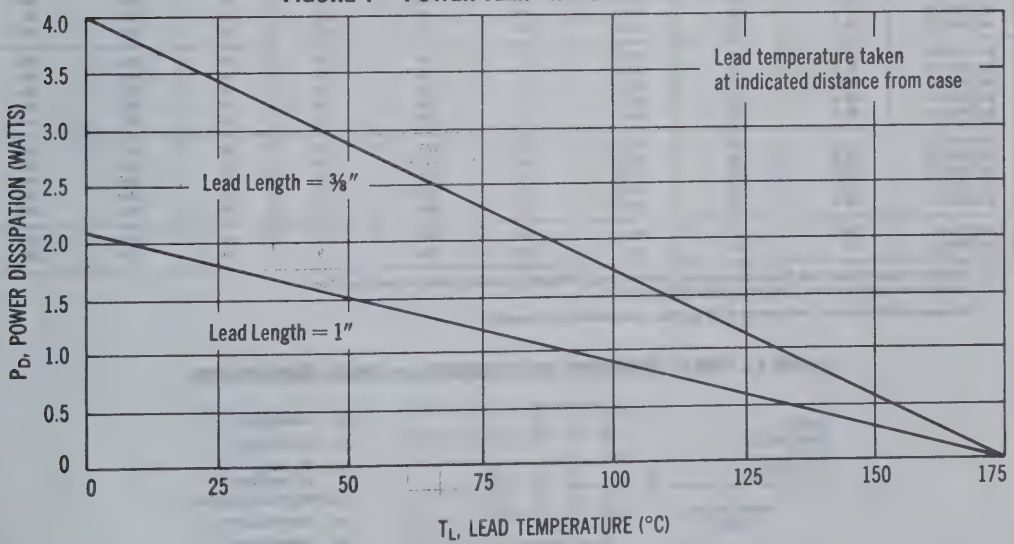
Miniature plastic encapsulated zener diodes for regulated power supply circuits, surge protection, arc suppression and other functions in television, automotive and other consumer product applications.

MAXIMUM RATINGS

Rating	Value	Unit
DC Power Dissipation @ T_L = 50°C	1.5	Watt
Derate above 50°C	8.33	mW/°C
Lead Temperature*	-65 to +175	°C

*Maximum lead temperature for 10 seconds at 1/16" from case = 230°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



MECHANICAL CHARACTERISTICS

CASE: Void free, transfer molded.

FINISH: All external surfaces are corrosion resistant. Leads are readily solderable.

POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.

MOUNTING POSITION: Any.

WEIGHT: 0.42 gram (approximately).

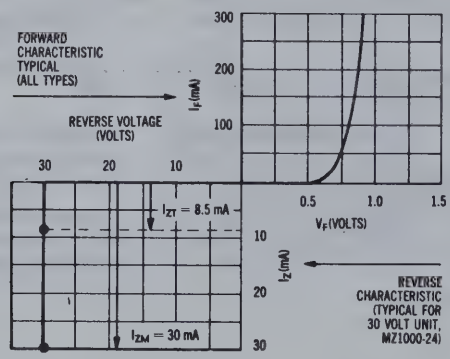
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted) V_F = 1.5 V max @ 200 mA on all types

Type No.	Zener Voltage V_Z @ I_{ZT} Volts *			Test Current I_{ZT} mA	Typical Z_{ZT} @ I_{ZT} Ohms	Max DC Zener Current I_{ZM} mA	Maximum Reverse Leakage Current		Temperature Coefficient %/°C
	Min	Nom	Max				I_R @ μA Max	V_R Volts	
MZ1000-1	2.97	3.3	3.63	76	15	276	150	1	-.070
MZ1000-2	3.24	3.6	3.96	69	15	252	150	1	-.065
MZ1000-3	3.51	3.9	4.29	64	13.5	234	75	1	-.060
MZ1000-4	3.87	4.3	4.73	58	13.5	217	20	1	-.050
MZ1000-5	4.23	4.7	5.17	53	12	193	20	1	-.043
MZ1000-6	4.59	5.1	5.61	49	10.5	178	20	1	±.030
MZ1000-7	5.04	5.6	6.16	45	7.5	162	20	2	±.028
MZ1000-8	5.58	6.2	6.82	41	3	146	20	3	+.045
MZ1000-9	6.12	6.8	7.48	37	5.25	133	20	4	.050
MZ1000-10	6.75	7.5	8.25	34	6	121	20	5	.058
MZ1000-11	7.38	8.2	9.02	31	6.75	110	20	5.9	.062
MZ1000-12	8.19	9.1	10.01	28	7.5	100	20	6.6	.068
MZ1000-13	9	10	11	25	10.5	91	20	7.2	.075
MZ1000-14	9.9	11	12.1	23	12	83	10	8.0	.076
MZ1000-15	10.8	12	13.2	21	13.5	76	10	8.6	.077
MZ1000-16	11.7	13	14.3	19	15	69	10	9.4	.079
MZ1000-17	13.5	15	16.5	17	21	61	10	10.8	.082
MZ1000-18	14.4	16	17.6	15.5	24	57	10	11.5	.083
MZ1000-19	16.2	18	19.8	14	30	50	10	13.0	.085
MZ1000-20	18	20	22	12.5	33	45	10	14.4	.086
MZ1000-21	19.8	22	24.2	11.5	34.5	41	10	15.8	.087
MZ1000-22	21.6	24	26.4	10.5	37.5	38	10	17.3	.088
MZ1000-23	24.3	27	29.7	9.5	52.5	34	10	19.4	.090
MZ1000-24	27	30	33	8.5	60	30	10	21.6	.091
MZ1000-25	29.7	33	36.3	7.5	67.5	27	10	23.8	.092
MZ1000-26	32.4	36	39.6	7	75	25	10	25.9	.093
MZ1000-27	35.1	39	42.9	6.5	90	23	10	28.1	.094
MZ1000-28	38.7	43	47.3	6	105	22	10	31.0	.095
MZ1000-29	42.3	47	51.7	5.5	120	19	10	33.8	.095
MZ1000-30	45.9	51	56.1	5	142.5	18	10	36.7	.096
MZ1000-31	50.4	56	61.6	4.5	165	16	10	40.3	.096
MZ1000-32	55.8	62	68.2	4	177.5	14	10	44.6	.097
MZ1000-33	61.2	68	74.8	3.7	225	13	10	49.0	.097
MZ1000-34	67.5	75	82.5	3.3	262.5	12	10	54.0	.098
MZ1000-35	73.8	82	90.2	3	300	11	10	59.0	.098
MZ1000-36	81.9	91	100.1	2.8	375	10	10	65.5	.099
MZ1000-37	90	100	110	2.5	525	9	10	72.0	.100

*1. Nominal voltages other than those stated above, matched sets, and tighter voltage tolerances are available. 1N4728 thru 1N4764 series (1M3.3ZS10 thru 1M100ZS10).

2. Voltages to 200 volts are available in other package configurations on request.

FIGURE 2 — TYPICAL ZENER DIODE CHARACTERISTICS and SYMBOL IDENTIFICATION



- I_F — Forward Current
- I_Z — Zener Current
- I_{ZM} — Maximum DC Zener Current (Limited by Power Dissipation)
- I_{ZT} — Zener Test Current
- V_F — Forward Voltage
- V_Z — Nominal Zener Voltage
- Z_Z — Zener Impedance
- Z_{ZT} — Zener Impedance at Test Current (I_{ZT})

MZ4614 thru MZ4627 (SILICON)

For Specifications, See 1N4099 Data.

M4L3052 thru M4L3056 (SILICON)

For Specifications, See 1N5158 Data.

HARDWARE

THE FOLLOWING SEMICONDUCTOR HARDWARE IS INCLUDED IN THIS SECTION.

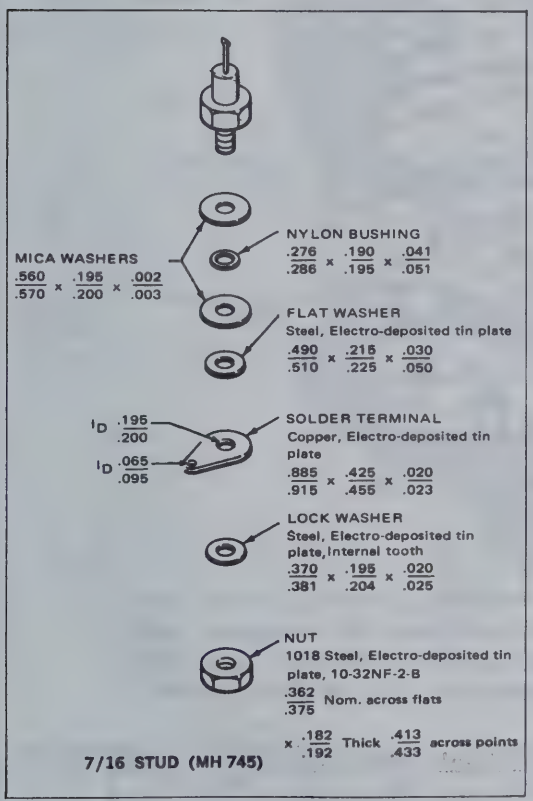
MH745 MH746	Rectifier - zener diode mounting hardware
MK10 MK15 MK20 MK25 MK30 MK35	Power transistor mounting hardware
MS10 MS15	Power transistor heat-sinks
XC63 XC72 XC73	Integrated circuit interconnecting patchboards

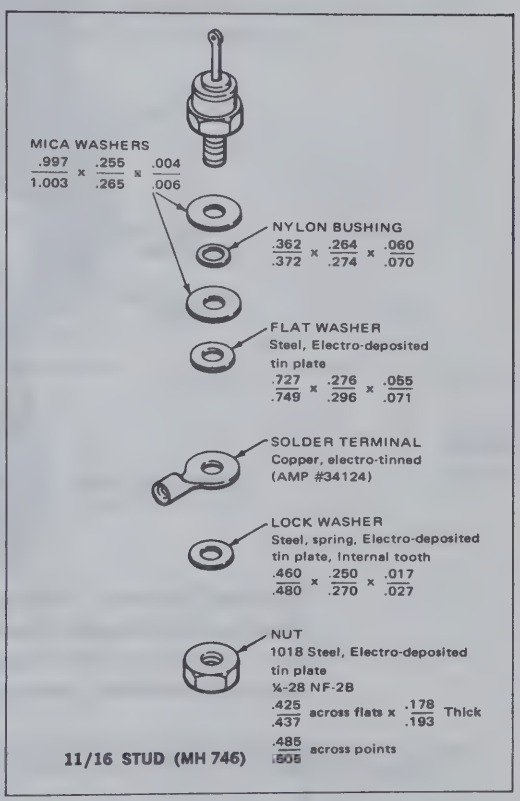
MH745
MH746

MOUNTING HARDWARE for STUD PACKAGES

7/16" RECTIFIER and 10 WATT ZENER DIODE

11/16" RECTIFIER and 50 WATT ZENER DIODE

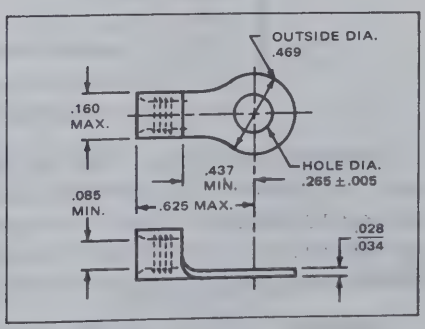




Mounting hardware is supplied with the units. For additional hardware, order by kit number:

MH745 — 7/16" STUD MOUNTING HARDWARE

MH746 — 11/16" STUD MOUNTING HARDWARE



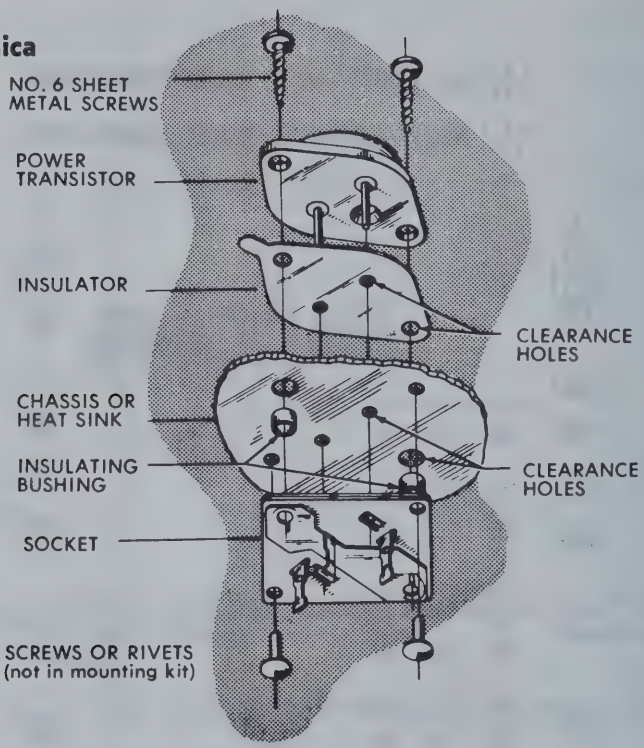
POWER TRANSISTOR MOUNTING KITS

MK-10 – teflon

MK-15 – mica

MK-20 – anodized aluminum

MK-25 – mica



Typical thermal characteristics for teflon, mica, and anodized aluminum insulators used in mounting kits are given in the table below. (Figures may vary with mounting torque applied. Do not over stress.)

KIT TYPE	INSULATING WASHER	TYPICAL THERMAL RESISTANCE (°C/Watt)	
		Dry	With DC4*
–	No Insulator	.20	.10
MK-10	Teflon	1.45	.80
MK-15	Mica	.80	.40
MK-20	Anodized Aluminum	.40	.35
MK-25	Mica	.80	.40

*DC4 is Dow Corning No. 4 Silicone Lubricant.

Mounting kits, types MK-10, MK-15, MK-20, and MK-25 provide the necessary hardware for correctly mounting all TO-3 and TO-66 industry standard power transistor types to a chassis. With these kits, power transistors can be electrically insulated from the heat sink chassis, while maintaining complete heat transfer characteristics.

Included in these highly useful kits are a transistor mounting socket, front and back mounting templates for hole drilling guides, two #6 mounting screws, two insulating bushings, an insulating washer and complete mounting instructions.

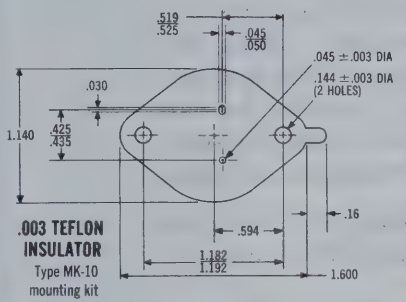
MK-10, MK-15, MK-20, MK-25 (continued)

The teflon-coated glass cloth insulating washer, included in kit MK-10, will find use in installations requiring an insulator of excellent durability. The mica insulator, in kit MK-15 and MK-25, is characterized by very high thermal conductivity. In applications where both good thermal conduction and durability are necessary, the anodized aluminum insulator supplied in kit MK-20, is recommended.

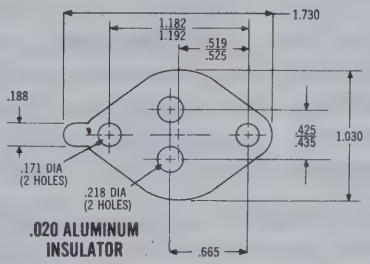
The transistor socket included in all mounting kits, is made of rugged laminated phenolic, with contacts of phosphor bronze.

Three cadmium plated solder lugs, having a 15-amp maximum current capacity, are provided for base, emitter and collector connections.

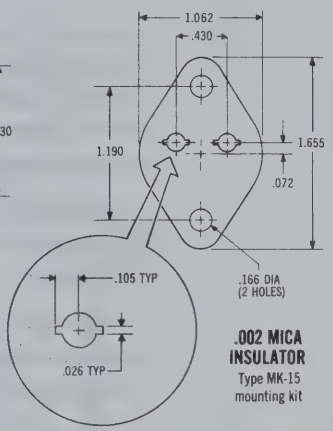
TO-3



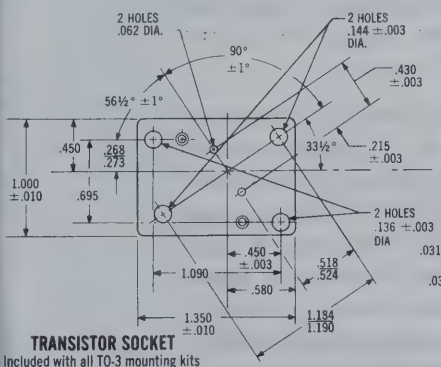
.003 TEFLON INSULATOR
Type MK-10 mounting kit



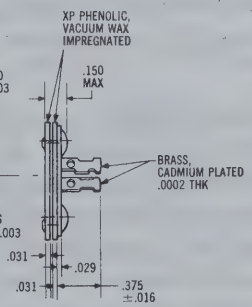
.020 ALUMINUM INSULATOR
Type MK-20 mounting kit

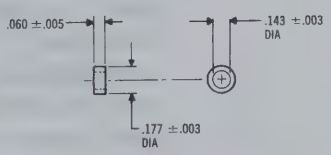


.002 MICA INSULATOR
Type MK-15 mounting kit



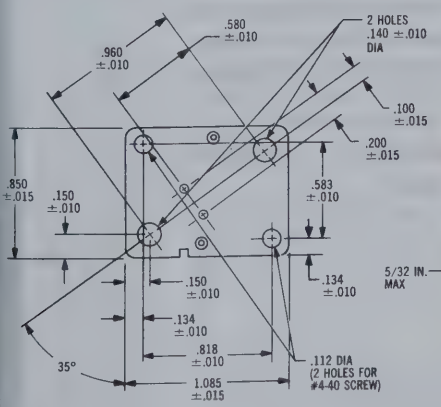
TRANSISTOR SOCKET
Included with all TO-3 mounting kits



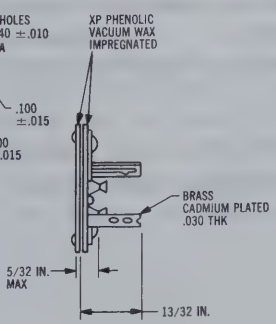


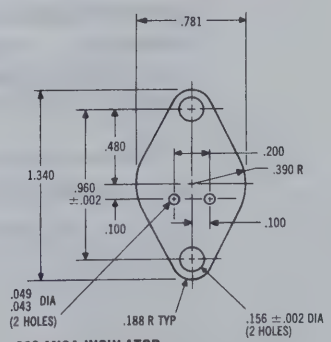
TEFLON INSULATING BUSHING
Included with all mounting kits

TO-66



TRANSISTOR SOCKET
Included with all TO-66 mounting kits





.002 MICA INSULATOR
Type MK-25 mounting kit

TEFLON INSULATING BUSHING
Included with all mounting kits
(Same as for TO-3)

POWER TRANSISTOR MOUNTING KITS

Mounting kits, types MK-30 and MK-35, provide the necessary hardware to properly mount the TO-36 case (standard industry-type power transistors) to the chassis. With these kits, power transistors can be electrically insulated from the heat sink chassis, while maintaining complete heat transfer characteristics

MK-30 Designed for use in applications requiring 30 Amps or less with solder connection to the transistor leads.

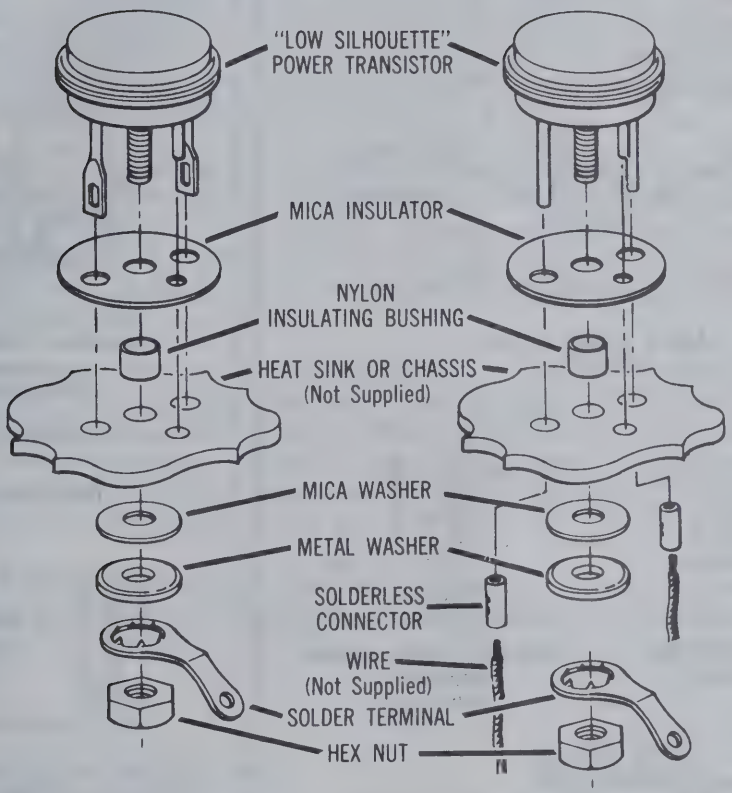
MK-35 Designed for use in applications requiring greater than 30 Amps with solderless connection to the transistor leads.

To obtain maximum contact area between case and heat sink for better heat transfer, it is recommended that the transistor first be mounted on the heat sink or chassis. Then, for maximum wire-to transistor lead strength and high-current capacity, the solderless connectors provided are crimped to the transistor leads and heavy wire. The wires may be soldered directly to the leads if strength and high currents (approximately 50 Amps) are not the primary considerations. (Solderless connector tools are available from the Thomas and Betts Co., Elizabeth, N. J. Possible wire types: AWG #12 regular strand (65 x 30) or #10 solid-tinned copper wire.)

These new mounting kits are individually packaged in a convenient polyethylene container.

MK-30
15 AND 30 AMP UNITS

MK-35
60 AMP UNITS



NOTE: The surface to which the transistor is mounted must be smooth, flat and free of burrs or irregularities which may damage insulation or prevent intimate contact with the transistor mounting base.

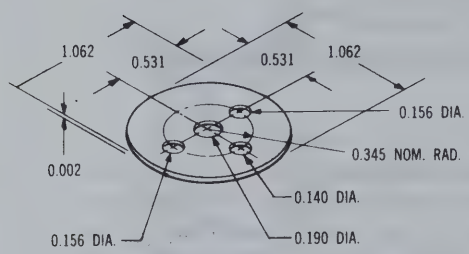
Typical thermal characteristics for mica insulators are given in the table below. (Figures may vary with mounting torque applied. Do not over stress.)

KIT TYPE	INSULATING WASHER	MAXIMUM THERMAL RESISTANCE (°C/Watt)	
		Dry	With DC4*
—	No Insulator	.20	.10
MK-30	Mica	.80	.40
MK-35	Mica	.80	.40

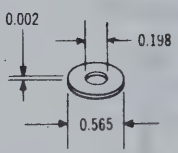
*DC4 is Dow Corning No. 4 Silicone Lubricant.

OUTLINE DIMENSIONS

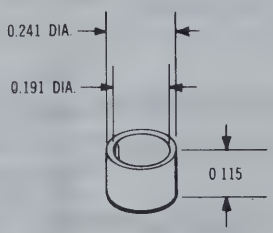
MK-30 / MK-35



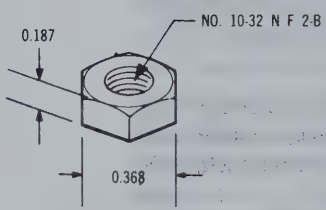
MICA INSULATOR
14B52600F06



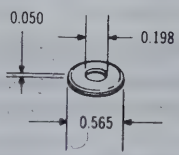
MICA WASHER
14B52600F01



NYLON INSULATING BUSHING
43B51547F01



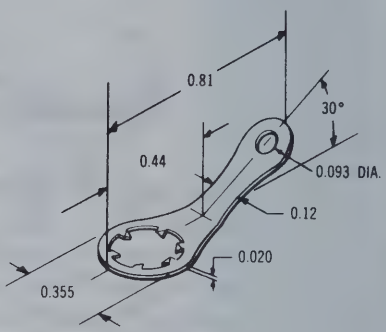
HEX NUT
(Cadmium Plated)
02B51568F13



METAL WASHER
(Cadmium Plated)
04B51567F17

NOTE: All Dimensions Nominal

MK-30 ONLY

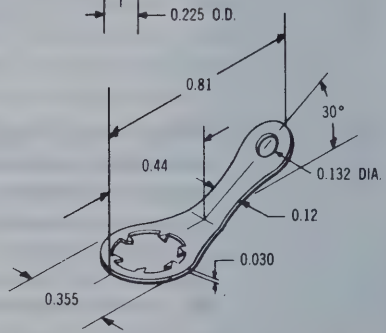


SOLDER TERMINAL
(Tin Dipped)
29B52595F13

MK-35 ONLY



SOLDERLESS CONNECTOR
10M52014A



SOLDER TERMINAL
(Cadmium Plated)
29B52595F09

MS-10 POWER TRANSISTOR HEAT SINK

Designed specifically for use with the industry standard type TO-3 (diamond) power transistor, this heat sink will reduce transistor junction temperatures and permit safe operation at higher power levels or under high ambient temperatures.

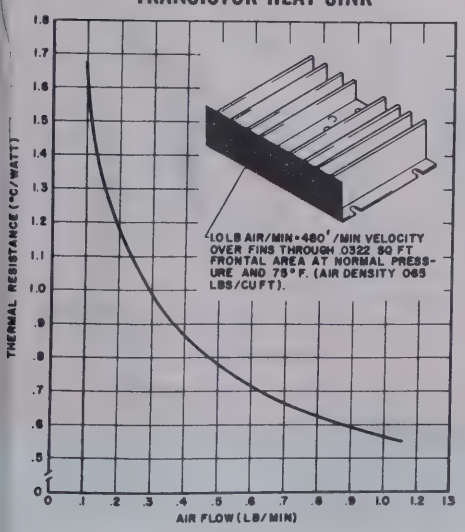
Cooling is accomplished with the MS-10 by conduction, convection and radiation. Although measuring only 4-1/2" by 3-1/16", the MS-10 makes possible thermal dissipation effectively equal to that of a flat sheet of aluminum 10" by 8" by 1/8". This greatly reduces the chassis area necessary for heat dissipation at higher power levels.

The transistor with use of silicon grease should be mounted directly to the MS-10 heat sink with the insulating washers placed at each of the (4) mounting points located on the heat sink flange. This is accomplished by placing (1) shoulder washer on the bottom and (1) flat washer on top of each mounting point of the heat sink. A mica washer is supplied to isolate the transistor from the heat sink if desired.

The MS-10 has a hole pattern arrangement which will accommodate the mounting of one TO-3 power transistor and/or two 10/32" stud mounting diodes. Provided with each MS-10 package is an MK-15 power transistor mounting kit which contains a power transistor socket, mounting screws, complete mounting instructions and a mica insulating washer for use in mounting transistors to the heat sink.

This heat sink is easy to install and does not interfere with the operation of the transistor. For optimum efficiency, the MS-10 should be mounted with the fins vertical.

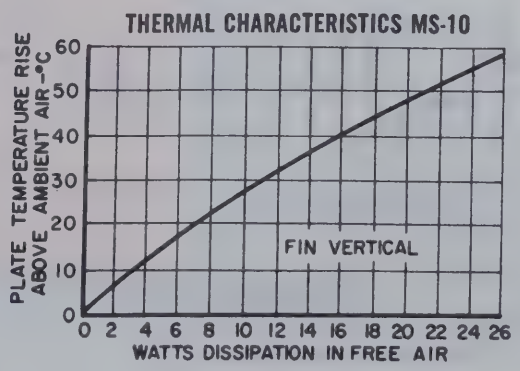
PERFORMANCE UNDER FORCED AIR FLOW OF MS-10 NATURAL CONVECTION TRANSISTOR HEAT SINK

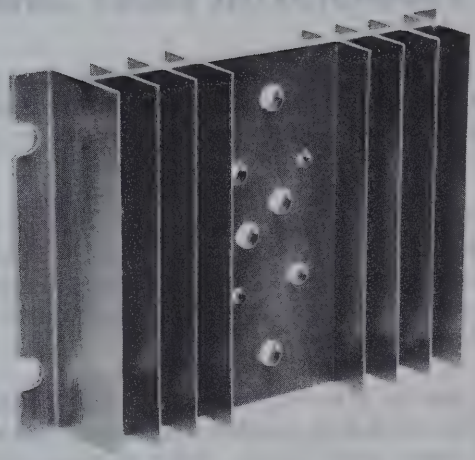


SPECIFICATIONS

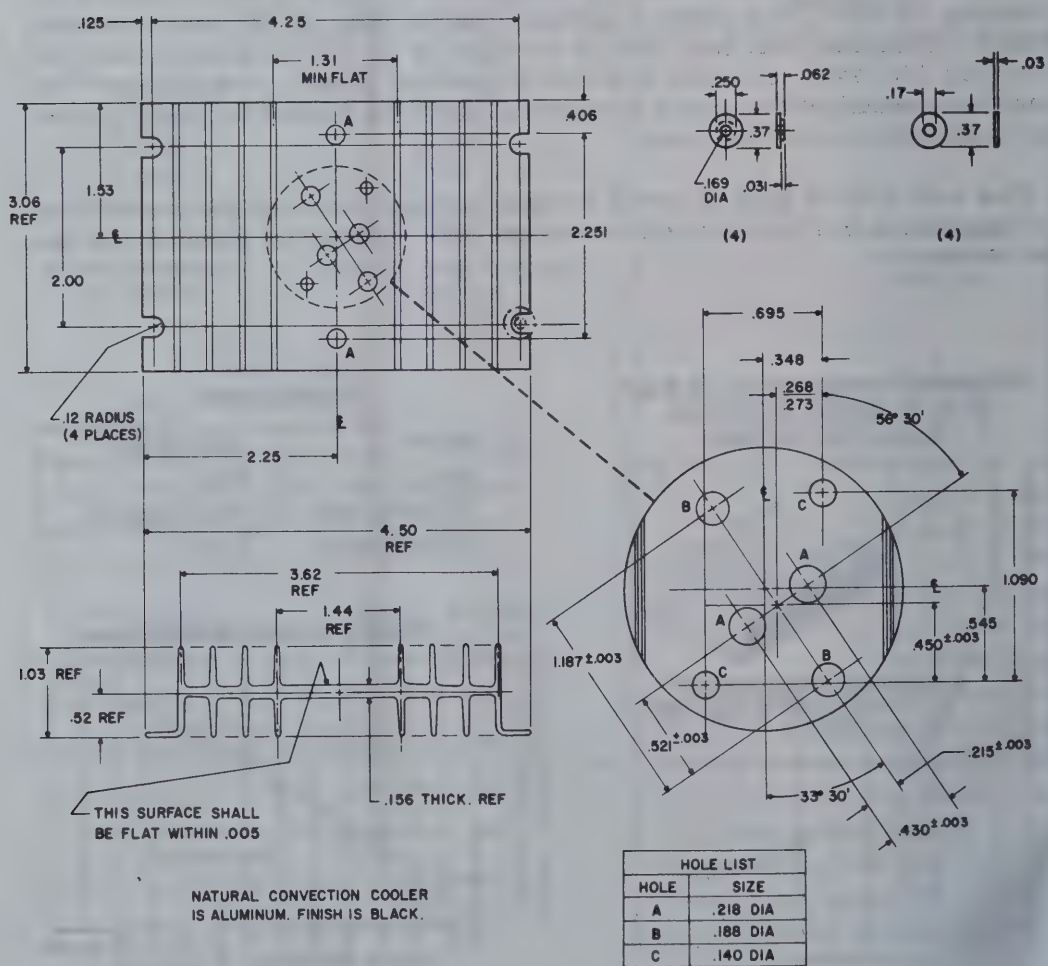
Material	Aluminum Alloy
Finish	Black
Total Surface Area	65 Sq. In. (approx.)
Thermal Resistance	3°C/watt

THERMAL CHARACTERISTICS MS-10





Providing cooling by conduction, convection and radiation, the MS-10 Heat Sink, measuring only 4-1/2" by 3-1/16", has thermal dissipation equal to that of a flat sheet of aluminum 10" x 8" x 1/8".



NATURAL CONVECTION COOLER
IS ALUMINUM. FINISH IS BLACK.

HOLE LIST	
HOLE	SIZE
A	.218 DIA
B	.188 DIA
C	.140 DIA

FIRST CLASS
Permit No. 2565
PHOENIX
ARIZONA

BUSINESS REPLY MAIL

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

POSTAGE WILL BE PAID BY –

MOTOROLA
Semiconductor Products Inc.

Technical Information Center
P. O. Box 20924
Phoenix, Arizona 85036

MS-15 POWER TRANSISTOR HEAT SINK

Designed specifically for use with the industry standard type TO-36 ("doorknob") power transistor, this heat sink will reduce transistor junction temperatures and permit safe operation at higher power levels or under high ambient temperatures.

Cooling is accomplished with the MS-15 by conduction, convection and radiation. Although measuring only 4-1/2" by 3-1/16", the MS-15 makes possible thermal dissipation effectively equal to that of a flat sheet of aluminum 10" by 8" by 1/8". This greatly reduces the chassis area necessary for heat dissipation at higher power levels.

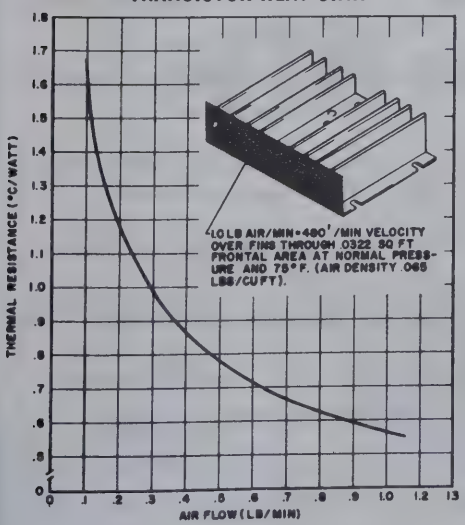
The MS-15 has a hole pattern arrangement which will accommodate the mounting of one TO-36 power transistor. Provided with each MS-15 package is assorted mounting hardware such as: insulating bushing, mica washer, nut, flat washer, solder terminal and insulating washers used in mounting the heat sink to the chassis.

The transistor with use of silicon grease should be mounted directly to the MS-15 heat sink with the insulating washers placed at each of the (4) mounting points located on the heat sink flange. This is accomplished by placing (1) shoulder washer on the bottom and (1) flat washer on top of each mounting point of the heat sink. A mica washer is supplied to isolate the transistor from the heat sink if desired.

NOTE: When mounting the transistor to the heat sink a torque of 20 in. lbs. max should be applied to the stud.

This heat sink is easy to install and does not interfere with the operation of the transistor. For optimum efficiency, the MS-15 should be mounted with the fins vertical.

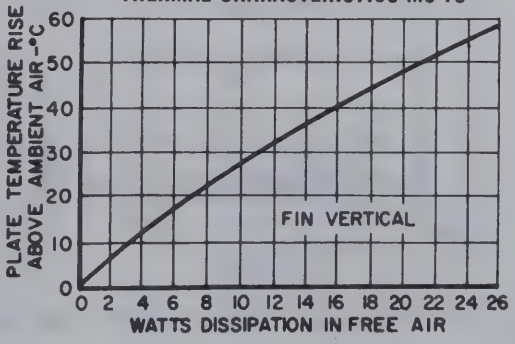
PERFORMANCE UNDER FORCED AIR FLOW OF MS-15 NATURAL CONVECTION TRANSISTOR HEAT SINK

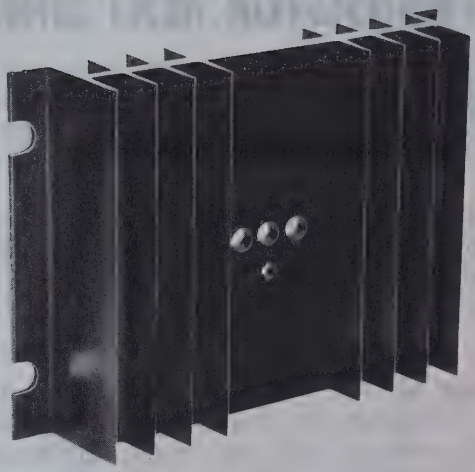


SPECIFICATIONS

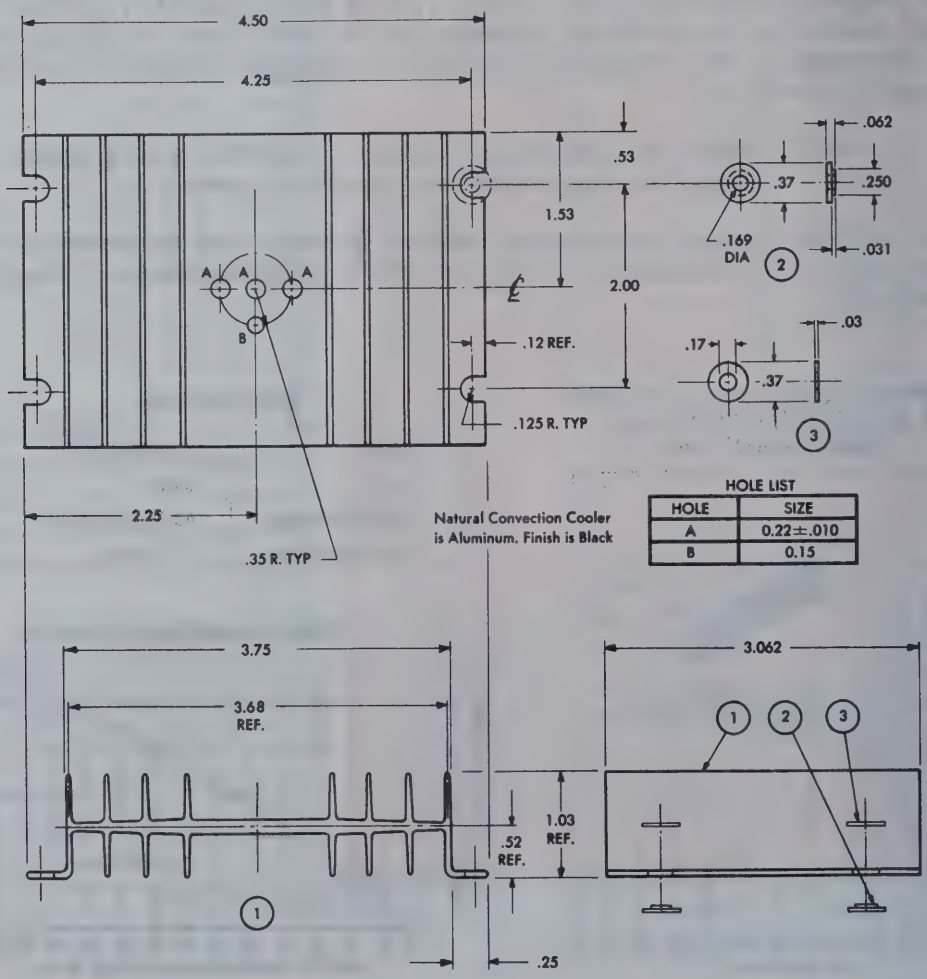
Material	Aluminum Alloy
Finish	Black
Total Surface Area	65 Sq. In. (approx.)
Thermal Resistance	3°C/watt

THERMAL CHARACTERISTICS MS-15





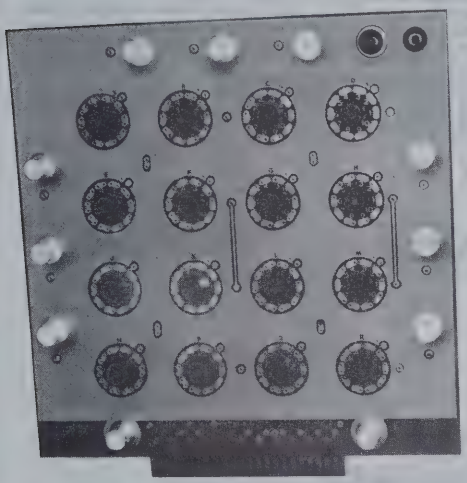
Providing cooling by conduction, convection and radiation, the MS-15 Heat Sink, measuring only 4-1/2" by 3-1/16", has thermal dissipation equal to that of a flat sheet of aluminum 10" x 8" x 1/8".



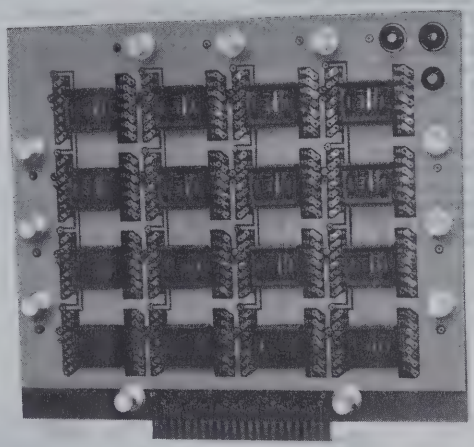
XC63
XC72
XC73

INTEGRATED CIRCUIT INTERCONNECTION BREADBOARDS

Integrated Circuit Interconnection Breadboards, designed to allow rapid interconnection and evaluation of individual integrated circuits or complete logic designs. Little or no soldering is required as a result of the extensive use of sockets and connectors.



XC63



XC72

BREADBOARD SPECIFICATIONS

Specification	XC63	XC72, XC73
Number of Sockets	16	16
Type of Socket	10-pin	14-pin
Number of Pin Jacks per Socket Pin	2	2
Input/Output	22-pin PC edge connector or 11 BNC coaxial connectors	22-pin PC edge connector or 11 BNC coaxial connectors
Power Connection	banana plugs or edge connector pins	banana plugs or edge connector pins
Power Distribution	3 voltage distribution points next to each socket	3 voltage distribution points next to each socket
Temperature Range	-65°C to +150°C	-65°C to +150°C
Printed Circuit	1/16" glass epoxy with 2 oz gold plated runs	1/16" glass epoxy with 2 oz gold plated runs
Frequency Range	DC to 50 MHz	DC to 50 MHz
Edge Connector*	22 pins	22 pins

*Fits into Amphenol 143-022-01 connector, which is not included with breadboard

HOW TO USE INTERCONNECTION PATCHBOARDS

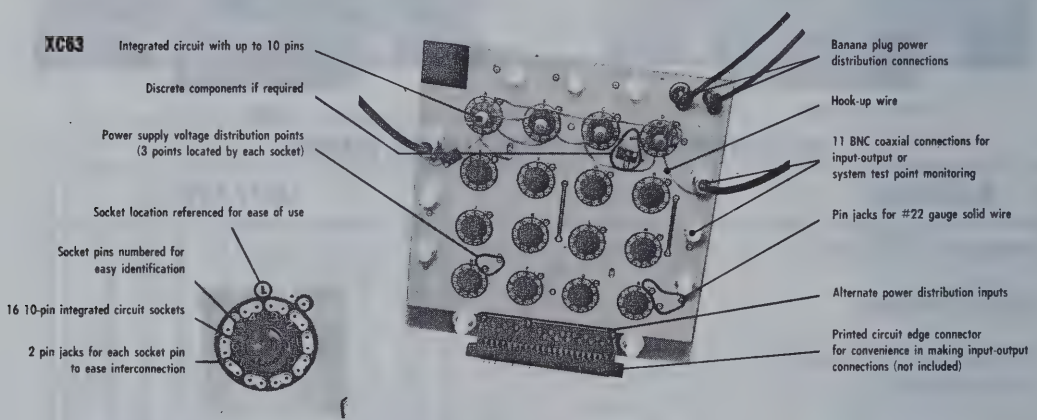
The Integrated Circuit Interconnection Patchboards are, in effect, "universal chassis" designed to simplify testing of individual devices and breadboarding of complete integrated circuit subsystems. Patchboard XC63 is designed for TO-5 integrated circuit packages with up to 10 leads, and Patchboard XC72 is designed for flat packs with up to 14 leads.

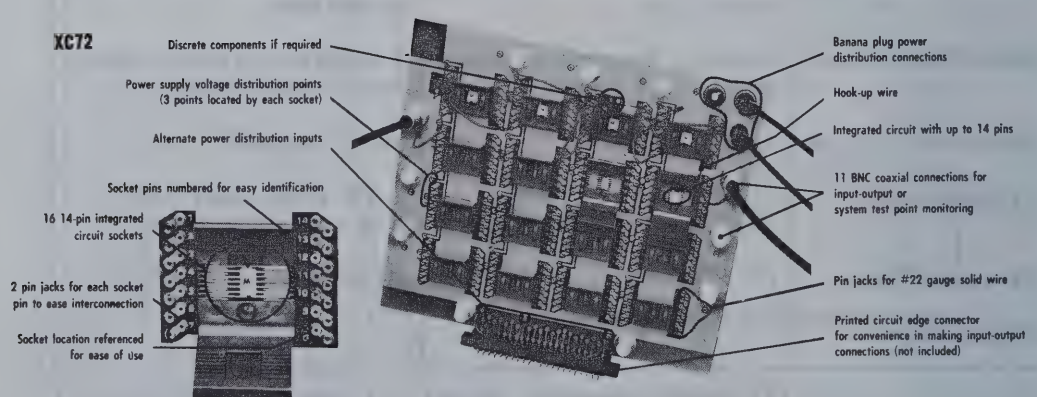
The boards contain 16 sockets for direct plug-in of integrated circuit packages. Associated with each socket are a number of spring-loaded pin jacks which are connected, through printed wiring, to the device pins. There are two pin jacks connected to each socket pin for greater interconnection flexibility. Interconnections between circuits are made simply by inserting 22 gauge (0.025 inch) solid hook-up wire into the appropriate pin jacks, which are designed for high retention capability even after numerous insertions.

A series of eleven BNC coaxial connectors, located around the periphery of the board provide convenient access points for applying input signals and sampling the outputs. Additional communication to and from the board can be made through 22 pin jacks, located on one edge of the board, which are wired to accommodate an edge-mounted, printed circuit strip connector (not supplied).

Three voltage-distribution planes are provided on each board. Two of these, in the form of a copper lamination on each side of the board, are accessible to power supply inputs through banana jacks mounted on the board. Two pin jacks near each socket location are in contact with the copper (one with each plane) and provide a ready means for applying the power supply voltages to the various jacks. A third voltage may be distributed from the edge-mounted strip connector pin jacks which have printed wiring runs to a number of additional pin jacks mounted at convenient locations throughout the board.

Each of the 16 integrated circuit sockets is lettered to aid in correlating logic block diagrams with the patchboard. The pins of each socket are numbered as a further aid. The use of these boards permits the same integrated circuits to be used repeatedly for the evaluation of many commonly used logic configurations with a minimum of effort. More complex designs may be studied by interconnecting several breadboards. Thus, all designs may be evaluated and finalized before the integrated circuits are permanently interconnected in the system.





MICROCIRCUIT COMPONENTS

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MICROCIRCUIT COMPONENTS INDEX

TYPE	DEVICE IDENT.
MCH5800 MCH5801 MCH5802 MCH5803 MCH5804 MCH5805	THIN-FILM INDUCTORS
MCH5862 MCH5867 MCH5871 MCH5872 MCH5875 MCH5880 MCH5883	BEAM-LEAD RESISTORS
MCH5901 MCH5902 MCH5903 MCH5904 MCH5905 MCH5907 MCH5908 MCH5909 MCH5910 MCH5911 MCH5912 MCH5914 MCH5915 MCH5916 MCH5917 MCH5918 MCH5919	BEAM-LEAD CAPACITORS
MJC007 MJC043 MJC044 MJC067 MJC069 MJC070 MJC076 MJC082	SILICON POWER TRANSISTORS
MMCD914 MMCD6100	SILICON SWITCHING DIODES
MMCR100 MMCR105 MMCR110	THIN-FILM RESISTORS
MMCS709	SILICON SWITCHING TRANSISTOR
MMCS910 MMCS918 MMCS929 MMCS930	SILICON AMPLIFIER TRANSISTORS
MMCS0122 MMCS0123 MMCS0125 MMCS0130 MMCS0131 MMCS0134	SILICON FIELD-EFFECT TRANSISTORS
MMCS0159	SILICON NPN RF TRANSISTOR
MMCS0172	SILICON NPN RF TRANSISTOR
MMCS2192 MMCS2193	SILICON SWITCHING & AMPLIFIER TRANSISTORS

TYPE	DEVICE IDENT.
MMCS2221 MMCS2221A MMCS2222 MMCS2222A	SILICON SWITCHING & AMPLIFIER TRANSISTORS ↓
MMCS2369	SILICON SWITCHING TRANSISTOR
MMCS2369A	SILICON SWITCHING TRANSISTOR
MMCS2483	SILICON AMPLIFIER TRANSISTOR
MMCS2484	SILICON AMPLIFIER TRANSISTOR
MMCS2857	SILICON NPN RF TRANSISTOR
MMCS2894	SILICON SWITCHING TRANSISTOR
MMCS2906 MMCS2906A MMCS2907 MMCS2907A	SILICON SWITCHING & AMPLIFIER TRANSISTORS ↓
MMCS3227	SILICON SWITCHING TRANSISTOR
MMCS3250 MMCS3250A MMCS3251 MMCS3251A	SILICON SWITCHING & AMPLIFIER TRANSISTORS ↓
MMCS3252 MMCS3253 MMCS3444 MMCS3467 MMCS3468	SILICON SWITCHING TRANSISTORS ↓
MMCS3498 MMCS3499 MMCS3500 MMCS3501	SILICON SWITCHING & AMPLIFIER TRANSISTORS ↓
MMCS3506 MMCS3507 MMCS3546	SILICON SWITCHING TRANSISTORS ↓
MMCS3634 MMCS3635 MMCS3636 MMCS3637	SILICON SWITCHING & AMPLIFIER TRANSISTORS ↓
MMCS3724 MMCS3725 MMCS3734 MMCS3735 MMCS3762 MMCS3763	SILICON SWITCHING TRANSISTORS ↓
MMCS3798	SILICON AMPLIFIER TRANSISTOR
MMCS3799	SILICON AMPLIFIER TRANSISTOR
MMCS3866	SILICON NPN RF TRANSISTOR
MMCS3903 MMCS3904 MMCS3905 MMCS3906	SILICON SWITCHING & AMPLIFIER TRANSISTORS ↓
MMCS3959	SILICON SWITCHING TRANSISTOR
MMCS4260	SILICON SWITCHING TRANSISTOR
MMCS4400 MMCS4401 MMCS4402 MMCS4403	SILICON SWITCHING & AMPLIFIER TRANSISTORS ↓

MICROCIRCUIT COMPONENTS INDEX

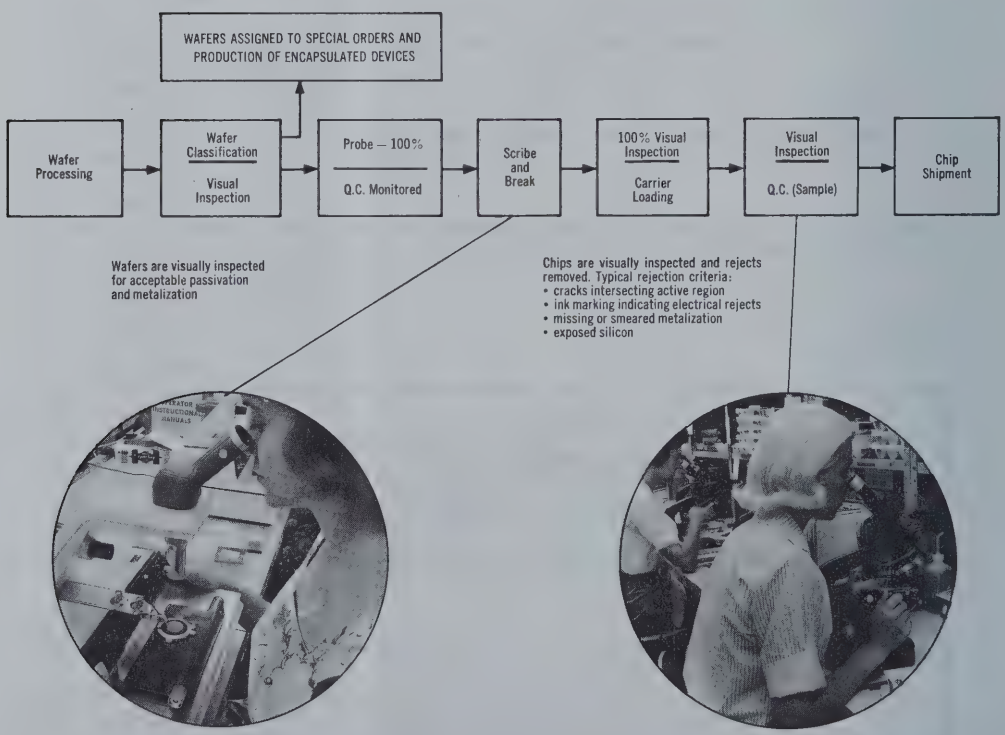
TYPE	DEVICE IDENT.
MMCS5087	SILICON AMPLIFIER TRANSISTOR
MMCS5088	SILICON AMPLIFIER TRANSISTOR
MMCS5636	SILICON NPN RF TRANSISTOR
MZC1.8B10 Thru MZC200B10	ZENER DIODES
MZC2.4A10 Thru MZC200A10	ZENER DIODES

STANDARD CHIP PROCESSING

The transistor and small-signal diode "chips" in Motorola's Standard Microcircuit Components line are produced on the same well-proven production lines that provide Motorola's standard encapsulated devices. They are subjected to the same rigid in-process controls used to insure the reliability and performance of the eventual packaged components. In fact, as shown in the flow chart below, all wafer processing is completed before the wafers are assigned either for subsequent encapsulation or for additional special testing and handling involved in selling unencapsulated components.

As with standard encapsulated products, the entire test and inspection sequence for chips is under the auspices of the Quality Control Department, providing independent quality assurance completely disassociated from production control.

CHIP PROCESSING AND QUALITY CONTROL SEQUENCE



NON-STANDARD CHIP PROCESSING

The standard unencapsulated semiconductors described in the following sections meet a wide variety of application requirements. Nevertheless, there may be occasions when a designer can benefit from a non-standard device for a specific circuit. To satisfy these requirements, almost any device from Motorola's broad line of conventional packaged semiconductors may be obtained on a specially negotiated basis. Moreover, though the electrical specifications of these special chips are limited by certain test limitations, the customer can negotiate additional tests. Please contact your Motorola sales representative for more information.

On special order, Motorola transistors other than those listed in data sheets may be obtained in both wafer and chip form. The following tables list test limitations for these devices. The tests indicated can be made on a 100% basis. The tests can also be negotiated on a sampling basis.

Frequency and switching performance correspond to the inherent capability of a particular product line; dynamic specifications cannot be obtained by probing a chip. Such parameters are measured with the chip sealed in a standard encapsulated package and the resulting measurement includes the package parasitics.

TABLE I — Electrical Test Capability for 100% Wafer Probing of "Special" Unencapsulated Small-Signal and RF Transistors

(Tests are limited to 3 of the 4 indicated breakdown voltages)

Parameter*	Test Condition	Limits
BV_{EBO}	I_C = 10 μAdc	10 Vdc
BV_{CBO}	I_C = 100 μAdc	200 Vdc
BV_{CES}	I_C = 100 μAdc	200 Vdc
BV_{CEO}	I_C = 10 mAdc	200 Vdc
h_{FE}**	I_C = 1 mAdc to 150 mAdc V_{CE} = 0 to 20 Vdc	**

*In addition to the listed parameters, leakage current may be probed to limits no tighter than 20 nAdc.

**Choice of one h_{FE} test to a maximum and a minimum limit or two h_{FE} tests, each to a maximum or minimum limit.

TABLE II — Electrical Test Capability for 100% Wafer Probing of "Special" Unencapsulated Power Transistors

Parameter	Test Condition	Limits
BV_{EBO}	10 μAdc-10 mA	30 Vdc
BV_{CBO}	50 μAdc-5.0 mAdc	500 Vdc @ 1.0 mAdc
BV_{CES}	50 μAdc-1.0 mAdc	500 Vdc @ 1.0 mAdc
BV_{CEO}	1.0 mAdc-100 mAdc	500 Vdc @ 1.0 mAdc
h_{FE}	I_C = 50 mAdc-1.0 Adc V_{CE} = 1.0-20 Vdc	–

Minimum leakage currents will be the same as the minimum currents listed for the breakdown voltages above. On high voltage material (100 Vdc) we convert the breakdown voltage to leakage currents for test purposes. h_{FE} is test equipment limited, higher currents are correlated.

HANDLING PRECAUTIONS

Standard microcircuit components listed in the data sheets in this catalog are passivated devices, as are most special selections. However, many other unpackaged components, such as high power thyristors, silicon mesa power transistors and germanium power transistors, require special handling. Consequently their parameters cannot be guaranteed.

For passivated devices, although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published (or negotiated) specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are processed in a non-inert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.

3. Processing equipment conforms to the minimum standards of equipment normally employed by semiconductor manufacturers.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

STANDARD CARRIER PACKAGES

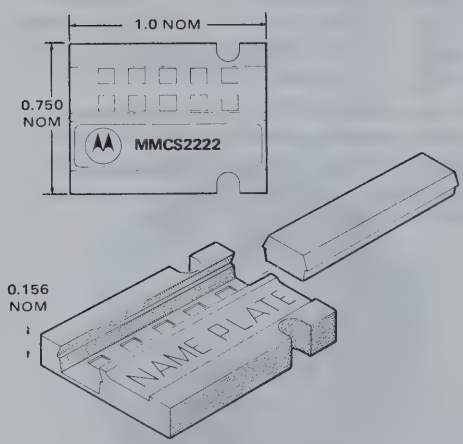
To accommodate customers with both small and large quantity requirements, Motorola supplies microcircuit components in two standard carriers, the Deka-Pak and the Multi-Pak. These carriers are shown in Figures 1 and 2. Both contain individual compartments to simplify user inventory recordkeeping and to protect the chips during storage.

The Deka-Pak holds 10 small-signal chips, and is ideal for prototype development.

The Multi-Pak is excellent for production use. Two versions, both 2 inches square, are available. One holds 400 small-signal chips, and the other is designed for 100 large chips such as power transistors.

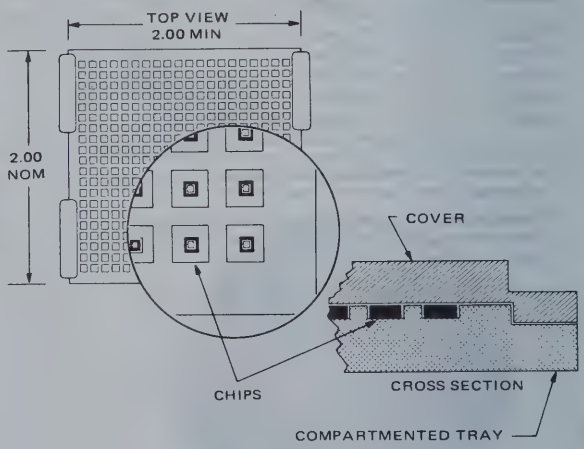
FIGURE 1 – DEKA-PAK

(10-chip carrier)



To accommodate the customer with limited quantity requirements, the Deka-Pak carrier contains individual compartments for 10 chips.

FIGURE 2 – MULTI-PAK



The Multi-Pak carrier is designed for production use. Two versions are available, one holding 400 small chips, and one holding 100 large chips such as those used for power transistors. All of the carriers are 2 inches square, and are vacuum sealed before shipment.

OPTIONAL SHIPPING METHODS

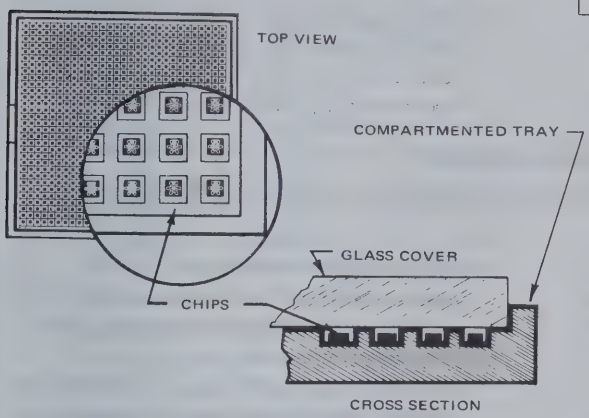
CHIP OPTIONS

For large quantity use, or special applications, shipping methods other than the standard Deka-Pak or Multi-Pak may be desired. Various packaging and shipping options are available on a negotiated basis. For more information on these options, please contact your Motorola sales representative.

TABLE I – Specification Options

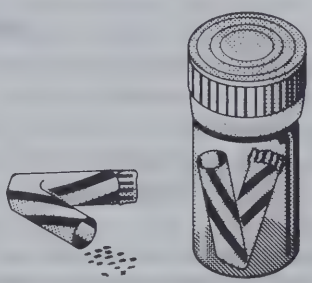
CHIPS	Shipping Options
1. 100% probed. Rejects inked but included in bulk shipment.	See Figure 4
2. 100% probed. Electrical and mechanical rejects removed.	See Figure 2 and Figure 3
3. Same as above, but sample tested in a package to meet negotiated acceptance criteria.	See Figure 2 and Figure 3

FIGURE 3 – K-PAK (1000-CHIP CARRIER)



This carrier holds 1000 chips. It is designed with individual compartments for each chip. The chips are placed in the carrier with the geometry side showing. (Very small chips may become inverted in transit.)

FIGURE 4 – STRAW-PAK PLASTIC VIAL BULK SHIPMENT



The Straw-Pak is a vial encompassing a straw that has one end closed. The chips are inserted in the straw, and then the straw is bent and placed in the plastic vial for shipment.

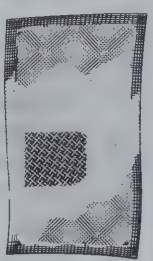
WAFER OPTIONS

Motorola unencapsulated transistors may be obtained in wafer form. The information in Table II gives the various specification verification and packaging options.

TABLE II – Specification Options

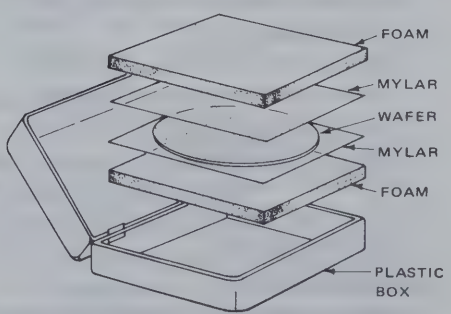
WAFERS	Shipping Options
1. Sample probed. Guaranteed minimum yield.	See Figure 6
2. 100% probed. Rejects inked.	See Figure 6
3. 100% probed. Rejects inked, scribed and broken. Wafer is placed between two sheets of mylar or filter paper and vacuum sealed in a plastic bag.	See Figure 5

FIGURE 5 – PLASTIC BAG SHIPMENT



Wafer is 100% probed. Rejects inked, scribed, and broken. Wafer is placed between two sheets of mylar and vacuum sealed in a plastic bag.

FIGURE 6 – WAFER SHIPMENT (UNSCRIBED)



Wafers are shipped between two layers of mylar, sandwiched between two layers of polyfoam pressed together in a plastic box. This prevents movement or damage to the wafer.

DEFINITION OF TERMS

Emitter-Base and Collector-Base Junctions. *The region where the base and collector, and the emitter and base meet. These junctions will be defined on the surface of the chip as an oxide step.*

Diffusion Window. *The opening etched through the oxide to permit the diffusion of the emitter and base.*

Active Junction. *A change in 'N' type to 'P' type doping or conversely, by a diffusion step. On discrete transistors there are 2 active junctions, the collector-base junction and the emitter-base junction.*

The Pre-Ohmic Window. *The opening etched through the oxide for metalization contact to the emitter and base regions.*

Pre-Ohmic Alignment. *The positioning of the oxide opening into which the metalization is placed.*

Passivated Region. *Any region covered by glass ($Si\ 0_2$), nitride, or other protective dielectric.*

Expanded Contact. *Any pattern that has metalization crossing a diffused junction.*

Attached Foreign Material. *A foreign substance that cannot be removed when subjected to a nominal gas flow. Lint, silicon dust, etc. are not considered attached since they can be removed after die mount.*

INSPECTION CRITERIA

Visual inspection is performed with a microscope using 40X-80X magnification for Silicon-Power Chips and 100X-125X for other devices.

SCRIBING DEFECTS

Excess Chip. A chip shall be rejected if a portion of an adjacent chip with metalization is still attached to subject chip.

Scribe Line Limits. A chip shall be rejected if a scribe line touches or crosses an active junction area or a metalized region.

MECHANICAL DEFECTS

Inspect each chip to insure there are no cracks or breaks that:

Non-Expanded Contacts

(a) Touch the collector-base junction (NPN).

(b) Extend through the annular ring (PNP).

Expanded Contacts

(a) Touch the collector-base junction (NPN).

(b) Extend through the annular ring (PNP).

(c) Extend under any metalized bonding pad.

Inspect each chip to insure there are no cracks greater than one mil. in length in a passivated region and extending toward an active area. (Does not apply to Silicon Power devices.)

ALIGNMENT DEFECTS

Pre-Ohmic Alignment. The chip shall not contain pre-ohmic windows that cross the edge of a diffusion window.

Diffusion Window Alignment. No diffusion window shall touch another diffusion window.

Metalization Alignment. The metalization must be aligned so that at least 50% of the pre-ohmic window is covered with metalization.

FOREIGN MATERIAL DEFECTS

Bridged-Across Metal. A chip shall be rejected when attached foreign material bridges across normally separated metalized areas.

Particle Size Inside Active Area. A chip shall be rejected when attached foreign material greater than 2 mils. is found inside collector-base junction or on the emitter-base bonding pads.

OXIDE DEFECTS

Exposed Silicon on Junction. A chip shall be rejected if exposed silicon touches or crosses the collector-base junction or the emitter-base junction.

Exposed Silicon Touching Metal. A chip shall be rejected if exposed silicon touches or extends under the bonding pad metalization. (Expanded contacts only.)

Oxide Defect in Active Area. A chip shall be rejected if an oxide defect occurs inside or on the collector-base junction with a major dimension greater than 1 mil. (Does not apply to Silicon Power Devices.)

Oxide Defect Crossing or Touching. A chip shall be rejected if gross oxide defects, evidenced by alternately colored bands (rainbow effect), emit from two separate ohmic contacts and either touch or cross each other, or cross the collector-base junction.

INSPECTION CRITERIA (continued)

Oxide Defect Under Bonding Pads. A chip shall be rejected if an oxide defect extends under 25% of the bonding pad.

METALIZATION DEFECTS

Expanded Contacts (finger geometries).

Missing Metalization on Bonding Pads. A chip shall be rejected when 25% of the metalization is missing from a bonding pad.

Metalization Width at Oxide Step. Any chip shall be rejected if the metalization width of any finger is reduced greater than 25% at any oxide step. 75% of the metal width must remain.

Metalization Width In First 50 Percent of Finger. A chip shall be rejected if the finger metalization is narrower than 50% of its original design width or if the finger width is reduced greater than 50% due to a severe scratch or void in the first 50% of the finger. A severe scratch is one which exposes the underlying surface.

Fingers Isolated or Missing. A chip shall be rejected if any finger is not 100% continuous over the first 50% of the finger (from the bonding pad).

Bubbled Metalization. A chip shall be rejected if it exhibits any bubbled metalization on a bonding pad.

Lifted Metalization. A chip shall be rejected if it exhibits any lifted metalization. Slight undercutting causing a lifted appearance is not cause for rejection.

Bridged Metalization. A chip shall be rejected for bridged metal shorting any two normally separated metalized areas.

Metal Corrosion. A chip shall be rejected if it exhibits any corroded metal. Corrosion is a chemical reaction or process causing abnormalities in the metalization. A rough metalization surface is not to be considered corrosion.

Non-Expanded Contacts

Missing Metalization. A chip shall be rejected when more than 25% of the metalization is missing from a bonding pad.

Lifted Metalization. A chip shall be rejected if it exhibits any lifted metalization. Slight undercutting causing a lifted appearance is not cause for rejection.

Bubbled Metalization. A chip shall be rejected if it exhibits any bubbled metalization on a bonding pad.

Bridged Metalization. A chip shall be rejected for bridged metal shorting any two normally separated metalized areas.

Narrow Metal Widths In Relation To Design Width. A chip shall be rejected if the metalization is narrower than 50% of its original design width.

Metal Corrosion. A chip shall be rejected if it exhibits any corroded metal. Corrosion is a chemical reaction or process causing abnormalities in the metalization. A rough metalization surface is not to be considered corrosion.

METALIZED ANNULAR RING

Missing Metalization. A chip shall be rejected when a metalized annular ring is not 100% continuous.

Bridged Metalization. A chip shall be rejected for bridged metal shorting the metalized annular ring with any other metalized area.

RECOMMENDED INCOMING INSPECTION PROCEDURES

Motorola assures that the devices will meet the customers' incoming visual inspection when inspected to the visual criteria and LTPD limits specified in the data sheet. Inspection must be performed at the power and magnification indicated. Motorola guarantees dc parameters to LTPD limits specified in the data sheet.

Returned Components

It is suggested that the customer perform incoming inspection in the following sequence:

1. Visual
2. Test dc electrical parameters

A. If the lot fails visual inspection, containers must be closed and secured and the entire lot returned to Motorola with a detailed inspection report. In no case will Motorola accept rejected material that the customer has inspected 100%.

B. After the lot has passed incoming visual inspection, samples are selected and subjected to electrical tests of the dc parameters. If samples do not pass the electrical tests, they shall be packaged separately and identified with all the information from the original package of chips. The shipping container must be closed and secured. The entire lot together with the test samples and a detailed inspection report shall be returned to Motorola. In no case will Motorola accept rejected material that the customer has inspected 100%.

UNENCAPSULATED AMPLIFIER TRANSISTORS

. . . with passivated Annular construction that provides high reliability and consistent performance. These chips are identical to the chips used in packaged Motorola transistors with 2N prefixes; i.e., the MMCS910 chip is used in the Motorola 2N910 transistor. For more detailed characteristic data, please refer to the equivalent Motorola 2N. . . . data sheet.

- DC Current Gains to 300 Minimum
- Breakdown Voltages to 100 Volts
- Noise Figures as Low as 0.8 dB Typical

SILICON TRANSISTORS

MMCS910
MMCS918
MMCS929
MMCS930
MMCS2483
MMCS2484
MMCS3798
MMCS3799
MMCS5087
MMCS5088

MAXIMUM RATINGS

TYPE	V_{CEO} Volts	V_{CB} Volts	V_{EB} Volts	I_C mA	Geometry
NPN					
MMCS910	60	100	7.0	–	1
MMCS918	15	30	3.0	50	2
MMCS929	45	45	5.0	30	3
MMCS930	45	45	5.0	30	3
MMCS2483	60	60	6.0	50	3
MMCS2484	60	60	6.0	50	3
MMCS5088	30	35	4.5	50	5
PNP					
MMCS3798	60	60	5.0	50	4
MMCS3799	60	60	5.0	50	4
MMCS5087	30	50	3.0	50	4

Operating and Storage Junction Temperature Range −65 to +200°C

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are die-and-wire bonded in a noninert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.

3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

AMPLIFIER TRANSISTORS (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$)

TYPE	BV_{CEO} @ I_C Volts min	mA	BV_{CBO} @ I_C Volts min	µA	BV_{EBO} @ I_E Volts min	µA	I_{CBO} @ V_{CB} nA max	Volts	h_{FE} @ I_C min/max	µA mA *	$V_{CE(sat)}$ & $V_{BE(sat)}$ @ I_C $V_{CE(sat)}$ Volts max	$V_{BE(sat)}$ Volts max	mA
NPN													
MMCS910	60	30	100	100	7.0	100	25	75	75/–	10*	0.4	0.8	10
MMCS918	15	3.0	30	1.0	3.0	10	10	15	20/–	3.0*	0.4	1.0	10
MMCS929	45	10	45	10	5.0	10	10	45	60/–	500	1.0	1.0	10
MMCS930	45	10	45	10	5.0	10	10	45	150/–	500	1.0	1.0	10
MMCS2483	60	10	60	10	6.0	10	10	45	75/–	100	0.35	–	1.0
MMCS2484	60	10	60	10	6.0	10	10	45	175/–	100	0.35	–	1.0
MMCS5088	30	1.0	35	100	4.5	10	50	20	300/900	100	0.5	–	10
PNP													
MMCS3798 ①	60	10	60	10	5.0	10	10	50	150/450	500	0.25	0.8	1.0
MMCS3799 ①	60	10	60	10	5.0	10	10	50	300/900	500	0.25	0.8	1.0
MMCS5087	30	1.0	50	100	3.0	10	50	35	250/800	100	0.3	–	10

AC* PARAMETERS

TYPE	C_{ob} pF max	C_{ib} pF max	$\|h_{fe}\|$ @ min	I_C mA	V_{CE} Volts	f MHz	NF @ dB max	f Hz
NPN								
MMCS910	15	85	2.5	50	10	20	14	1.0 K
MMCS918	1.7	2.0	6.0	4.0	10	100	6.5	60 M
MMCS929	8.0	–	1.0	0.5	5.0	30	5.0	10-15.7 K
MMCS930	8.0	–	1.0	0.5	5.0	30	4.0	10-15.7 K
MMCS2483	6.0	8.0	2.0	0.5	5.0	30	5.0	10-15.7 K
MMCS2484	6.0	8.0	2.0	0.5	5.0	30	4.0	10-15.7 K
MMCS5088	–	–	2.0	0.5	5.0	20	4.0	10-15.7 K
PNP								
MMCS3798 ①	4.0	–	0.8	0.5	5.0	30	1.0 typ	1.0 K
MMCS3799 ①	4.0	–	0.8	0.5	5.0	30	0.8 typ	1.0 K
MMCS5087	4.0	–	1.6	0.5	5.0	20	3.0	10-15.7 K

① SMALL-SIGNAL CHARACTERISTICS

(I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz.)

TYPE	h_{ie} k ohms min/max	h_{re} x 10^{-4} max	h_{oe} µmhos min/max
PNP			
MMCS3798	2.4/18	30	4.0/70
MMCS3799	8.0/48	30	4.0/70

*AC parameter values are as specified in the standard 2N data sheets. (encapsulated devices).

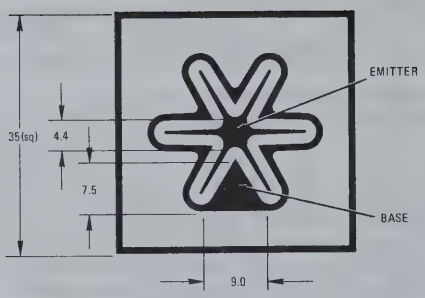
PARAMETER LIMITATIONS AND WARRANTY

Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20. Visual inspection is performed to an LTPD of 20. See "Visual Inspection Criteria" in General Information Section.

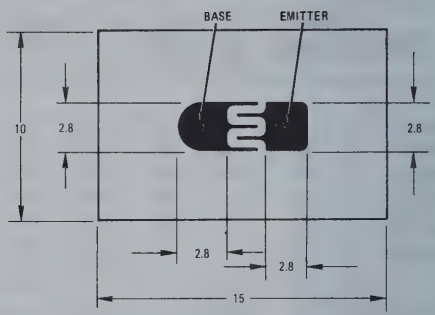
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

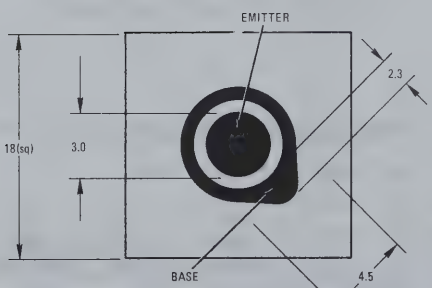
ALL DIMENSIONS ARE IN MILS



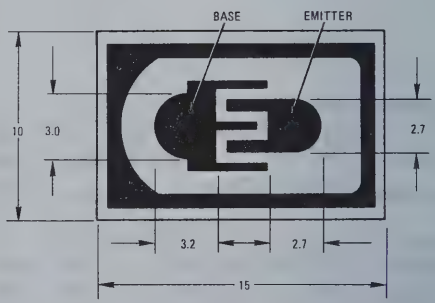
GEOMETRY 1 MMCS910 NPN



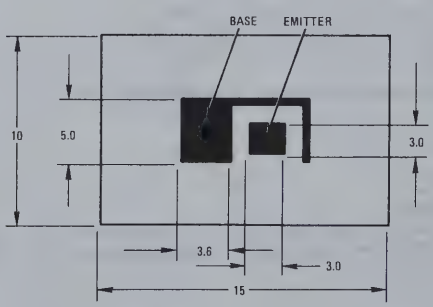
GEOMETRY 2 MMCS918 NPN



GEOMETRY 3 MMCS929 MMCS930 MMCS2483 MMCS2484 NPN



GEOMETRY 4 MMCS3798 MMCS3799 MMCS5087 PNP



GEOMETRY 5 MMCS5088 NPN

UNENCAPSULATED SWITCHING TRANSISTORS

. . . with passivated Annular construction that provides high reliability and consistent performance. These chips are identical to the chips used in packaged Motorola transistors with 2N prefixes; i.e., the MMCS709 chip is used in the Motorola 2N709 transistor. For more detailed characteristic data, please refer to the equivalent Motorola 2N. . . . data sheet.

- Breakdown Voltage to 80 Volts
- Switching Times as Low as 3.5 ns

SILICON TRANSISTORS

MMCS709	MMCS3507
MMCS2369	MMCS3546
MMCS2369A	MMCS3724
MMCS2894	MMCS3725
MMCS3227	MMCS3734
MMCS3252	MMCS3735
MMCS3253	MMCS3762
MMCS3444	MMCS3763
MMCS3467	MMCS3959
MMCS3468	MMCS4260
MMCS3506	

MAXIMUM RATINGS

TYPE	V_{CEO} Volts	V_{CB} Volts	V_{EB} Volts	I_C Peak† mA	Geometry
NPN					
MMCS709	6.0	15	4.0	100	1
MMCS2369	15	40	4.5	500†	2
MMCS2369A	15	40	4.5	200	2
MMCS3227	20	40	6.0	500†	2
MMCS3252	30	60	5.0	1000	4
MMCS3253	40	75	5.0	1000	4
MMCS3444	50	80	5.0	1000	4
MMCS3506	40	60	5.0	3000	6
MMCS3507	50	80	5.0	3000	6
MMCS3724	30	50	6.0	1000	4
MMCS3725	50	80	6.0	1000	4
MMCS3734	30	50	5.0	1500	8
MMCS3735	50	75	5.0	1500	8
MMCS3959	12	20	4.5	30	9
PNP					
MMCS2894	12	12	4.0	200	3
MMCS3467	40	40	5.0	1000	5
MMCS3468	50	50	5.0	1000	5
MMCS3546	12	15	4.5	200	7
MMCS3762	40	40	5.0	1500	5
MMCS3763	60	60	5.0	1500	5
MMCS4260	15	15	4.5	30	10

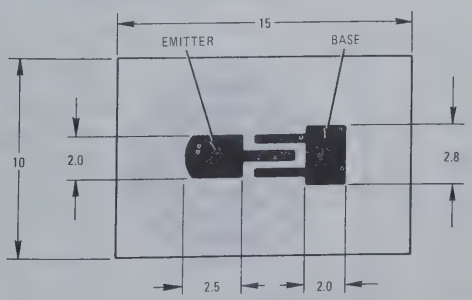
Operating and Storage Junction Temperature Range −65 to +200°C

HANDLING PRECAUTIONS

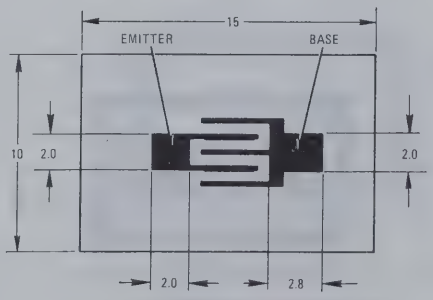
Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.
2. Devices are die-and-wire bonded in a non-inert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.
3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.



GEOMETRY 1 MMCS709 NPN



GEOMETRY 2 MMCS2369 MMCS3227 MMCS2369A NPN

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

TYPE	BV_{CEO} @ I_C Volts / mA min		BV_{CBO} @ I_C Volts / µA min		BV_{EBO} @ I_E Volts / µA min		I_{CBO} @ V_{CB} nA / Volts max		h_{FE} @ I_C min/max / mA		$V_{CE(sat)}$ Volts max	$V_{BE(sat)}$ @ I_C Volts / mA max	
NPN													
MMCS709	6.0	10	15	10	4.0	10	50	5.0	20/200	10	0.35	0.85	3.0
MMCS2369	15	10	40	10	4.5	10	400	20	40/120	10	0.25	0.85	10
MMCS2369A	15	10	40	10	4.5	10	400	20	30/–	30	0.2	0.85	10
MMCS3227	20	10	40	10	6.0	10	200	20	100/300	10	0.25	0.85	10
MMCS3252	30	10	60	10	5.0	10	500	40	30/90	500	0.5	1.3	500
MMCS3253	40	10	75	10	5.0	10	500	60	25/75	500	0.6	1.3	500
MMCS3444	50	10	80	10	5.0	10	500	60	20/60	500	0.6	1.3	500
MMCS3506	40	10	60	100	5.0	10	1000	30	40/200	1500	1.0	1.4	1500
MMCS3507	50	10	80	100	5.0	10	1000	40	30/150	1500	1.0	1.4	1500
MMCS3724	30	10	50	10	6.0	10	500	40	60/150	100	0.42	1.2	500
MMCS3725	50	10	80	10	6.0	10	500	60	60/150	100	0.42	1.2	500
MMCS3734	30	10	50	10	5.0	10	200	25	30/120	1000	0.5	1.2	500
MMCS3735	50	10	75	10	5.0	10	200	40	20/80	1000	0.5	1.2	500
MMCS3959	12	10	20	10	4.5	10	50	10	40/200	10	0.2	–	1.0
PNP													
MMCS2894	12	10	12	10	4.0	10	10	6.0	40/150	30	0.2	1.2	30
MMCS3467	40	10	40	10	5.0	10	100	30	40/120	500	0.5	1.2	500
MMCS3468	50	10	50	10	5.0	10	100	30	25/75	500	0.6	1.2	500
MMCS3546	12	10	15	10	4.5	10	10	10	30/120	10	0.15	0.9	10
MMCS3762	40	10	40	10	5.0	10	100	30	30/120	1000	0.9	1.4	1000
MMCS3763	60	10	60	10	5.0	10	100	50	20/80	1000	0.9	1.4	1000
MMCS4260	15	10	15	10	4.5	10	50	12	30/150	10	0.35	1.0	10

AC* PARAMETERS

TYPE	C_{ob} pF max	C_{ib} pF max	$\|h_{fe}\|$ @ I_C mA min	V_{CE} Volts	f MHz	t_d, t_r, t_{on}* ns max	t_s, t_f, t_{off}* ns max	Test Circuit Fig. No.
NPN								
MMCS709	3.0	2.0	5.0	5.0	4.0	100	18*	18*	1
MMCS2369	4.0	4.0	5.0	10	10	100	15*	20*	2
MMCS2369A	4.0	–	5.0	10	10	100	14*	20*	3
MMCS3227	4.0	4.0	5.0	10	10	100	15*	20*	2
MMCS3252	12	80	1.8	50	10	100	18,35	50,35	5
MMCS3253	12	80	1.5	50	10	100	18,40	50,35	5
MMCS3444	12	80	1.5	50	10	100	18,40	50,35	5
MMCS3506	40	300	2.5	100	5.0	20	18,40	65,40	7
MMCS3507	40	300	2.5	100	5.0	20	18,40	65,40	7
MMCS3724	12	70	2.0	50	10	100	45*	75*	9
MMCS3725	10	70	2.0	50	10	100	45*	75*	9
MMCS3734	9.0	80	2.0	50	10	100	10,45	35,35	10
MMCS3735	9.0	80	2.0	50	10	100	10,45	35,35	10
MMCS3959	2.5	2.5	11	5.0	4.0	100	2.4,3.0(1)	1.6,3.3(1)	12
PNP								
MMCS2894	6.0	6.0	3.2	30	10	100	70*	100*	4
MMCS3467	25	100	1.6	50	10	100	10,30	80,30	6
MMCS3468	25	100	1.4	50	10	100	10,30	80,30	6
MMCS3546	6.0	6.0	7.0	10	10	100	48*	35*	8
MMCS3762	18	95	1.5	50	10	100	10,40	95,40	11
MMCS3763	18	95	1.2	50	10	100	10,40	95,40	11
MMCS4260	2.5	2.5	10	5.0	4.0	100	1.0,0.5(1)	1.0,1.0(1)	13

*AC parameters are as specified in the standard 2N data sheets (encapsulated devices)

(1) Typical Switching Times

PARAMETER LIMITATIONS AND WARRANTY

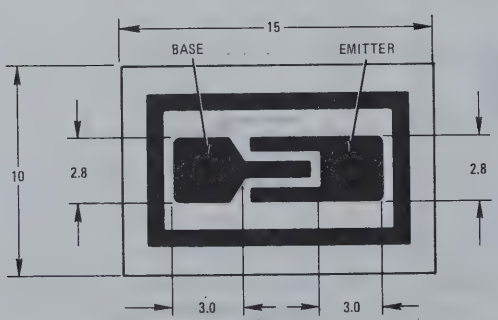
Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20.

Visual Inspection is performed to an LTPD of 20. See "Visual Inspection Criteria" in General Information Section.

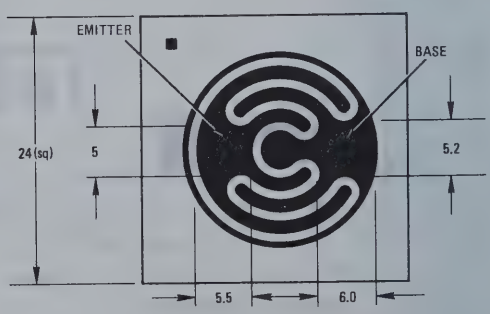
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

ALL DIMENSIONS ARE IN MILS



GEOMETRY 3 MMCS2894 PNP

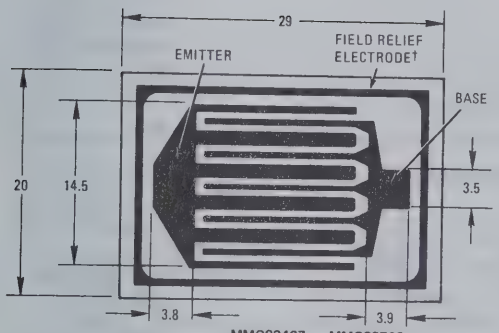


GEOMETRY 4 MMCS3252 MMCS3253 MMCS3444 MMCS3724 MMCS3725 NPN

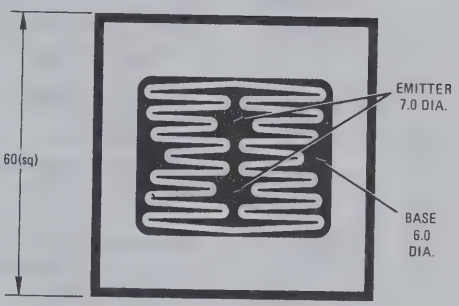
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

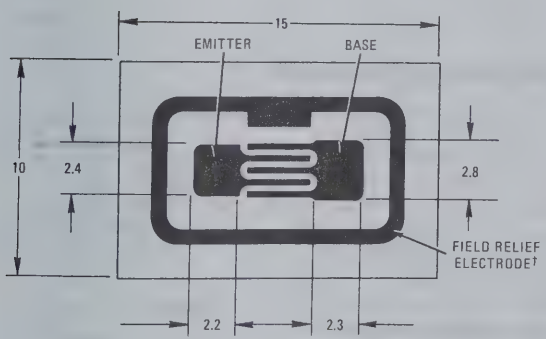
ALL DIMENSIONS ARE IN MILS



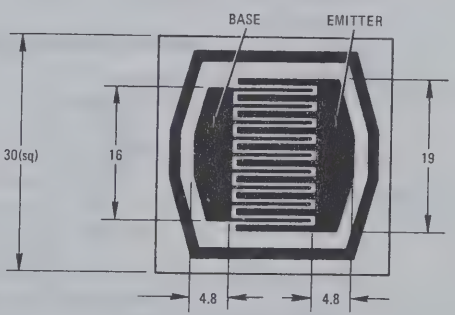
GEOMETRY 5 MMCS3467 MMCS3468 MMCS3762 MMCS3763 PNP



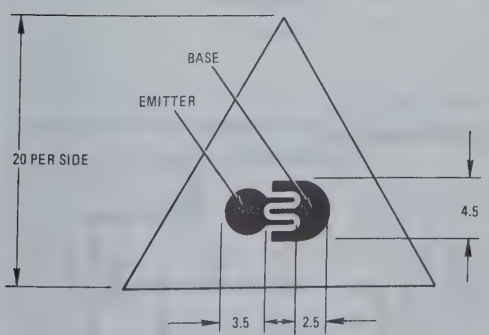
GEOMETRY 6 MMCS3506 MMCS3507 NPN



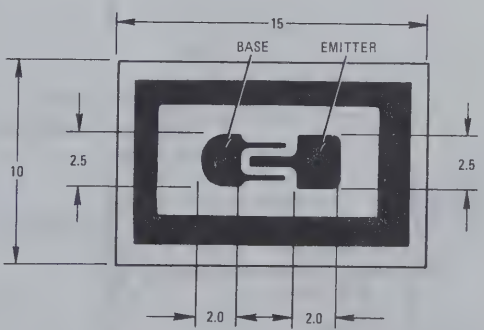
GEOMETRY 7 MMCS3546 PNP



GEOMETRY 8 MMCS3734 MMCS3735 NPN



GEOMETRY 9 MMCS3959 NPN



GEOMETRY 10 MMCS4260 PNP

†Patented by Motorola – Patent No. 3,302,076

TEST CIRCUITS

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT

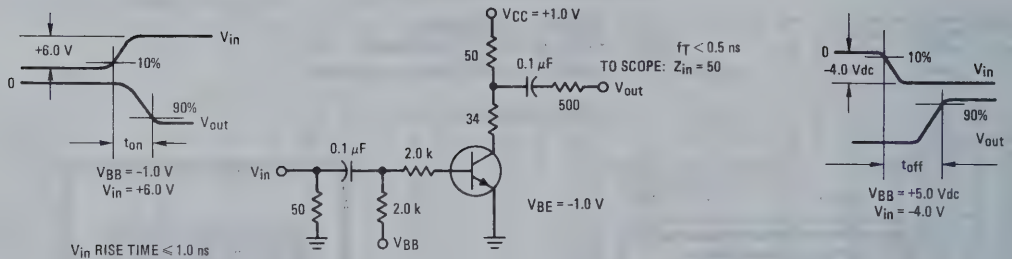
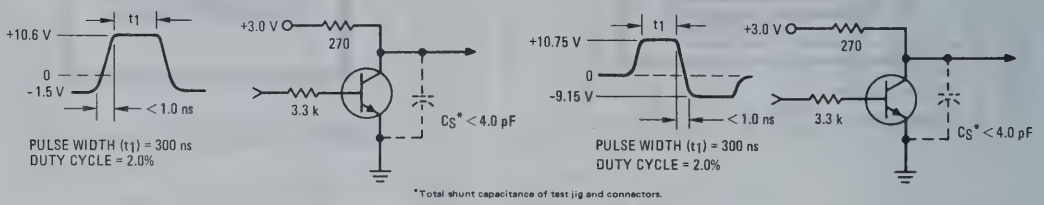
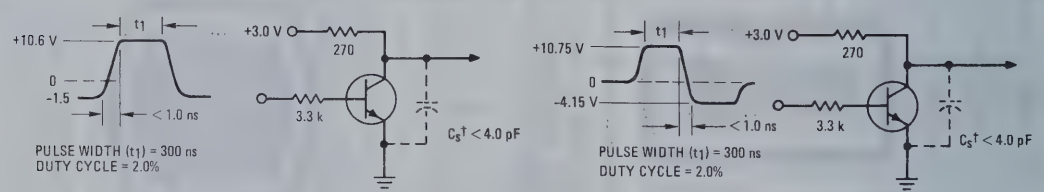


FIGURE 2 – SWITCHING TIME EQUIVALENT TEST CIRCUITS



*Total shunt capacitance of test jig and connectors.

FIGURE 3 – SWITCHING TIME EQUIVALENT TEST CIRCUITS



†Total shunt capacitance of test jig and connectors.

FIGURE 4 – SWITCHING TIME TEST CIRCUIT

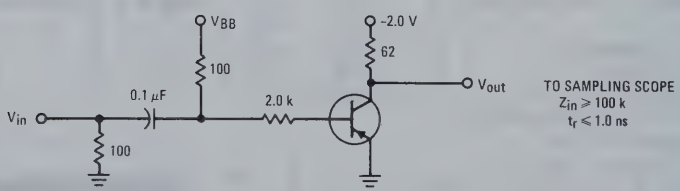
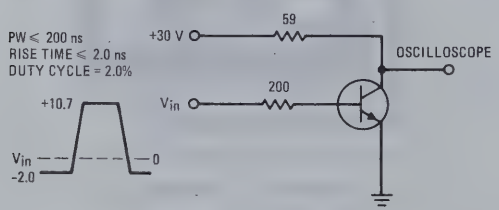


FIGURE 5 – EQUIVALENT CIRCUIT FOR MEASURING DELAY AND RISE TIMES



STORAGE AND FALL TIMES

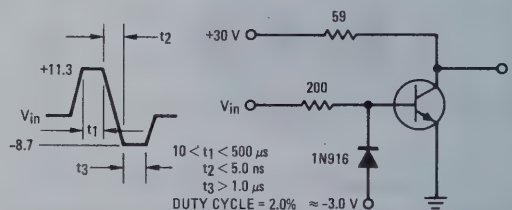


FIGURE 6 – EQUIVALENT TEST CIRCUT

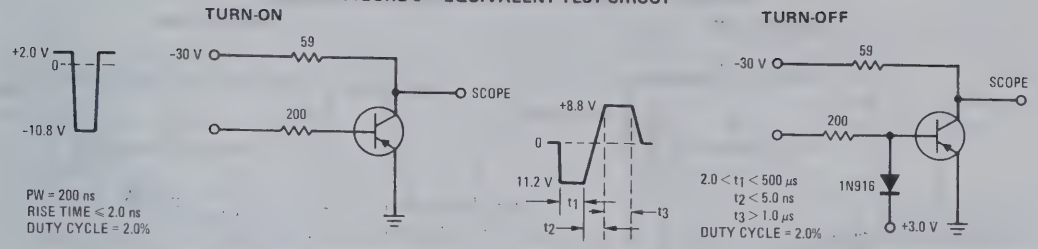


FIGURE 7 – EQUIVALENT CIRCUIT FOR MEASURING
DELAY AND RISE TIMES
STORAGE AND FALL TIMES

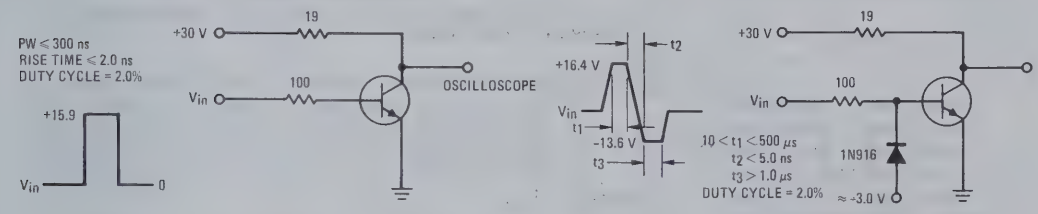


FIGURE 8 – SWITCHING TIME TEST CIRCUIT

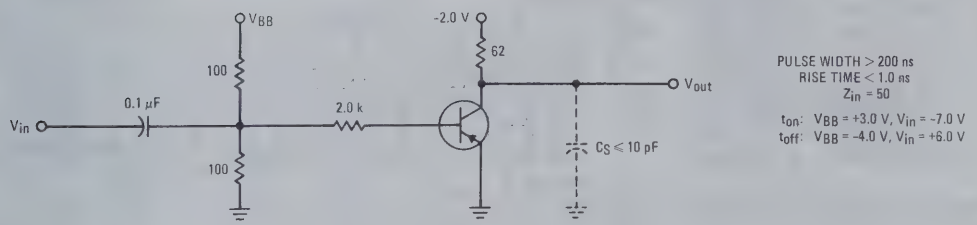


FIGURE 9 – SWITCHING TIMES TEST CIRCUIT

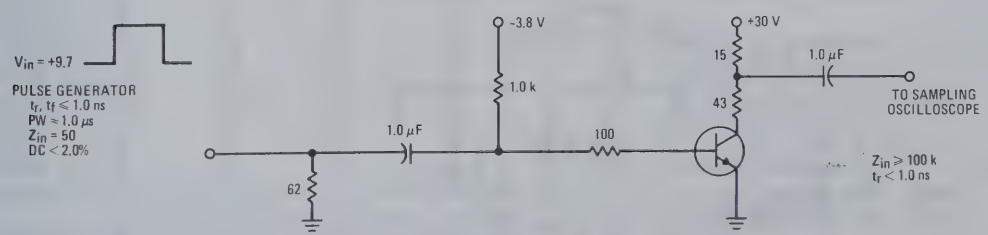


FIGURE 10 – SWITCHING TIME EQUIVALENT TEST CIRCUITS

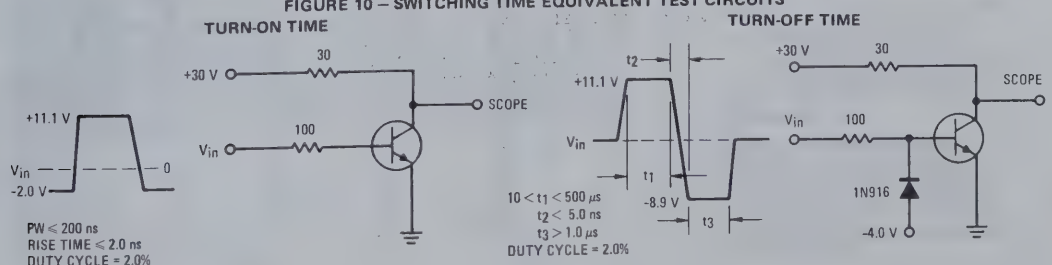


FIGURE 11 – SWITCHING TIME EQUIVALENT TEST CIRCUITS

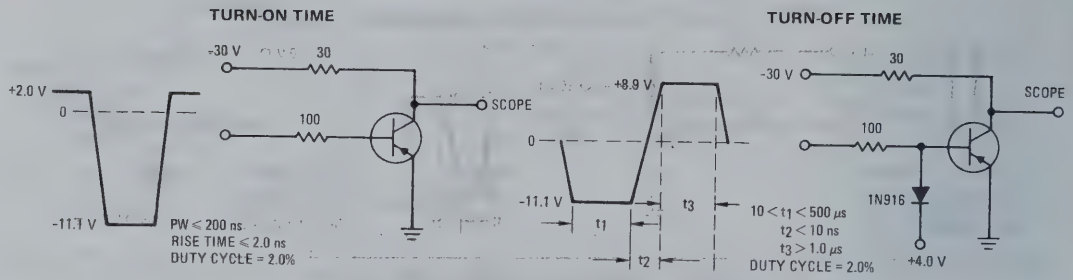
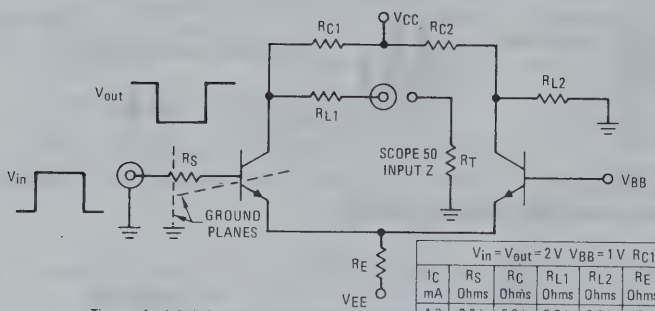


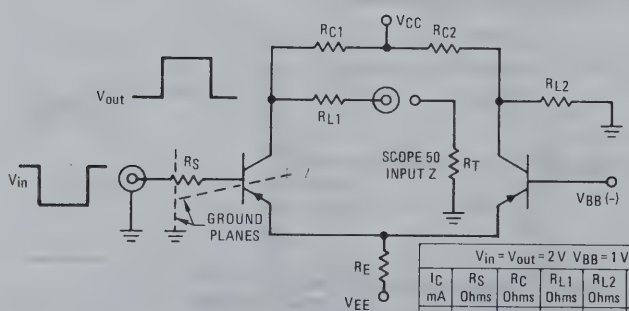
FIGURE 12 – TEST CIRCUIT



The test circuit is designed to simulate a series of cascaded identical circuits, with input Z equal to output Z.

	$V_{in} = V_{out} = 2\ V$ $V_{BB} = 1\ V$ $R_{C1} = R_{C2}$								$V_{in} = V_{out} = 1\ V$ $V_{BB} = 0.5\ V$ $R_{C1} = R_{C2}$						
I_C mA	R_S Ohms	R_C Ohms	R_{L1} Ohms	R_{L2} Ohms	R_E Ohms	V_{EE} Volts	V_{CC} Volts		R_S Ohms	R_C Ohms	R_{L1} Ohms	R_{L2} Ohms	R_E Ohms	V_{EE} Volts	V_{CC} Volts
1.0	2.0 k	6.0 k	3.0 k	3.0 k	10 k	10	16		1.0 k	6.0 k	1.2 k	1.2 k	24 k	24	32
5.0	360	3.56 k	400	450	2.0 k	10	47		175	1.0 k	200	250	3.0 k	15	27
10	160	1.0 k	200	250	3.0 k	30	26.3		75	300	100	150	3.0 k	30	17
20	62	300	100	150	1.0 k	20	16		25	150	25	75	1.0 k	20	11
30	28	157	66	116	1.0 k	30	13		8.0	77	0	50	1.0 k	30	9.0

FIGURE 13 – TEST CIRCUIT



The test circuit is designed to simulate a series of cascaded identical circuits, with input Z equal to output Z.

	$V_{in} = V_{out} = 2\ V$ $V_{BB} = 1\ V$ $R_{C1} = R_{C2}$							$V_{in} = V_{out} = 1\ V$ $V_{BB} = 0.5\ V$ $R_{C1} = R_{C2}$						
I_C mA	R_S Ohms	R_C Ohms	R_{L1} Ohms	R_{L2} Ohms	R_E Ohms	V_{EE} Volts	V_{CC} Volts	R_S Ohms	R_C Ohms	R_{L1} Ohms	R_{L2} Ohms	R_E Ohms	V_{EE} Volts	V_{CC} Volts
1.0	2.0 k	6.0 k	3.0 k	3.0 k	10 k	40	16	1.0 k	6.0 k	1.2 k	1.2 k	24 k	24	32
5.0	360	3.56 k	400	450	2.0 k	10	47	175	1.0 k	200	250	3.0 k	15	27
10	160	1.0 k	200	250	3.0 k	30	26.3	75	300	100	150	3.0 k	30	17
20	62	300	100	150	1.0 k	20	16	25	150	25	75	1.0 k	20	11
30	28	157	66	116	1.0 k	30	13	8.0	77	0	50	1.0 k	30	9.0

UNENCAPSULATED SWITCHING AND AMPLIFIER TRANSISTORS

. . . with passivated Annular construction that provides high reliability and consistent performance. These chips are identical to the chips used in packaged Motorola transistors with 2N prefixes; i.e., the MMCS2192 chip is used in the Motorola 2N2192 transistor. For more detailed characteristic data, please refer to the equivalent Motorola 2N. . . . data sheet.

- DC Current Gain to 100 Minimum
- Breakdown Voltages to 175 Volts
- f_T to 300 MHz

SILICON TRANSISTORS

MMCS2192	MMCS3499
MMCS2193	MMCS3500
MMCS2221	MMCS3501
MMCS2221A	MMCS3634
MMCS2222	MMCS3635
MMCS2222A	MMCS3636
MMCS2906	MMCS3637
MMCS2906A	MMCS3903
MMCS2907	MMCS3904
MMCS2907A	MMCS3905
MMCS3250	MMCS3906
MMCS3250A	MMCS4400
MMCS3251	MMCS4401
MMCS3251A	MMCS4402
MMCS3498	MMCS4403

MAXIMUM RATINGS

TYPE	V_{CEO} Volts	V_{CB} Volts	V_{EB} Volts	I_C mA	Geometry
NPN					
MMCS2192	40	60	5.0	1000	1
MMCS2193	50	80	8.0	1000	1
MMCS2221	30	60	5.0	800	2
MMCS2221A	40	75	6.0	800	2
MMCS2222	30	60	5.0	800	2
MMCS2222A	40	75	6.0	800	2
MMCS3498	100	100	6.0	500	1
MMCS3499	100	100	6.0	500	1
MMCS3500	150	150	6.0	300	1
MMCS3501	150	150	6.0	300	1
MMCS3903	40	60	6.0	200	6
MMCS3904	40	60	6.0	200	6
MMCS4400	40	60	6.0	600	7
MMCS4401	40	60	6.0	600	7
PNP					
MMCS2906	40	60	5.0	600	3
MMCS2906A	60	60	5.0	600	3
MMCS2907	40	60	5.0	600	3
MMCS2907A	60	60	5.0	600	3
MMCS3250	40	50	5.0	200	5
MMCS3250A	60	60	5.0	200	5
MMCS3251	40	50	5.0	200	5
MMCS3251A	60	60	5.0	200	5
MMCS3634	140	140	5.0	1000	4
MMCS3635	140	140	5.0	1000	4
MMCS3636	175	175	5.0	1000	4
MMCS3637	175	175	5.0	1000	4
MMCS3905	40	40	5.0	200	5
MMCS3906	40	40	5.0	200	5
MMCS4402	40	40	5.0	600	8
MMCS4403	40	40	5.0	600	8

Operating and Storage Junction Temperature Range −65 to +200°C

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are die-and-wire bonded in a noninert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.

3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

SWITCHING & AMPLIFIER TRANSISTORS (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

TYPE	BV_{CEO} @ I_C Volts min / mA	BV_{CBO} @ I_C Volts min / µA	BV_{EBO} @ I_E Volts min / µA	I_{CBO} @ V_{CB} nA max / Volts	h_{FE} @ I_C min/max / mA	$V_{CE(sat)}$, $V_{BE(sat)}$ @ I_C Volts max / Volts max / mA
NPN						
MMCS2192	40 25	60 100	5.0 100	10 30	100/300 150	0.35 1.3 150
MMCS2193	50 25	80 100	8.0 100	10 60	40/120 150	0.35 1.3 150
MMCS2221	30 10	60 10	5.0 10	10 50	40/120 150	0.4 1.3 150
MMCS2221A	40 10	75 10	6.0 10	10 60	40/120 150	0.3 1.2 150
MMCS2222	30 10	60 10	5.0 10	10 50	100/300 150	0.4 1.3 150
MMCS2222A	40 10	75 10	6.0 10	10 60	100/300 150	0.3 1.2 150
MMCS3498 ①	100 10	100 10	6.0 10	50 50	40/120 150	0.6 1.4 300
MMCS3499 ①	100 10	100 10	6.0 10	50 50	100/300 150	0.6 1.4 300
MMCS3500 ①	150 10	150 10	6.0 10	50 75	40/120 150	0.4 1.2 150
MMCS3501 ①	150 10	150 10	6.0 10	50 75	100/300 150	0.4 1.2 150
MMCS3903	40 1.0	60 10	6.0 10	50 30	50/150 10	0.2 0.85 10
MMCS3904	40 1.0	60 10	6.0 10	50 30	100/300 10	0.2 0.85 10
MMCS4400	40 1.0	60 100	6.0 100	100 35	50/150 150	0.4 0.95 150
MMCS4401	40 1.0	60 100	6.0 100	100 35	100/300 150	0.4 0.95 150
PNP						
MMCS2906	40 10	60 10	5.0 10	20 50	40/120 150	0.4 1.3 150
MMCS2906A	60 10	60 10	5.0 10	10 50	40/120 150	0.4 1.3 150
MMCS2907	40 10	60 10	5.0 10	20 50	100/300 150	0.4 1.3 150
MMCS2907A	60 10	60 10	5.0 10	10 50	100/300 150	0.4 1.3 150
MMCS3250	40 10	50 10	5.0 10	20 40	50/150 10	0.25 0.9 10
MMCS3250A	60 10	60 10	5.0 10	20 40	50/150 10	0.25 0.9 10
MMCS3251	40 10	50 10	5.0 10	20 40	100/300 10	0.25 0.9 10
MMCS3251A	60 10	60 10	5.0 10	20 40	100/300 10	0.25 0.9 10
MMCS3634 ①	140 10	140 100	5.0 10	100 100	50/150 50	0.5 0.9 50
MMCS3635 ①	140 10	140 100	5.0 10	100 100	100/300 50	0.5 0.9 50
MMCS3636 ①	175 10	175 100	5.0 10	100 100	50/150 50	0.5 0.9 50
MMCS3637 ①	175 10	175 100	5.0 10	100 100	100/300 50	0.5 0.9 50
MMCS3905	40 1.0	40 10	5.0 10	50 30	50/150 10	0.25 0.85 10
MMCS3906	40 1.0	40 10	5.0 10	50 30	100/300 10	0.25 0.85 10
MMCS4402	40 1.0	40 100	5.0 100	100 35	50/100 150	0.4 0.95 150
MMCS4403	40 1.0	40 100	5.0 100	100 35	100/300 150	0.4 0.95 150

AC* PARAMETERS

TYPE	C_{ob} C_{cb}* pF max	C_{ib} C_{eb}* pF max	$\|h_{fe}\|$ @ I_C, V_{CE}, f min / mA / Volts / MHz	t_d, t_r t_{on}* ns max	t_s, t_f t_{off}* ns max	Test Circuit Fig. No.
NPN						
MMCS2192	20	–	2.0 50 10 20	–,85	180,60	1
MMCS2193	20	–	2.0 50 10 20	–,85	180,60	1
MMCS2221	8.0	30	2.5 20 20 100	26*(1)	70*(1)	2
MMCS2221A	8.0	30	2.5 20 20 100	26*(1)	70*(1)	2
MMCS2222	8.0	30	2.5 20 20 100	26*(1)	70*(1)	2
MMCS2222A	8.0	30	2.5 20 20 100	26*(1)	70*(1)	2
MMCS3498 ①	10	80	1.5 20 20 100	20,35	300,80	–
MMCS3499 ①	10	80	1.5 20 20 100	20,35	300,80	–
MMCS3500 ①	8.0	80	1.5 20 20 100	20,35	300,80	–
MMCS3501 ①	8.0	80	1.5 20 20 100	20,35	300,80	–
MMCS3903	4.0	3.0	2.0 10 20 100	40,40	200,60	6
MMCS3904	4.0	8.0	2.5 10 20 100	40,40	240,60	6
MMCS4400	6.5*	30*	1.8 20 10 100	18,25	260,35	8
MMCS4401	6.5*	30*	2.3 20 10 100	18,25	260,35	8
PNP						
MMCS2906	8.0	30	2.0 50 20 100	26*(1)	70*(1)	3
MMCS2906A	8.0	30	2.0 50 20 100	26*(1)	70*(1)	3
MMCS2907	8.0	30	2.0 50 20 100	26*(1)	70*(1)	3
MMCS2907A	8.0	30	2.0 50 20 100	26*(1)	70*(1)	3
MMCS3250	6.0	8.0	2.3 10 20 100	40,40	200,60	4
MMCS3250A	6.0	8.0	2.3 10 20 100	40,40	200,60	4
MMCS3251	6.0	8.0	2.8 10 20 100	40,40	240,60	4
MMCS3251A	6.0	8.0	2.8 10 20 100	40,40	240,60	4
MMCS3634 ①	10	75	1.2 30 30 100	480*	720*	5
MMCS3635 ①	10	75	1.6 30 30 100	480*	720*	5
MMCS3636 ①	10	75	1.2 30 30 100	480*	720*	5
MMCS3637 ①	10	75	1.6 30 30 100	480*	720*	5
MMCS3905	4.5	10	1.6 10 20 100	40,40	240,70	7
MMCS3906	4.5	10	2.0 10 20 100	40,40	250,85	7
MMCS4402	8.5*	30*	1.3 20 10 100	18,25	260,35	9
MMCS4403	8.5*	30*	1.8 20 10 100	18,25	260,35	9

① SMALL-SIGNAL CHARACTERISTICS

(I_C = 10 mA, V_{CE} = 10 V, f = 1.0 kHz)

TYPE	h_{ie} k ohms min/max	h_{re} x 10^{-4} max	h_{oe} µmhos min/max
NPN			
MMCS3498	0.16/1.2	3.0	8.0/120
MMCS3499	0.2/1.5	4.8	16/240
MMCS3500	0.16/1.2	3.0	8.0/120
MMCS3501	0.2/1.5	4.8	16/240
PNP			
MMCS3634	80/720	3.6	–/240
MMCS3635	165/1400	3.6	–/240
MMCS3636	80/720	3.6	–/240
MMCS3637	165/1400	3.6	–/240

*AC parameter values are as specified in the standard 2N data sheets. (encapsulated devices)

(1) Typical Switching Times

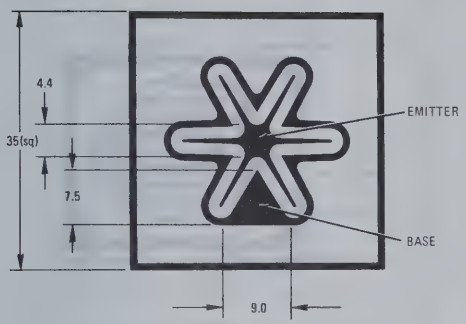
PARAMETER LIMITATIONS AND WARRANTY

Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20. Visual Inspection is performed to an LTPD of 20. See "Visual Inspection Criteria" in General Information Section.

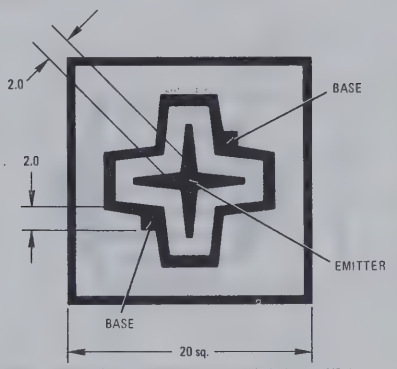
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

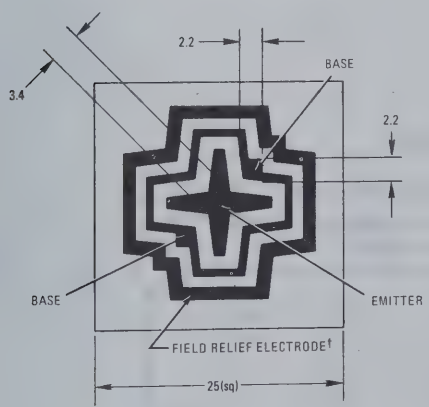
ALL DIMENSIONS ARE IN MILS



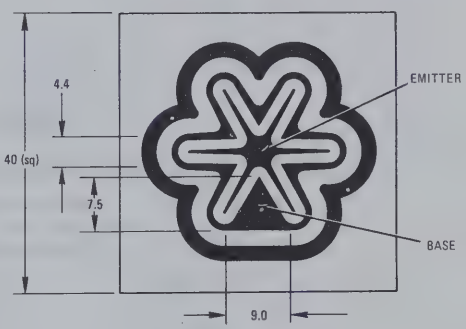
GEOMETRY 1 MMCS2192 MMCS3498 MMCS3500 NPN
MMCS2193 MMCS3499 MMCS3501



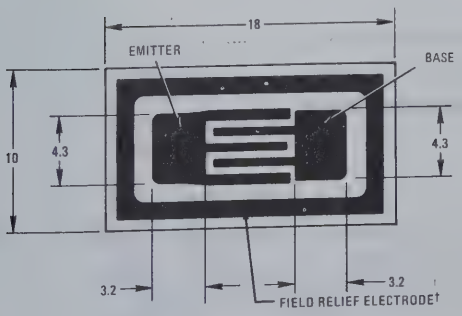
GEOMETRY 2 MMCS2221 MMCS2222 NPN
MMCS2221A MMCS2222A



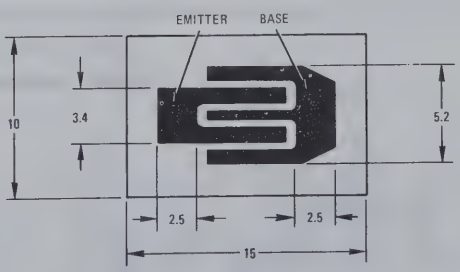
GEOMETRY 3 MMCS2906 MMCS2907 PNP
MMCS2906A MMCS2907A



GEOMETRY 4 MMCS3634 MMCS3636 PNP
MMCS3635 MMCS3637



GEOMETRY 5 MMCS3250 MMCS3251A PNP
MMCS3250A MMCS3905
MMCS3251 MMCS3906



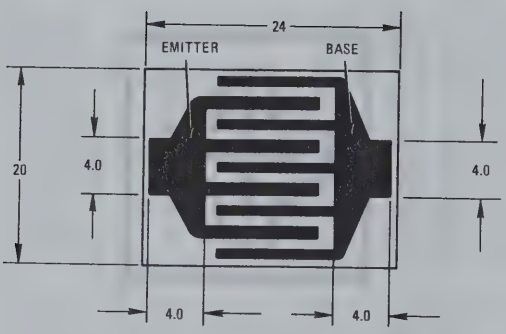
GEOMETRY 6 MMCS3903 MMCS3904 NPN

†Patented by Motorola – Patent No. 3, 302, 076.

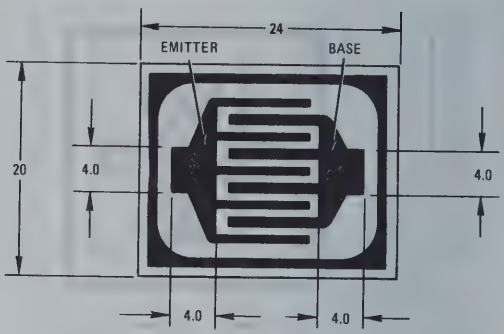
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

ALL DIMENSIONS ARE IN MILS



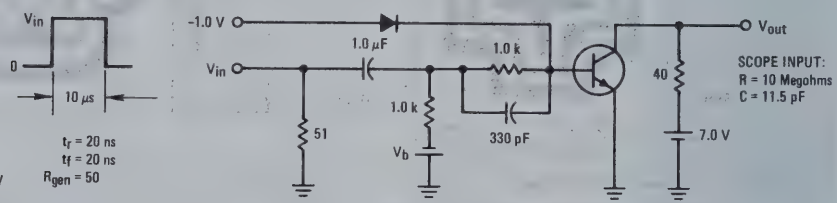
GEOMETRY 7 MMCS4400 MMCS4401 NPN



GEOMETRY 8 MMCS4402 MMCS4403 PNP

TEST CIRCUITS

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



MMCS2192 – V_{in} = 7.5 V, V_b = 7.5 V
MMCS2193 – V_{in} = 15 V, V_b = 15 V

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

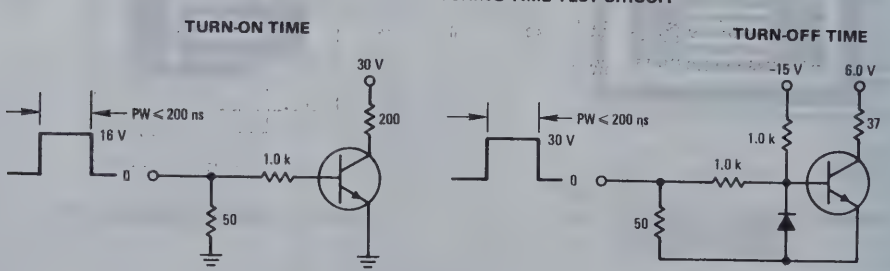


FIGURE 3 – SATURATED SWITCHING TIME TEST CIRCUIT

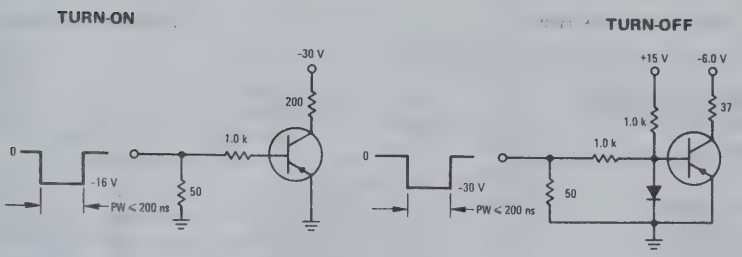


FIGURE 4 – EQUIVALENT TEST CIRCUIT

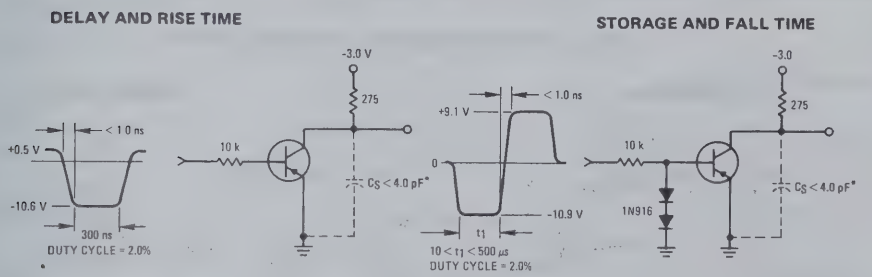
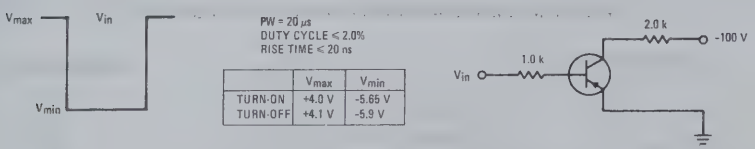


FIGURE 5 – SWITCHING TIME TEST CIRCUIT



	Vmax	Vmin
TURN-ON	+4.0 V	-5.65 V
TURN-OFF	+4.1 V	-5.9 V

FIGURE 6 – EQUIVALENT TEST CIRCUIT

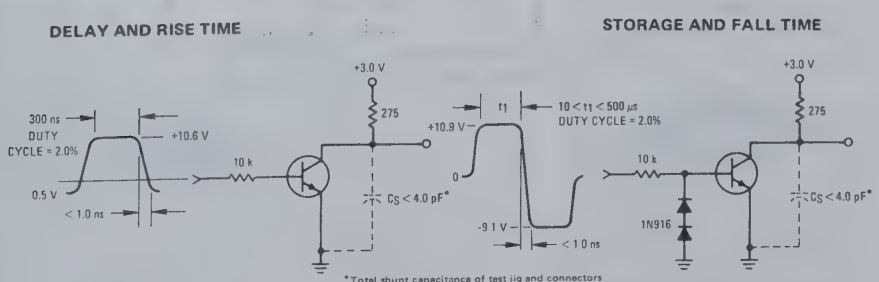


FIGURE 7 – EQUIVALENT TEST CIRCUIT

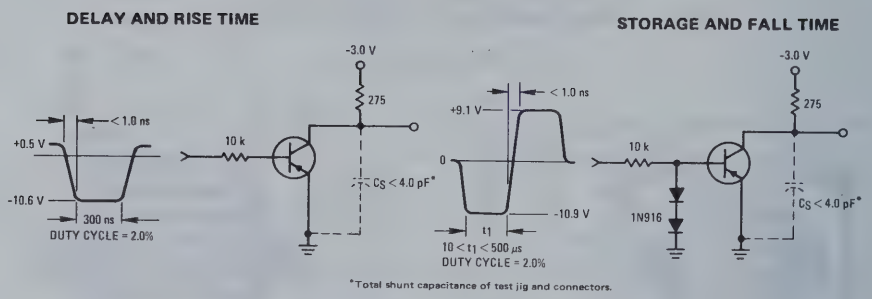


FIGURE 8 – SWITCHING TIME EQUIVALENT TEST CIRCUITS

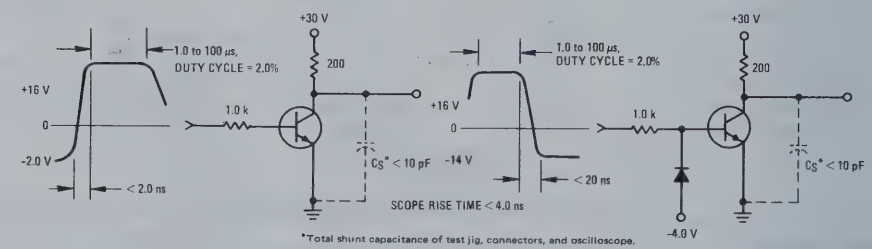
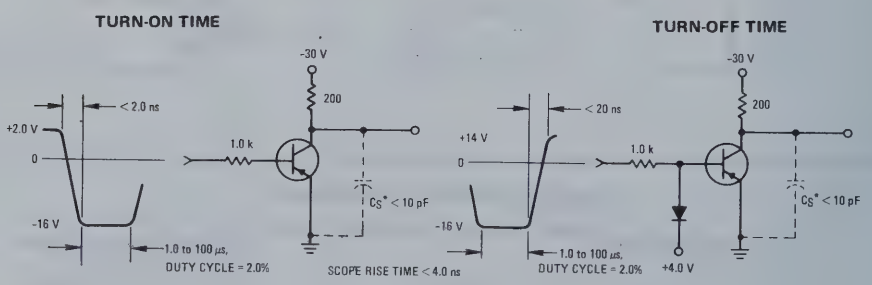


FIGURE 9 – SWITCHING TIME EQUIVALENT TEST CIRCUIT



UNENCAPSULATED NPN RF TRANSISTORS

These devices are passivated Silicon RF transistor chips. The MMCS2857, MMCS3866, and MMCS5636 chips are identical to the chips used in the packaged Motorola transistors with 2N prefixes; i.e., the MMCS2857 chip is used in the Motorola 2N2857 transistor. The MMCS0159 and MMCS0172 are electrically similar to the MM1605, MM1606, MM1607 series and MM8002 respectively.

- Power Outputs to 8.4 Watts Typical at 400 MHz
- f_T to 2000 MHz Typical

SILICON TRANSISTORS

MMCS0159
MMCS0172
MMCS2857
MMCS3866
MMCS5636

MAXIMUM RATINGS

TYPE	V_{CEO} Volts	V_{CB} Volts	V_{EB} Volts	I_C mA	Geometry
NPN					
MMCS0159	10	20	3.0	70	1
MMCS0172	30	40	3.5	400	2
MMCS2857	15	30	2.5	40	3
MMCS3866	30	55	3.5	400	2
MMCS5636	35	60	4.0	400	4

Operating and Storage Junction Temperature Range −65 to +200°C

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

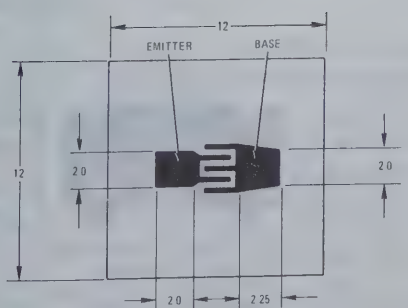
1. Such devices are stored in an environment of no more than 30% relative humidity.
2. Devices are die-and-wire bonded in a non-inert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.
3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

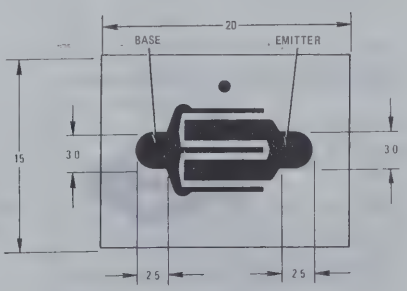
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

ALL DIMENSIONS ARE IN MILS



GEOMETRY 1 MMCS0159



GEOMETRY 2 MMCS0172 MMCS3866

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

TYPE	BV_{CEO} @ I_C		BV_{CBO} @ I_C		BV_{EBO} @ I_E		I_{CBO} @ V_{CB} / I_{CEO}* @ V_{CE}*		h_{FE} @ I_C	
	Volts min	mA	Volts min	µA	Volts min	mA	µA max	Volts	min/max	mA
NPN										
MMCS0159	10	1.0	20	100	3.0	0.1	0.01	4.0	25/200	25
MMCS0172	30	5.0	40	100	3.5	0.1	20*	28*	30/–	50
MMCS2857	15	3.0	30	1.0	2.5	0.01	0.01	15	30/150	3.0
MMCS3866	30	5.0	55	100	3.5	0.1	20*	28*	10/200	50
MMCS5636	35	200	50	100	4.0	5.0	1000	30	5.0/–	200

AC* PARAMETERS

TYPE	C_{cb} C_{ob}*	f_T	$r_b'C_c$	G_{pe} @ f		P_{out} @ $P_{out(osc)}$*	P_{in} & V_{CE} & f			NF @ f	
	pF max	MHz typ	ps typ	dB typ	MHz	Watt typ	Watt	Volts	MHz	dB typ	MHz
NPN											
MMCS0159	1.0	2000	15	–	–	–	–	–	–	–	–
MMCS0172	3.5*	1500	–	11.4	200	–	–	–	–	2.7	200
MMCS2857	1.0	1500	15	15	450	0.035*	–	10	500	4.0	450
MMCS3866	3.0*	800	–	11	400	1.3	0.1	28	400	–	–
MMCS5636	20	–	–	7.0	400	8.4	2.0	28	400	–	–

*AC parameter values are as specified in the standard 2N or MM data sheets. (encapsulated devices)

PARAMETER LIMITATIONS AND WARRANTY

Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20. Visual inspection is performed to an LTPD of 20. See "Visual Inspection Criteria" in General Information Section.

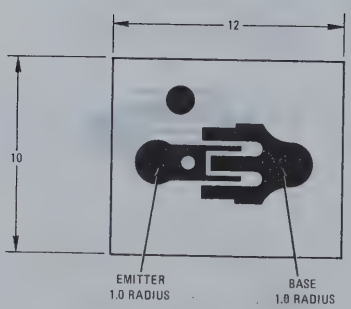
MECHANICAL INFORMATION

MATERIAL – SILICON

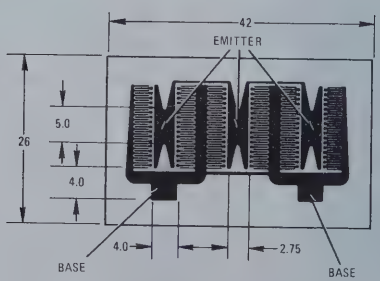
FRONT METALIZATION – ALUMINUM

BACK METALIZATION – GOLD (Collector Contact)

ALL DIMENSIONS ARE IN MILS



GEOMETRY 3 MMCS2857



GEOMETRY 4 MMCS5636

UNENCAPSULATED FIELD-EFFECT TRANSISTORS

These devices are passivated Field-Effect transistor chips electrically similar to those listed in Table 1. For more detailed characteristic data, please refer to the appropriate Motorola data sheet.

- MOS FETs are Silicon Nitride Passivated
- MOS and Junction Types
- P-Channel and N-Channel

SILICON TRANSISTORS

MMCS0122
MMCS0123
MMCS0125
MMCS0130
MMCS0131
MMCS0134

MAXIMUM RATINGS

MOS FETS

TYPE	V_{DS} Volts	V_{DG} Volts	V_{GS} Volts	I_D mA	Geometry	Application
N-Channel						
MMCS0122	25	±30	±30	30	1	Low Power Switch
P-Channel						
MMCS0123	25	±30	±30	30	1	Low Power Switch

JUNCTION FETS

TYPE	V_{DS} Volts	V_{DG} Volts	$V_{GS(r)}$ Volts	$I_{G(f)}$ mA	I_D mA	Geometry	Application
N-Channel							
MMCS0130	25	25	-25	10	20	2	VHF Amplifier and Mixer
MMCS0131	25	25	-25	10	20	3	General-Purpose Audio and Switching
MMCS0134	30	30	-30	10	—	4	Chopper
P-Channel							
MMCS0125	40	40	40	10	20	2	General-Purpose Amplifier

Operating and Storage Junction Temperature Range −65 to +200°C

TABLE 1 — CROSS REFERENCE CHART

DEVICE	ELECTRICAL CHARACTERISTICS SIMILAR TO:
MMCS0122	2N4351
MMCS0123	2N4352, 3N155, 3N155A, 3N156, 3N156A, 3N157, 3N157A, 3N158, 3N158A
MMCS0125	2N5460, 2N5461, 2N5462, 2N5463, 2N5464, 2N5465, MPF161, MFE4007, MFE4008, MFE4009, MFE4010, MFE4011, MFE4012
MMCS0130	2N3821, 2N3822, 2N3823, 2N3824, 2N4223, 2N4224, 2N5668, 2N5669, 2N5670, MPF102
MMCS0131	2N4220, 2N4220A, 2N4221, 2N4221A, 2N4222, 2N4222A, 2N5457, 2N5458, 2N5459
MMCS0134	2N4091, 2N4092, 2N4093, 2N4391, 2N4392, 2N4393, MFE2004, MFE2005, MFE2006

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are die-and-wire bonded in a noninert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.

3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

MOS FETS

TYPE	$V_{GS(th)}$ Volts min/max	$V_{DS(on)}$ Volts max	$I_{D(on)}$ mA min	$V_{BR(DSS)}$ Volts min	I_{GSS} pA typ	I_{DSS} nA max	$r_{ds(on)}$ Ohms max	$\|y_{fs}\|$ µmhos min	C_{iss} pF max	C_{rss} pF max	$C_{d(sub)}$ pF max	t_d, t_r ns max	t_s, t_f ns max
N-Channel													
MMCS0122	1.0/5.0	1.0	3.0	25	0.10	10	300	1000	5.0	1.3	5.0	45,65	60,100
P-Channel													
MMCS0123	-1.0/-5.0	-1.0	-3.0	-25	0.10	-10	600	1000	5.0	1.3	4.0	45,65	60,100

JUNCTION FETS

TYPE	$V_{BR(GSS)}$ Volts min	$V_{GS(off)}$ Volts min/max	I_{GSS} nA max	I_{DSS} mA min/max	V_{GS} Volts min/max	$\|y_{fs}\|$ µmhos typ/max	$\|y_{os}\|$ µmhos max	C_{iss} pF max	C_{rss} pF max	$r_{DS(on)}$ Ohms max
N-Channel										
MMCS0130	-25	0.2/8.0	-5.0	2.0/20	0.5/7.5	3000/7000	75	7.0	3.0	–
MMCS0131	-25	0.5/8.0	-5.0	1.0/16	0.5/7.5	1000/6000	50	7.0	3.0	–
MMCS0134	30	1.0/12	5.0	8.0/–	1.0/10	–	–	16	5.0	100
P-Channel										
MMCS0125	40	0.2/8.0	5.0	0.5/14	0.5/7.5	2500/6000	75	7.0	2.0	–

PARAMETER LIMITATIONS AND WARRANTY

Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20. Visual inspection is performed to an LTPD of 20. See "Visual Inspection Criteria" in General Information Section.

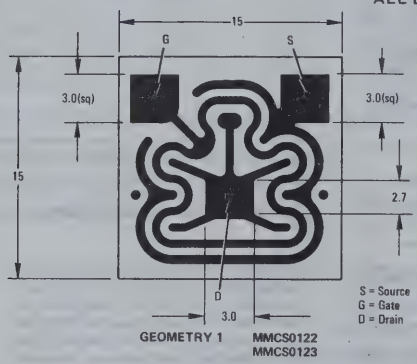
MECHANICAL INFORMATION

MATERIAL – SILICON

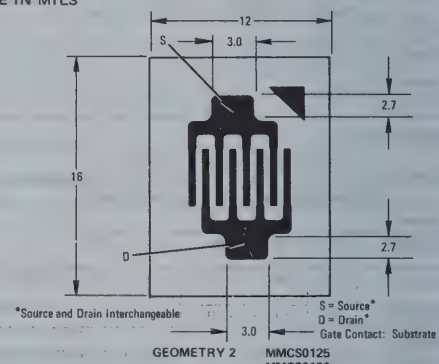
FRONT METALIZATION – ALUMINUM

BACK METALIZATION – GOLD (Substrate)

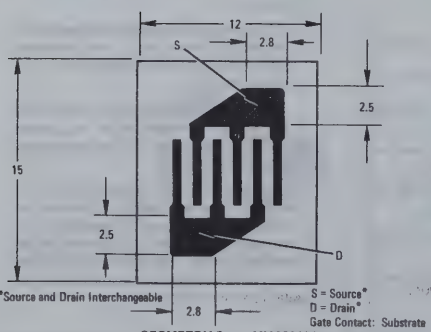
ALL DIMENSIONS ARE IN MILS



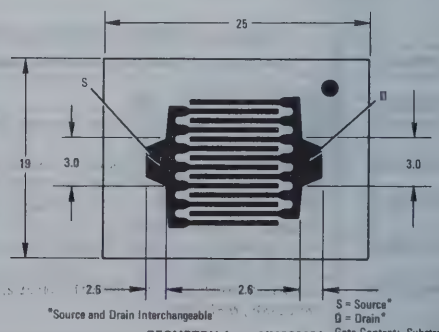
GEOMETRY 1 MMCS0122 MMCS0123



GEOMETRY 2 MMCS0125 MMCS0130



GEOMETRY 3 MMCS0131



GEOMETRY 4 MMCS0134

UNENCAPSULATED SILICON POWER TRANSISTORS

These devices are passivated Silicon power transistor chips suitable for collector currents to 25 amperes. Both NPN and PNP devices are available for maximum versatility and may be used in complementary circuitry.

- Collector Currents to 25 Amperes
- Breakdown Voltage to 60 Volts
- DC Current Gains to 30 Volts Minimum
- High f_T (30 MHz Minimum)

SILICON TRANSISTORS

MJC007
MJC043
MJC044
MJC067
MJC069
MJC070
MJC076
MJC082

MAXIMUM RATINGS

TYPE	V_{CEO} Volts	V_{EB} Volts	I_C Amp	Geometry
NPN				
MJC044	60	5.0	1.0	2
MJC076	50	5.0	3.0	1
MJC082	60	5.0	5.0	3
MJC070	60	5.0	25	4
PNP				
MJC043	60	5.0	1.0	2
MJC007	50	5.0	3.0	1
MJC067	60	5.0	5.0	3
MJC069	60	5.0	25	4

Operating and Storage Junction Temperature Range −65 to +200°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

TYPE	I_C Amp	BV_{EBO} @ I_E Volts min / μA	BV_{CEO} @ I_C Volts min / mA	BV_{CES} @ I_C Volts min / μA	h_{FE} @ I_C, V_{CE} min/max / Amp / Volts			f_T MHz min
NPN								
MJC044	1.0	5.0 / 500	60 / 100	60 / 100	30/180	0.250	1.0	30
MJC076	3.0	5.0 / 100	50 / 10	50 / 100	20/180	1.0	2.0	30
MJC082	5.0	5.0 / 100	60 / 10	60 / 100	30/180	2.0	2.0	30
MJC070	25	5.0 / 100	60 / 10	60 / 100	20/180	10	3.0	30
PNP								
MJC043	1.0	5.0 / 500	60 / 100	60 / 100	30/180	0.250	1.0	30
MJC007	3.0	5.0 / 100	50 / 10	50 / 100	20/180	1.0	2.0	30
MJC067	5.0	5.0 / 100	60 / 10	60 / 100	30/180	2.0	2.0	30
MJC069	25	5.0 / 100	60 / 10	60 / 100	20/180	10	3.0	30

PARAMETER LIMITATIONS AND WARRANTY

Probe limitations allow 100% testing of low level dc parameters only. Limits for all parameters listed for power transistor chips have been selected to insure the electrical characteristics to an LTPD of 20.

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

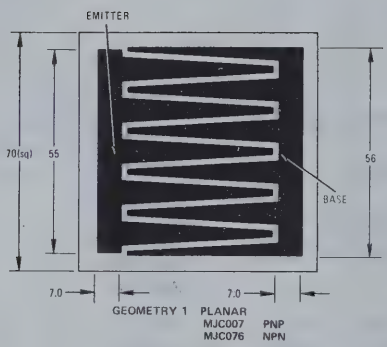
1. Such devices are stored in an environment of no more than 30% relative humidity.
2. Devices are die-and-wire bonded in an inert atmosphere not exceeding 400°C.
3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

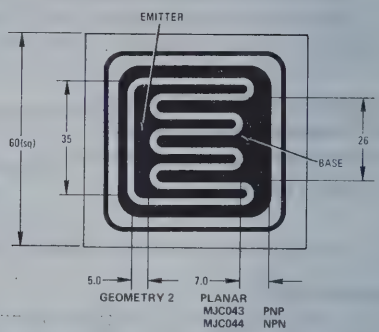
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

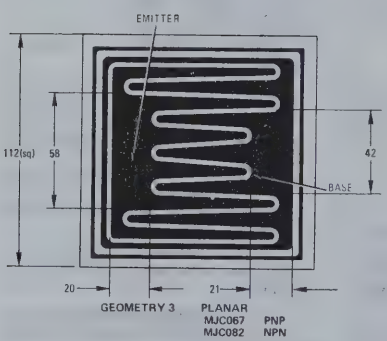
ALL DIMENSIONS ARE IN MILS



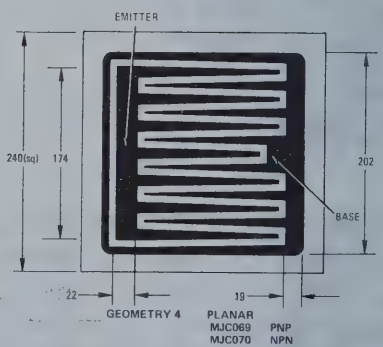
GEOMETRY 1 PLANAR
MJC007 PNP
MJC076 NPN



GEOMETRY 2 PLANAR
MJC043 PNP
MJC044 NPN



GEOMETRY 3 PLANAR
MJC067 PNP
MJC082 NPN



GEOMETRY 4 PLANAR
MJC069 PNP
MJC070 NPN

UNENCAPSULATED
HIGH-SPEED SWITCHING DIODES

These devices are passivated High-Speed Switching diode chips. The MMCD914 has electrical characteristics similar to the 1N914. The MMCD6100 is the same chip as used in the Motorola MSD6100.

- Reverse Voltage to 100 Volts
- Forward Current to 225 mA
- Reverse Recovery Time of 4.0 ns

SILICON SWITCHING DIODES

MMCD914

MMCD6100

MAXIMUM RATINGS

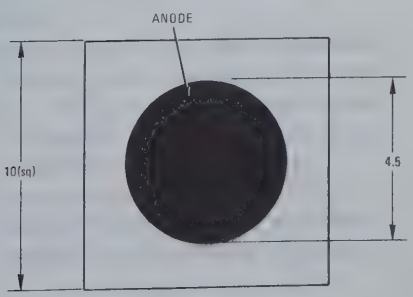
TYPE	V_R Volts	I_O mA	I_F mA	$I_{F(surge)}$ mA	T_J, T_{stg} °C	Geometry
MMCD914	75	75	225	500	-65 to +150	1
MMCD6100	100	--	200	500	-55 to +135	1

Operating and Storage Junction Temperature Range -65 to +200°C

MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Cathode Contact)

ALL DIMENSIONS ARE IN MILS



GEOMETRY 1 MMCD914 MMCD6100

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are die-and-wire bonded in a noninert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.

3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

TYPE	$V_{(BR)}$ @ $I_{(BR)}$ = 100 μA Volts min	I_R @ V_R μA max	Volts	I_R @ V_R nA max	Volts	V_F @ I_F = 10 mA min/max	C @ V_R = 0 pF max
MMCD914 ①	100	5.0	75	25	20	–/1.0	4.0
MMCD6100 ②	100	5.0	100	100	50	0.65/0.85	1.5

① Reverse recovery time = 5.0 ns @ I_F = 10 mA, V_R = 6.0 V, i_{rr} = 1.0 mA

② Reverse recovery time = 5.0 ns @ I_F = I_R = 10 mA, V_R = 5.0 V, i_{rr} = 1.0 mA

PARAMETER LIMITATIONS AND WARRANTY

Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20.

MOTOROLA SPECIAL MICROCIRCUIT ZENER DIODE SELECTION

I Special Microcircuit Component Selection

Most standard zener diode devices are available in chip form to meet a wide variety of application requirements. Nonstandard chips are available on a negotiated basis. Special zero-temperature-compensated zener diode chips are also available upon request. Contact your local Motorola representative for more information.

II General Features

1. The MZC2.4A10 and MZC1.8B10 series have gold-backed metalization. All other chips have a chrome-silver-gold backing.
2. All zener diode chips have silicon-oxide-passivated junctions.
3. Zener chips are available in 10% (standard), 5%, 3%, 2% and 1% tolerances.
4. Most standard zener diode and current regulator chips are available.

III Electrical Parameter Test Capability

The following parameters may be tested on a 100% basis:

Zener Diodes	Current Regulators
1. V_Z	1. I_p
2. I_R	2. Z_T
3. Z_{ZT}	3. Z_K
4. Z_{ZK}	4. V_L
5. V_f	

IV Policies

1. Devices shipped in Deka-Pak and Multi-Pak containers are equipped with a tamper-proof seal. No returns will be accepted once the "tamper-proof" seal has been broken, due to the possibility of mechanical damage.
2. Devices shipped in other than preferred packages (see "Packaging" section) require special negotiation to prevent negation of warranty.

V Order Quantity Requirements

1. Zener diode chips must be ordered in multiples of 10 to facilitate packaging and warehousing requirements.
2. All orders must state type of packaging required (see packaging section).

VI Mounting and Handling

1. General
   (A) Both chip mounting and lead bonding should be carried out in a carefully controlled atmosphere for best results. Vacuum probes should be used for handling the chips. Handling should be minimized, and a cleaning operation must be performed as soon as possible prior to mounting. Also, extreme care should be taken when probing electrically to avoid scratching or cracking the chip.

   The mounting pads must be large enough to permit "scrubbing", and lead bonds must be "looped" from the chip to substrate to eliminate possible shorting.

2. Gold-Backed Chips (MZC Series)
   (A) For chip mounting, a gold-silicon eutectic bond is normally used. Electrically conductive epoxies may also be used. Since fluxes are not used, the chip must be "scrubbed", either manually or ultrasonically, on a preheated mounting surface to get a reliable ohmic chip contact. Use of a solder preform during mounting minimizes the chip-mount thermal resistance; the preform usually is gold or gold-doped with arsenic or

antimony. Power dissipation is dependent on the quality of the chip mount. Lead bonding is normally accomplished either by ultrasonic or thermal compression techniques using gold or aluminum wire.

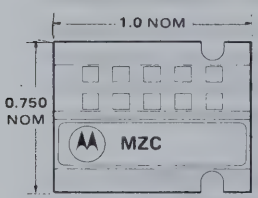
3. Chrome-Silver-Gold-Backed Chips (Conventional Series)

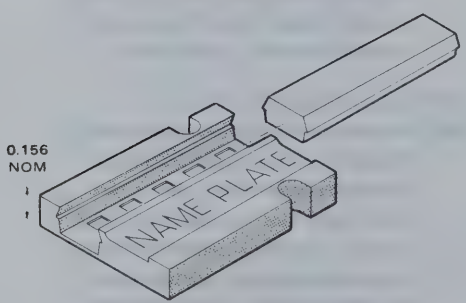
   (A) The chrome-silver-gold-backed chips used for conventional packaged zeners cannot be eutectically bonded. We would recommend a solder bond, but electrically conductive epoxies may be used. Motorola uses a gold-germanium solder (12.5% germanium, 1% indium, balance gold); however, the customer may have others which work as well or better. Information specified for the MZC series also applies.

VII Packaging

1. The following types of packaging are available:

   (A) Deka-Pak (10-chip carrier) — Preferred for orders of 30 or less:

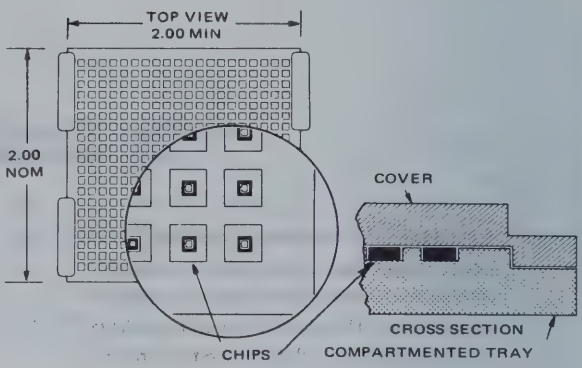




Standard Chip Carrier Package

To accommodate the customer with limited quantity requirements, the 10-chip carrier contains individual compartments for the chips and affords ease of inventory for the user. The carrier protects the chips during storage and handling and permits visual inspection without removing the chips.

(B) Multi-Pak (400-chip carrier) — Preferred for orders of 40 or more:



The Multi-Pak carrier is designed with an individual compartment for each chip.

Features of this carrier include:

(a) visual inspection without removal from carrier.
(b) carrier usable in customer production area.
(c) storage container for unused chips.

(C) Straw-Pak (1500 chip maximum) Non-Preferred:



The Straw-Pak is a vial encompassing a straw that has one end closed. The zener chips are inserted in the straw, and then the straw is bent and placed in the plastic vial for shipment.

2. The carrier package options are available for 37-mil square or smaller chips (500 mW or less on a conventional series). Packaging of larger geometry chips must be negotiated.
3. Chips will be placed randomly in their carriers with either side up for visual inspection requirements.
4. All packages are shipped with "tamper-proof" seals to insure that only qualified personnel will handle chips and to insure proper protection during transit.

SILICON ZENER DIODE CHIPS

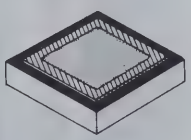
. . . for use in compact and high performance circuits that are beyond the present state of monolithic production capability.

- Available in 10% (Standard), 5%, 3%, 2% and 1% Tolerance Options (See Note 1)
- Silicon Oxide Passivated Junctions
- Full Voltage Range – 2.4 thru 200 Volts – "A" Series; 1.8 thru 200 Volts – "B" Series
- Limits Guaranteed on Four Electrical Parameters
- Both Anode and Cathode Chip Metalization Compatible with all Wire and Die Bonding Techniques

SILICON ZENER DIODES

MZC2.4A10 thru MZC200A10
HIGH LEVEL SERIES

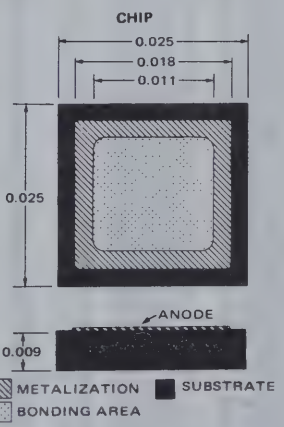
MZC1.8B10 thru MZC200B10
LOW LEVEL SERIES



CHIP (MZC)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_A = 50^oC$ Derate 3.2 mW/^oC above 50^oC	P_D	400	mW
When Mounted on a 1.0" x 1.0" x 0.010" Aluminum Plate			
Junction and Storage Temperature Range	T_J, T_{stg}	–65 to +175	^oC



MZC SERIES – This is a series of gold-backed silicon oxide passivated chips. Chips are compatible with all standard die bonding techniques used in hybrid circuits

DIMENSIONS: NOMINAL

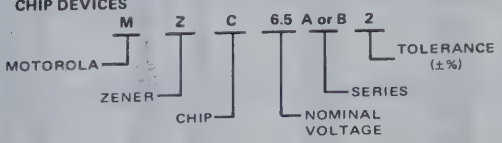
MZC

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

Tolerance Designation – The device type numbers listed have a tolerance of ±10%. For a ±5%, 3%, 2%, or 1%, change the suffix "10" to the desired tolerance.

Voltage Designation – To order devices with Zener voltages other than those listed, the Motorola type number should be modified as shown below.

CHIP DEVICES



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)
V_F = 1.5 V Max @ I_F = 200 mA for all types.

Type Number (Note 1)	Nearest 1N Equivalent	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 1)	Test Current I_{ZT} mA	Max Zener Impedance Z_{ZT} @ I_{ZT} Ohms	Max Reverse Leakage Current I_R @ V_R Volts μA	Tolerance 10%	Tolerance 5.0%	Max Zener Voltage Temp. Coeff. θ_{VZ} (%/°C) (For Reference Only)
MZC2.4A10	1N5221	2.4	21	53	100	0.95	1.0	-0.085
MZC2.5A10	1N5222	2.5	20	53	100	0.95	1.0	-0.085
MZC2.7A10	1N5223	2.7	19	52	75	0.95	1.0	-0.080
MZC2.8A10	1N5224	2.8	18	51	75	0.95	1.0	-0.080
MZC3.0A10	1N5225	3.0	17	50	50	0.95	1.0	-0.075
MZC3.3A10	1N5226	3.3	15	47	25	0.95	1.0	-0.070
MZC3.6A10	1N5227	3.6	14	43	15	0.95	1.0	-0.065
MZC3.9A10	1N5228	3.9	13	35	10	0.95	1.0	-0.060
MZC4.3A10	1N5229	4.3	12	29	5.0	0.95	1.0	±0.055
MZC4.7A10	1N5230	4.7	11	24	5.0	1.9	2.0	±0.030
MZC5.1A10	1N5231	5.1	9.8	21	5.0	1.9	2.0	±0.030
MZC5.6A10	1N5232	5.6	8.9	25	5.0	2.9	3.0	+0.038
MZC6.0A10	1N5233	6.0	8.3	30	5.0	3.3	3.5	+0.038
MZC6.2A10	1N5234	6.2	8.1	31	5.0	3.8	4.0	+0.045
MZC6.8A10	1N5235	6.8	7.3	38	3.0	4.8	5.0	+0.050
MZC7.5A10	1N5236	7.5	6.7	43	3.0	5.7	6.0	+0.058
MZC8.2A10	1N5237	8.2	6.1	49	3.0	6.2	6.5	+0.062
MZC8.7A10	1N5238	8.7	5.7	52	3.0	6.2	6.5	+0.065
MZC9.1A10	1N5239	9.1	5.5	54	3.0	6.7	7.0	+0.068
MZC10A10	1N5240	10	5.0	60	3.0	7.6	8.0	+0.075
MZC11A10	1N5241	11	4.5	66	2.0	8.0	8.4	+0.076
MZC12A10	1N5242	12	4.2	71	1.0	8.7	9.1	+0.077
MZC13A10	1N5243	13	3.8	74	0.5	9.4	9.9	+0.079
MZC14A10	1N5244	14	3.6	33	0.1	9.5	10	+0.082
MZC15A10	1N5245	15	3.3	37	0.1	10.5	11	+0.082
MZC16A10	1N5246	16	3.1	42	0.1	11.4	12	+0.083
MZC17A10	1N5247	17	2.9	47	0.1	12.4	13	+0.084
MZC18A10	1N5248	18	2.8	52	0.1	13.3	14	+0.085
MZC19A10	1N5249	19	2.6	58	0.1	13.3	14	+0.086
MZC20A10	1N5250	20	2.5	65	0.1	14.3	15	+0.086
MZC22A10	1N5251	22	2.3	70	0.1	16.2	17	+0.087
MZC24A10	1N5252	24	2.1	92	0.1	17.1	18	+0.088
MZC25A10	1N5253	25	2.0	100	0.1	18.1	19	+0.089
MZC27A10	1N5254	27	1.9	115	0.1	20	21	+0.090
MZC28A10	1N5255	28	1.8	120	0.1	20	21	+0.091
MZC30A10	1N5256	30	1.7	140	0.1	22	23	+0.091
MZC33A10	1N5257	33	1.5	170	0.1	24	25	+0.092
MZC36A10	1N5258	36	1.4	200	0.1	26	27	+0.093
MZC39A10	1N5259	39	1.3	230	0.1	29	30	+0.094
MZC43A10	1N5260	43	1.2	280	0.1	31	33	+0.095
MZC47A10	1N5261	47	1.1	330	0.1	34	36	+0.095
MZC51A10	1N5262	51	0.98	390	0.1	37	39	+0.096
MZC56A10	1N5263	56	0.89	460	0.1	41	43	+0.096
MZC60A10	1N5264	60	0.83	530	0.1	44	46	+0.097
MZC62A10	1N5265	62	0.81	560	0.1	45	47	+0.097
MZC68A10	1N5266	68	0.74	680	0.1	49	52	+0.097
MZC75A10	1N5267	75	0.67	800	0.1	53	56	+0.098
MZC82A10	1N5268	82	0.61	980	0.1	59	62	+0.098
MZC87A10	1N5269	87	0.57	1050	0.1	65	68	+0.099
MZC91A10	1N5270	91	0.55	1150	0.1	66	69	+0.099
MZC100A10	1N5271	100	0.50	1400	0.1	72	76	+0.110
MZC110A10	1N5272	110	0.45	1700	0.1	80	84	+0.110
MZC120A10	1N5273	120	0.42	2000	0.1	86	91	+0.110
MZC130A10	1N5274	130	0.38	2300	0.1	94	99	+0.110
MZC140A10	1N5275	140	0.36	2700	0.1	101	106	+0.110
MZC150A10	1N5276	150	0.33	3000	0.1	108	114	+0.110
MZC160A10	1N5277	160	0.31	3400	0.1	116	122	+0.110
MZC170A10	1N5278	170	0.29	3900	0.1	123	129	+0.110
MZC180A10	1N5279	180	0.28	4300	0.1	130	137	+0.110
MZC190A10	1N5280	190	0.26	4800	0.1	137	144	+0.110
MZC200A10	1N5281	200	0.25	5200	0.1	144	152	+0.110

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)
V_F = 1.5 V Max @ I_F = 200 mA for all types.

Type Number (Note 1)	Nearest 1N Equivalent	Nominal Zener Voltage V_Z @ I_{ZT} = 250 μA Volts (Note 1)	Max Zener Impedance Z_{ZT} @ I_{ZT} = 250 μA Ohms	Max Reverse Leakage Current @ V_R Volts		
				I_R μA	Tolerance 10%	Tolerance 5.0%
MZC1.8B10	1N4614	1.8	1200	7.5	0.9	1.0
MZC2.0B10	1N4615	2.0	1250	5.0	0.9	1.0
MZC2.2B10	1N4616	2.2	1300	4.0	0.9	1.0
MZC2.4B10	1N4617	2.4	1400	2.0	0.9	1.0
MZC2.7B10	1N4618	2.7	1500	1.0	0.9	1.0
MZC3.0B10	1N4619	3.0	1600	0.8	0.9	1.0
MZC3.3B10	1N4620	3.3	1650	7.5	1.0	1.5
MZC3.6B10	1N4621	3.6	1700	7.5	1.5	2.0
MZC3.9B10	1N4622	3.9	1650	5.0	1.5	2.0
MZC4.3B10	1N4623	4.3	1600	4.0	1.5	2.0
MZC4.7B10	1N4624	4.7	1550	10	2.5	3.0
MZC5.1B10	1N4625	5.1	1500	10	2.5	3.0
MZC5.6B10	1N4626	5.6	1400	10	3.5	4.0
MZC6.2B10	1N4627	6.2	1200	10	4.5	5.0
MZC6.8B10	1N4099	6.8	200	10	4.8	5.2
MZC7.5B10	1N4100	7.5	200	10	5.5	5.7
MZC8.2B10	1N4101	8.2	200	1.0	6.0	6.3
MZC8.7B10	1N4102	8.7	200	1.0	6.2	6.6
MZC9.1B10	1N4103	9.1	300	1.0	6.7	6.9
MZC10B10	1N4104	10	400	1.0	7.0	7.6
MZC11B10	1N4105	11	400	0.05	8.0	8.5
MZC12B10	1N4106	12	300	0.05	8.7	9.1
MZC13B10	1N4107	13	200	0.05	9.4	9.9
MZC14B10	1N4108	14	200	0.05	9.5	10.7
MZC15B10	1N4109	15	200	0.05	10.5	11.4
MZC16B10	1N4110	16	200	0.05	11.4	12.2
MZC17B10	1N4111	17	200	0.05	12.4	12.9
MZC18B10	1N4112	18	200	0.05	13.3	13.7
MZC19B10	1N4113	19	200	0.05	13.3	14.5
MZC20B10	1N4114	20	200	0.01	14.3	15.2
MZC22B10	1N4115	22	200	0.01	16.2	16.7
MZC24B10	1N4116	24	200	0.01	17.1	18.5
MZC25B10	1N4117	25	200	0.01	18.1	19.0
MZC27B10	1N4118	27	200	0.01	20	20.5
MZC28B10	1N4119	28	200	0.01	20	21.3
MZC30B10	1N4120	30	200	0.01	22	22.6
MZC33B10	1N4121	33	200	0.01	24	25.1
MZC36B10	1N4122	36	200	0.01	26	27.4
MZC39B10	1N4123	39	200	0.01	29	29.7
MZC43B10	1N4124	43	250	0.01	31	32.7
MZC47B10	1N4125	47	250	0.01	34	35.8
MZC51B10	1N4126	51	300	0.01	37	38.8
MZC56B10	1N4127	56	300	0.01	41	42.6
MZC60B10	1N4128	60	300	0.01	44	45.6
MZC62B10	1N4129	62	300	0.01	45	47.1
MZC68B10	1N4130	68	400	0.01	49	51.7
MZC75B10	1N4131	75	500	0.01	53	57.0
MZC82B10	1N4132	82	600	0.01	59	62.3
MZC87B10	1N4133	87	700	0.01	65	66.1
MZC91B10	1N4134	91	800	0.01	66	69.2
MZC100B10	1N4135	100	1000	0.01	72	76.0
MZC110B10	–	110	1300	0.01	80	84.0
MZC120B10	–	120	1600	0.01	86	91.0
MZC130B10	–	130	1900	0.01	94	99.0
MZC140B10	–	140	2200	0.01	101	106
MZC150B10	–	150	2600	0.01	108	114
MZC160B10	–	160	3000	0.01	116	122
MZC170B10	–	170	3500	0.01	123	129
MZC180B10	–	180	4000	0.01	130	137
MZC190B10	–	190	4600	0.01	137	144
MZC200B10	–	200	5200	0.01	144	152

FIGURE 1 – TYPICAL CAPACITANCE

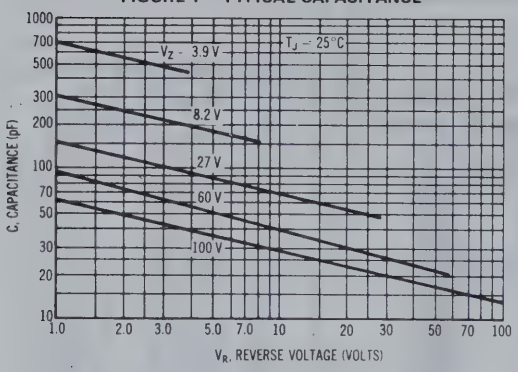


FIGURE 2 – TYPICAL FORWARD CHARACTERISTICS

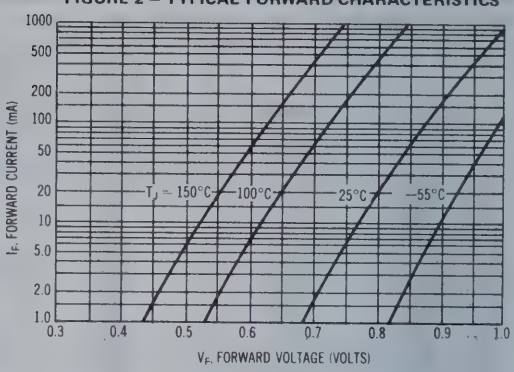


FIGURE 3 – TYPICAL NOISE DENSITY

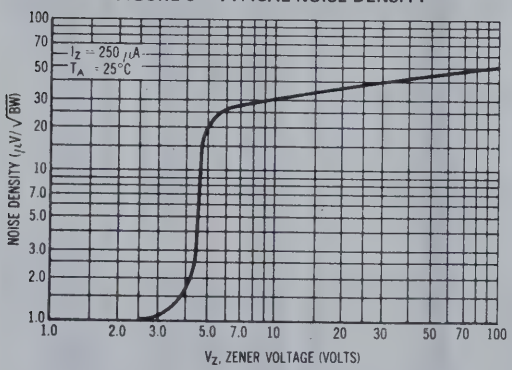
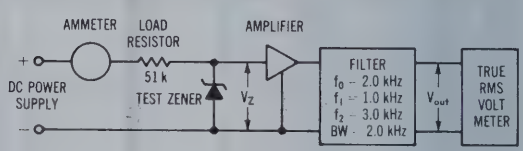


FIGURE 4 – NOISE DENSITY MEASUREMENT METHOD



NOISE DENSITY (VOLTS PER SQUARE ROOT BANDWIDTH) = $\frac{V_{out}}{\text{OVERALL GAIN } \sqrt{BW}}$

WHERE: BW = FILTER BANDWIDTH (Hz)
V_{out} = OUTPUT NOISE (VOLTS RMS)

The input voltage and load resistance are high so that the zener diode is driven from a constant current source. The noise of the amplifier is low so that it is negligible compared to that of the test zener. The filter bandpass is known so that the noise density can be calculated from the formula shown.

UNENCAPSULATED THIN-FILM RESISTORS

This data sheet lists a series of multi-tap 10-percent resistor chips designed for the manufacturer of hybrid circuits. These chips are particularly useful for trimming production circuits and for building prototype circuits. These chips have gold-alloy backing that is suitable for eutectic bonding directly to a metalized substrate; or may be bonded to a kovar or ceramic tab and then attached to the substrate using epoxy adhesive or other suitable methods. Electrical connection from the aluminum bonding pads of the resistor chip to other circuit elements is accomplished using conventional wire bonding techniques.

THIN-FILM RESISTORS

MMCR100

RESISTOR CHARACTERISTICS

Characteristic	Value	Unit
Power Rating @ T_A = 25°C Derate to 0 at 200°C	250 max	mW
Temperature Coefficient Resistance See Figure 1	-30 to +300	ppm/°C
Shunt Capacitance to Substrate	1.0 max	pF
Breakdown Voltage to Substrate	400 min	Volts
Resistance to Substrate	10^{15} min	Ohms
Voltage Coefficient	0.001 max	%/Volt
Drift @ 50% rated Power and 125°C	0.05 max 0.01 max	%/first 100 hours %/1000 hours

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are die-and-wire bonded in an inert atmosphere not exceeding 400°C.

3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

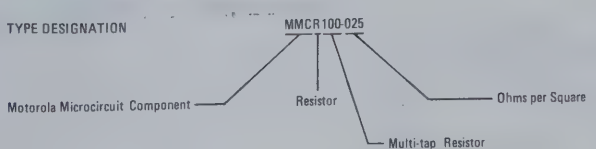


TABLE 1 RESISTANCE VALUES

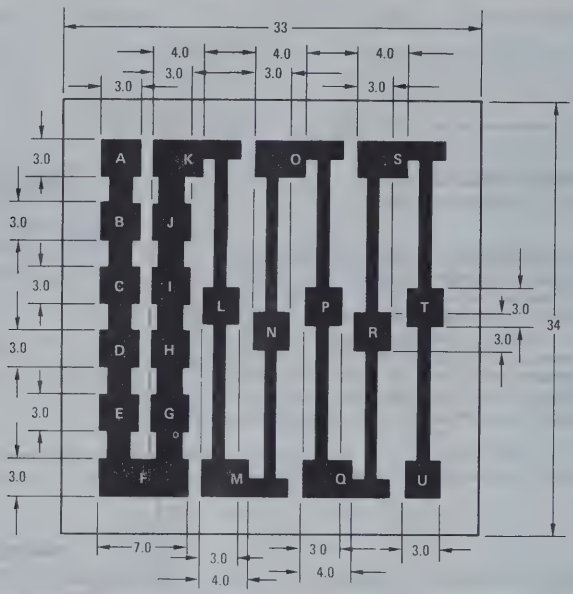
PART NUMBER	OHMS/□	END-TO-END RESISTANCE
MMCR100-025	25	2,750 Ohms
MMCR100-050	50	5,500 Ohms
MMCR100-100	100	11,000 Ohms
MMCR100-200	200	22,000 Ohms
MMCR100-300	300	33,000 Ohms

Each resistor chip is divided into 10 sections of 1 square, and 10 sections of 10 squares.

CONSTRUCTION DETAILS

SUBSTRATE – N-TYPE SILICON – 3 to 8 MILS THICK
ISOLATION LAYER – 10,000 Å SILICON DIOXIDE
RESISTOR ELEMENTS – NICKLE-CHROMIUM ALLOY
CONTACT METALIZATION – ALUMINUM
BACKING – GOLD-ALLOY

All dimensions are in mils



CHIP GEOMETRY

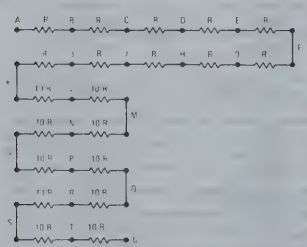


FIGURE 2 – EQUIVALENT CIRCUIT OF THIN-FILM RESISTOR CHIP

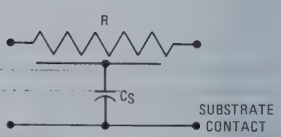
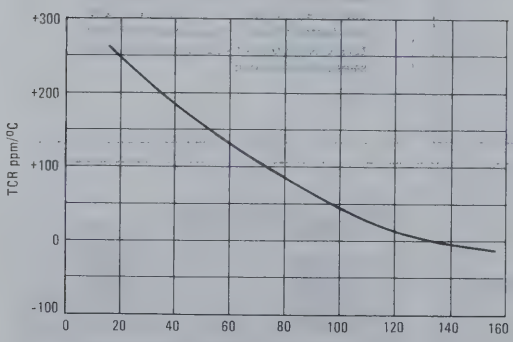


FIGURE 1 – NICHROME TEMPERATURE COEFFICIENT RESISTANCE



UNENCAPSULATED THIN-FILM RESISTORS

This data sheet lists a series of 5 and 10 percent resistor chips designed for the manufacturer of hybrid microcircuits. These chips may be used in conjunction with screened or deposited resistors or may replace them entirely. The chips have a gold-alloy backing that is suitable for eutectic bonding directly to a substrate; or they may be bonded to a kovar or ceramic tab and then attached to the substrate using epoxy adhesive or other suitable methods. Electrical connection from the aluminum bonding pads of the resistor chip to other circuit elements is accomplished using conventional wire bonding techniques.

THIN-FILM RESISTORS

MMCR105
MMCR110

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

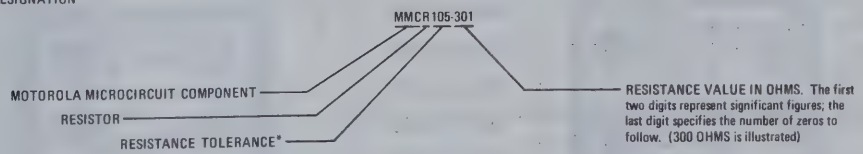
1. Such devices are stored in an environment of no more than 30% relative humidity.
2. Devices are die-and-wire bonded in an inert atmosphere not exceeding 400°C.
3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

RESISTOR CHARACTERISTICS

Characteristic	Value	Unit
Power Rating @ T_A = 25°C Derates to 0 at 200°C	250 max	mW
Temperature Coefficient Resistance (See Figure 1)	-30 to +300	ppm/°C
Shunt Capacitance to Substrate	1.0 max	pF
Breakdown Voltage to Substrate	400 min	Volts
Resistance to Substrate	10^{15} min	Ohms
Voltage Coefficient	0.001 max	%/Volt
Drift @ 50% rated power and 125°C	0.05 max 0.01 max	%/first 100 hrs. %/1000 hrs.

TYPE DESIGNATION



*RESISTANCE TOLERANCE

SYMBOL	RESISTANCE TOLERANCE PERCENT
101	1
102	2
105	5
110	10
120	20

NOTE: Only 5 and 10 percent tolerance resistors are available as standard products and are listed in this data sheet. 1, 2 and 20 percent resistors are available on special order.

TABLE I – RESISTANCE VALUES

Nominal Resistance In Ohms	Part Number 5% Resistors	Part Number 10% Resistors	Geometry Figure	Pad Terminations (Note 1)
10	MMCR105-100	MMCR110-100	1	A-B
11	MMCR105-110		1	A-B
12	MMCR105-120	MMCR110-120	1	A-B
13	MMCR105-130		1	A-B
15	MMCR105-150	MMCR110-150	1	C-D
16	MMCR105-160		1	C-D
18	MMCR105-180	MMCR110-180	1	C-D
20	MMCR105-200		1	C-D
22	MMCR105-220	MMCR110-220	1	C-D
24	MMCR105-240		1	C-D
27	MMCR105-270	MMCR110-270	1	B-D
30	MMCR105-300		1	A-D
33	MMCR105-330	MMCR110-330	1	A-D
36	MMCR105-360		1	A-D
39	MMCR105-390	MMCR110-390	1	A-D
43	MMCR105-430		1	A-D
47	MMCR105-470	MMCR110-470	1	A-D
51	MMCR105-510		1	A-D
56	MMCR105-560	MMCR110-560	2	C-D
62	MMCR105-620		2	C-D
68	MMCR105-680	MMCR110-680	2	C-D
75	MMCR105-750		2	C-D
82	MMCR105-820	MMCR110-820	2	B-D
91	MMCR105-910		2	B-D
100	MMCR105-101	MMCR110-101	2	B-D
110	MMCR105-111		2	B-D
120	MMCR105-121	MMCR110-121	2	A-D
130	MMCR105-131		2	A-D
150	MMCR105-151	MMCR110-151	2	B-D
160	MMCR105-161		2	A-D
180	MMCR105-181	MMCR110-181	2	A-D
200	MMCR105-201		2	A-D
220	MMCR105-221	MMCR110-221	2	A-D
240	MMCR105-241		2	A-D
270	MMCR105-271	MMCR110-271	2	A-D
300	MMCR105-301		2	A-D
330	MMCR105-331	MMCR110-331	3	A-B
360	MMCR105-361		3	A-B
390	MMCR105-391	MMCR110-391	3	A-B
430	MMCR105-431		3	A-B
470	MMCR105-471	MMCR110-471	3	A-B
510	MMCR105-511		3	A-B
560	MMCR105-561	MMCR110-561	3	A-B
620	MMCR105-621		3	C-D
680	MMCR105-681	MMCR110-681	3	C-D
750	MMCR105-751		3	A-B
820	MMCR105-821	MMCR110-821	3	C-D
910	MMCR105-911		3	C-D
1000	MMCR105-102	MMCR110-102	3	C-D
1100	MMCR105-112		3	C-D
1200	MMCR105-122	MMCR110-122	3	C-D
1300	MMCR105-132		3	C-D
1500	MMCR105-152	MMCR110-152	3	C-D
1600	MMCR105-162		3	A-D
1800	MMCR105-182	MMCR110-182	3	A-D
2000	MMCR105-202		3	A-D
2200	MMCR105-222	MMCR110-222	3	A-D
2400	MMCR105-242		4	A-D
2700	MMCR105-272	MMCR110-272	3	A-D
3000	MMCR105-302		4	A-D
3300	MMCR105-332	MMCR110-332	4	A-C
3600	MMCR105-362		4	A-C
3900	MMCR105-392	MMCR110-392	4	A-C
4300	MMCR105-432		4	A-C
4700	MMCR105-472	MMCR110-472	4	A-C
5100	MMCR105-512		4	A-C
5600	MMCR105-562	MMCR110-562	4	A-C
6200	MMCR105-622		4	A-C
6800	MMCR105-682	MMCR110-682	4	A-C
7500	MMCR105-752		4	A-C
8200	MMCR105-822	MMCR110-822	4	A-C
9100	MMCR105-912		4	A-C

TABLE I – RESISTANCE VALUES (continued)

Nominal Resistance In Ohms	Part Number 5% Resistors	Part Number 10% Resistors	Geometry Figure	Pad Terminations (Note 1)
10,000	MMCR105-103	MMCR110-103	5	A-C
11,000	MMCR105-113		5	A-C
12,000	MMCR105-123	MMCR110-123	5	A-C
13,000	MMCR105-133		5	A-C
15,000	MMCR105-153	MMCR110-153	5	A-C
16,000	MMCR105-163		5	A-C
18,000	MMCR105-183	MMCR110-183	5	A-C
20,000	MMCR105-203		5	A-C
22,000	MMCR105-223	MMCR110-223	5	A-C
24,000	MMCR105-243		5	A-C
27,000	MMCR105-273	MMCR110-273	5	A-C
30,000	MMCR105-303		5	A-C
33,000	MMCR105-333	MMCR110-333	6	A-C
36,000	MMCR105-363		6	A-C
39,000	MMCR105-393	MMCR110-393	6	A-C
43,000	MMCR105-433		6	A-C
47,000	MMCR105-473	MMCR110-473	6	A-C
51,000	MMCR105-513		6	A-C
56,000	MMCR105-563	MMCR110-563	7	A-C
62,000	MMCR105-623		7	A-C
68,000	MMCR105-683	MMCR110-683	7	A-C
75,000	MMCR105-753		7	A-C
82,000	MMCR105-823	MMCR110-823	7	A-C
91,000	MMCR105-913		7	A-C
100,000	MMCR105-104	MMCR110-104	7	A-C

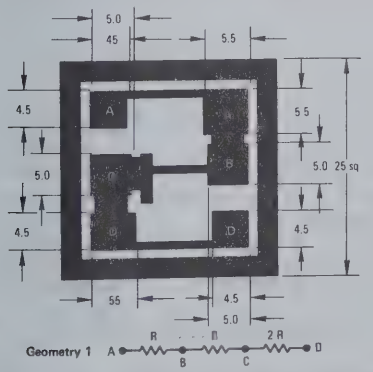
Note 1: The nominal resistance is measured between pad terminations as listed. Other resistances are available on the chip, with approximate values as shown in the schematic with the geometry, but these values are not tested or guaranteed.

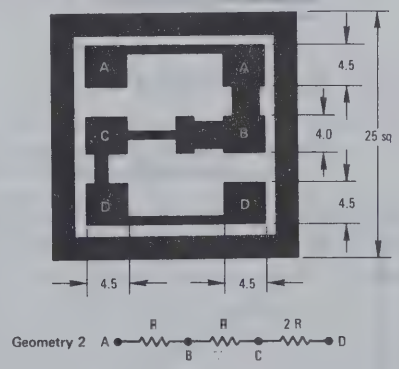
CONSTRUCTION DETAILS

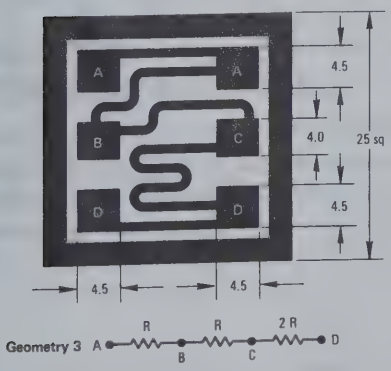
SUBSTRATE – N-TYPE SILICON – 3 to 8 MILS THICK CONTACT METALIZATION – ALUMINUM

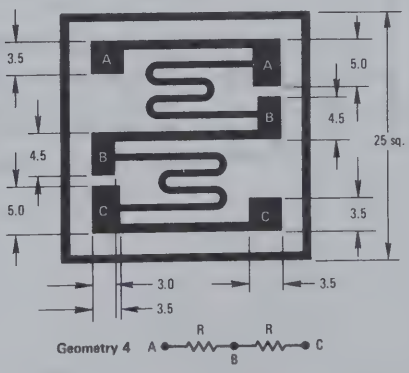
ISOLATION LAYER – 10,000 A SILICON DIOXIDE BACKING – GOLD-ALLOY

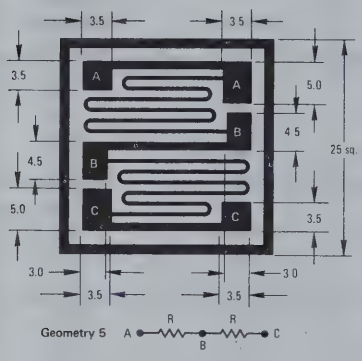
All Dimensions in mils RESISTOR ELEMENT – NICKEL-CHROMIUM ALLOY

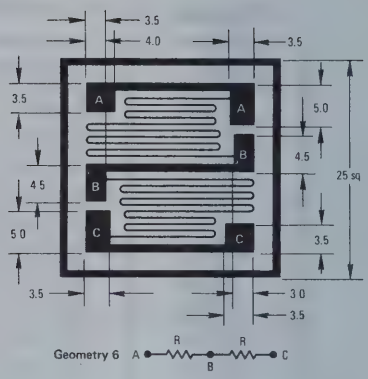


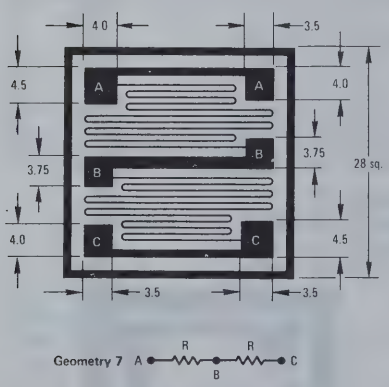












EQUIVALENT CIRCUIT OF THE THIN-FILM RESISTOR CHIP

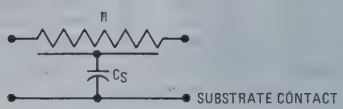
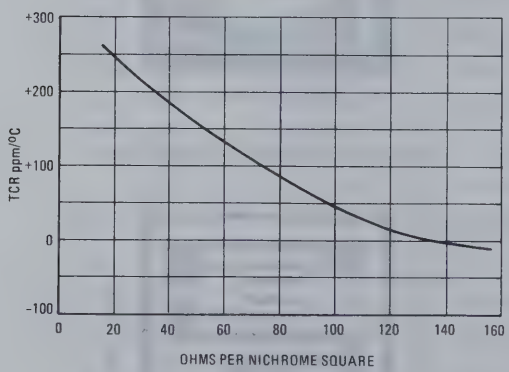


FIGURE 1 – NICHROME TEMPERATURE COEFFICIENT RESISTANCE



GEOMETRY	Number of Nichrome Squares
1	1
2	4
3	60
4	101
5	350
6	1132
7	1588

Advance Information

MICROWAVE RESISTORS

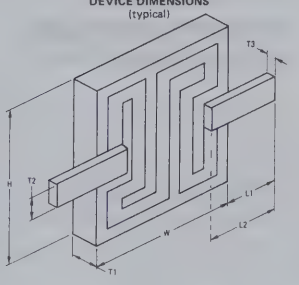
MCH5862 MCH5867 MCH5871 MCH5872 MCH5875 MCH5880 MCH5883

UNENCAPSULATED BEAM-LEAD RESISTORS

Beam-lead resistor chips designed for hybrid applications at frequencies up to and including microwave wavelengths.

- Small Die Size — 50 Mils Square typ
- Excellent Temperature Stability — 50 PPM typ
- Power Dissipation — 125 mW max
- Very Low Series Inductance

DEVICE DIMENSIONS
(typical)



(MCH5875-1500 ohms is shown)

Inches ±10 mils	H	L1	L2	W	T1	T2	T3
	0.050	0.010	0.020	0.050	0.00300	0.005	0.0003

TYPICAL ELECTRICAL CHARACTERISTICS (T_A = +25 C unless otherwise noted, ±10% tolerance)

Characteristics	Symbol	MCH5862	MCH5867	MCH5871	MCH5872	MCH5875	MCH5880	MCH5883	Unit
Nominal Resistance	R(nom)	5.0	50	250	500	1500	5000	10,000	Ohms
Temperature Coefficient	TC	50	50	50	50	50	50	50	PPM/°C

GENERAL INFORMATION and SPECIFICATIONS:

Fabrication and Material: Each device consists of a 400-Å-thick nichrome film deposit on a glass substrate.

Size and Weight: The die substrate size is 50 x 50 x 1.75 mils typ, beam dimensions are 5.0 x 20 x 0.3 mils typ. Approximate weight is 0.00013 gram each.

Handling: Restrict handling to a vacuum needle type operation.

Bonding: Restricted to lead-bonded accomplished by thermo-compression or ultrasonic techniques.

Packaging: Devices are packaged in 25-piece holders.

Minimum Order: Twenty-five units per type per single shipment.

THIN-FILM INDUCTORS

28 to 230 nH

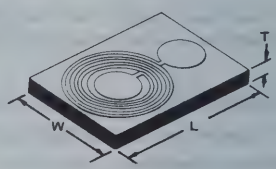
MCH5800 thru MCH5805

UNENCAPSULATED THIN-FILM CHIP INDUCTORS

. . . designed for use in UHF and microwave hybrid circuits for tuning and biasing applications.

- High Q
- Uniform Inductance
- High Self-Resonant Frequency
- Small Physical Size

DEVICE OUTLINE AND DIMENSIONS



Type No.	(Inches ±10 m) L	W	T
MCH5800	0.190	0.190	0.010
MCH5801	0.192	0.192	0.010
MCH5802	0.220	0.220	0.010
MCH5803	0.225	0.225	0.010
MCH5804	0.233	0.233	0.010
MCH5805	0.240	0.240	0.010

MAXIMUM RATINGS (T_A = +25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Operating Current	$I_{C(max)}$	250	mA
Peak Device Temperature (relative to mounting)	T_{pk}	300	°C

TYPICAL ELECTRICAL CHARACTERISTICS (T_A = +25°C unless otherwise noted)

Characteristic	Symbol	MCH5800	MCH5801	MCH5802	MCH5803	MCH5804	MCH5805	Unit
Inductance	L_S	28	35	115	150	195	230	nH
Figure of Merit	Q	19	21	27	25	29	30	–
Test Frequency	f	200	200	200	100	100	100	MHz
Self-Resonant Frequency	f_R	1800	1700	1030	920	810	740	MHz
Series Resistance	R_S	1.8	2.1	5.5	4.0	4.5	5.0	ohms
Stray Capacitance	C_S	0.27	0.25	0.21	0.20	0.20	0.20	pF

APPLICATIONS INFORMATION

1. Equivalent Circuit of Thin-Film Inductor:
   Figure 1 is an equivalent circuit of the thin-film inductor.
   C_S – Distributed capacitance
   R_S – Resistance of inductor (function of frequency)
   L_S – Actual inductance (low-frequency)
2. Equivalent Series Circuit of Thin-Film Inductor:
   The presence of distributed capacitance affects the actual series resistance and inductance of the coil resulting in the equivalent series circuit shown in Figure 2.
   The equivalent inductance and resistance is related to the actual inductance and resistance according to the equations below:

$$L_{equiv} = \frac{L_S}{1-K^2}; \text{ where } K = \frac{f}{f_R},$$

f is the frequency of interest, and f_R is the frequency at which the coil inductance is resonant with distributed capacitance (C_S).

$$R_{equiv} = \frac{R_S}{(1-K^2)2}$$

3. Self-Resonant Frequency:
   The self-resonant frequency of the thin-film inductor is:

$$f_R = \frac{1}{2\pi\sqrt{L_S C_S}}$$

C_S (pF) varies with the number of turns and is found to be $C_S = 0.15 + \frac{0.42}{N}$; where N is the number of turns.

4. Inductance as Function of Turns:
   A plot of inductance (actual) versus the number of turns is shown in Figure 3.
5. Spiral Inductor Figure of Merit, Q:
   The Q of a spiral inductor can be shown as:

$$Q = \frac{\omega L_{equiv}}{R_{equiv}}$$

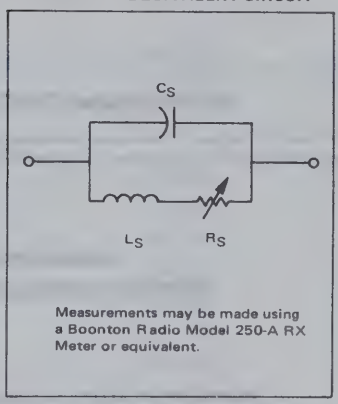
For design purposes at frequencies approximately $\frac{f_R}{8}$ or lower, C_S can be neglected, therefore Q can be written as $Q = \frac{\omega L_S}{R_S}$.

6. General Formulas Involving Q:
   (A) $R_P = R_{equiv}(1 + Q^2)$; where
   R_P = equivalent parallel resistance
   (B) $L_P = L_{equiv}\frac{1+Q^2}{Q^2}$; where L_P = equivalent parallel inductance
   (C) $Q = \frac{f_c}{f1 - f2}$; where f1 and f2 are half power points and f_c is center frequency
   (D) $Q = \frac{R_P}{\omega L_P}$

NOTE: These miniature thin-film inductors are fabricated on a 0.010" thick alumina substrate using copper as the primary material. Motorola uses a unique photo-resist processing technique which makes possible conductor thicknesses not previously achievable in this small geometry.

We recommend that the devices be mounted using a nonconductive organic adhesive such as epoxy. Wire bonds can be made using parallel gap welding, soldering, ultrasonic, or thermo-compression bonding techniques.

FIGURE 1 – EQUIVALENT CIRCUIT



Measurements may be made using a Boonton Radio Model 250-A RX Meter or equivalent.

FIGURE 2 – EQUIVALENT SERIES CIRCUIT

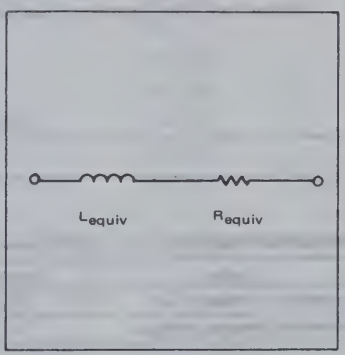
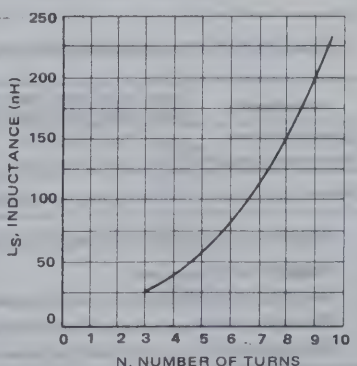


FIGURE 3 – TYPICAL ACTUAL INDUCTANCE per NUMBER of TURNS



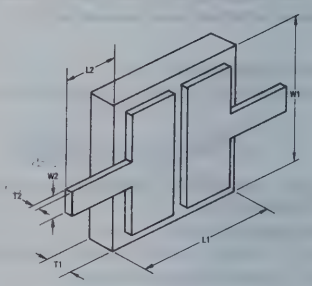
Advance Information

MICROWAVE CAPACITORS
1.8 to 57 pF

MCH5900 SERIES

UNENCAPSULATED THIN-FILM BEAM-LEAD CAPACITORS

. . . designed for use in UHF and microwave hybrid circuits as coupling or blocking capacitors. The gold beam-leads can be thermocompression bonded directly across small gaps in microcircuit lines. The beam-lead capacitors are of MOS construction with gold metalization and silicon-dioxide dielectric grown by a thermal diffusion process on a silicon substrate (possessing a low resistivity constant).



DIMENSIONS (mils typ ± 10%)

DEVICE	L_1	L_2	W_1	W_2	T_1	T_2
MCH5901	26	10	26	5	3	0.3
MCH5902	26	10	26	5	3	0.3
MCH5903	26	10	26	5	3	0.3
MCH5904	26	10	26	5	3	0.3
MCH5905	26	10	26	5	3	0.3
MCH5907	42	8	42	6	3	0.3
MCH5908	42	8	42	6	3	0.3
MCH5909	42	8	42	6	3	0.3
MCH5910	42	8	42	6	3	0.3
MCH5911	42	8	42	6	3	0.3
MCH5912	42	8	42	6	3	0.3
MCH5914	84	16	84	12	3	0.3
MCH5915	84	16	84	12	3	0.3
MCH5916	84	16	84	12	3	0.3
MCH5917	84	16	84	12	3	0.3
MCH5918	84	16	84	12	3	0.3
MCH5919	84	16	84	12	3	0.3

MAXIMUM RATINGS (T_A = +25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Breakdown Voltage	V_{bd}	100	Volts
Operating Temperature Range	T_A	-55 to +150	°C

TYPICAL ELECTRICAL CHARACTERISTICS (f = 1.0 MHz, T_A = +25°C unless otherwise noted)

Characteristics	MCH 5901	MCH 5902	MCH 5903	MCH 5904	MCH 5905	MCH 5907	MCH 5908	MCH 5909	MCH 5910	MCH 5911	MCH 5912	MCH 5914	MCH 5915	MCH 5916	MCH 5917	MCH 5918	MCH 5919	Unit
Capacitance (nom)*	1.8	2.5	3.2	4.0	4.8	6.6	8.0	9.6	11.2	13	15.6	23	27.5	33	40	48	57	pF
Temperature Coefficient**	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	PPM/°C

*Nominal Capacitance: MCH5901 ± 20%, other devices listed in the table have a tolerance of ± 10%. **Maximum

GENERAL INFORMATION and SPECIFICATIONS:

Weight: 0.00013 gram each.

Handling: Restrict handling to a vacuum needle type operation.

Packaging: Devices are packaged in twenty-five piece holders.

Minimum Order: Twenty-five units per type per single shipment.

INTEGRATED CIRCUITS

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DEVICE TYPE	FAMILY
MC301F,G MC302F,G MC303F,G MC304F,G MC305F,G MC306F,G MC307F,G MC308F,G MC309F,G MC310F,G	MECL
MC311F,G MC312AF,G MC312F,G MC313F MC314F,G MC315F,G MC316F,G MC317F,G MC318F,G MC351F,G	
MC352AF,G MC352F,G MC353F,G MC354F,G MC355F,G MC356F,G MC357F,G MC358AF,G MC359F,G MC360F,G	
MC361F,G MC362AF,G MC362F,G MC363F MC364F,G MC365F,G MC366F,G MC367F,G MC368F,G MC369F,G	
MC400F,L,P MC401F,L,P MC402F,L,P MC403F,L,P MC404F,L,P MC405F,L,P MC406F,L,P MC407F,L,P MC408F,L,P MC409F,L,P	MTTL I
MC410F,L,P MC411F,L,P MC412F,L,P MC413F,L,P MC414F,L,P MC415F,L,P MC416F,L,P MC417F,L,P MC418F,L,P MC419F,L,P	

DEVICE TYPE	FAMILY
MC420F,L,P MC421F,L,P MC422F,L,P MC423F,L,P MC424F,L,P MC425F,L,P MC426F,L,P MC427F,L,P MC428F,L,P MC450F,L,P,	MTTL I
MC451F,L,P MC452F,L,P MC453F,L,P MC454F,L,P MC455F,L,P MC456F,L,P MC457F,L,P MC458F,L,P MC459F,L,P MC460F,L,P	
MC461F,L,P MC462F,L,P MC463F,L,P MC464F,L,P MC465F,L,P MC466F,L,P MC467F,L,P MC468F,L,P MC469F,L,P MC470F,L,P	
MC471F,L,P MC472F,L,P MC473F,L,P MC474F,L,P MC475F,L,P MC476F,L,P MC477F,L,P MC478F,L,P MC500F,L MC501F,L	
MC502F,L MC503F,L MC504F,L MC505F,L MC506F,L MC507F,L MC508F,L MC509F,L MC510F,L MC511F,L	
MC512F,L MC513F,L MC514F,L MC515F,L MC516F,L MC517F,L MC518F,L MC519F,L MC520F,L MC521F,L	

INDEX (continued)

DEVICE TYPE	FAMILY
MC522F,L	MTTL I
MC523F,L	
MC524F,L	
MC525F,L	
MC526F,L	
MC527F,L	
MC528F,L	
MC550F,L	
MC551F,L	
MC552F,L	
MC553F,L	
MC554F,L	
MC555F,L	
MC556F,L	
MC557F,L	
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MC562F,L	
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MC565F,L	
MC566F,L	
MC567F,L	
MC568F,L	
MC569F,L	
MC570F,L	
MC571F,L	
MC572F,L	
MC573F,L	
MC574F,L	
MC575F,L	
MC576F,L	
MC577F,L	
MC578F,L	
MC660L,P	MHTL
MC661L,P	
MC662L,P	
MC663L,P	
MC664L,P	
MC665L,P	
MC666L,P	
MC667L,P	
MC668L,P	
MC669L,P	
MC670L,P	
MC671L,P	
MC672L,P	
MC673L,P	
MC674L,P	
MC675L,P	
MC677L,P	
MC678L,P	
MC679L,P	
MC700F	Commercial MRTL
MC700G	
MC701G	
MC702G	
MC703F	
MC703G	
MC704F	
MC704G	
MC705F	
MC705G	
MC706F	
MC706G	
MC707F	
MC707G	
MC708F	Commercial mW MRTL
MC708G	
MC709F	
MC709G	
MC710F	
MC710G	
MC711F	
MC711G	
MC712F	
MC712G	
MC713F	
MC713G	

DEVICE TYPE	FAMILY
MC714F	Commercial MRTL
MC714G	
MC715F	
MC715G	
MC715P	Plastic MRTL
MC717F	Commercial mW MRTL
MC717P	Plastic mW MRTL
MC718F	Commercial mW MRTL
MC718G	Commercial mW MRTL
MC718P	Plastic mW MRTL
MC719F	Commercial mW MRTL
MC719P	Plastic mW MRTL
MC720F	Commercial mW MRTL
MC720G	
MC721F	
MC721G	
MC722F	
MC722G	
MC722P	Plastic mW MRTL
MC723F	Commercial MRTL
MC723G	Commercial MRTL
MC723P	Plastic MRTL
MC724F	Commercial MRTL
MC724P	Plastic MRTL
MC725F	Commercial MRTL
MC725P	Plastic MRTL
MC726F	Commercial MRTL
MC726G	Commercial MRTL
MC726P	Plastic MRTL
MC727F	Commercial MRTL
MC727G	Commercial MRTL
MC728F	Commercial mW MRTL
MC728G	Commercial mW MRTL
MC729F	Commercial MRTL
MC729G	Commercial MRTL
MC764P	Plastic mW MRTL
MC767P	
MC770P	
MC771F	Commercial MRTL
MC771P	Plastic MRTL
MC774G	Commercial MRTL
MC775F	Commercial MRTL
MC775P	Plastic MRTL
MC776F	Commercial mW MRTL
MC776P	Plastic mW MRTL
MC777P	Plastic MRTL
MC778F	Commercial mW MRTL
MC778P	Plastic mW MRTL
MC779P	Plastic MRTL
MC780P	Plastic MRTL
MC781G	Commercial mW MRTL
MC782G	Commercial mW MRTL
MC783F	Commercial MRTL
MC783P	Plastic MRTL
MC784F	Commercial MRTL
MC784P	Plastic MRTL
MC785F	Commercial MRTL
MC785P	Plastic MRTL
MC786F	Commercial MRTL
MC786P	Plastic MRTL
MC787P	Plastic MRTL
MC788F	Commercial MRTL
MC788P	Plastic MRTL
MC789F	Commercial MRTL
MC789P	Plastic MRTL
MC790F	Commercial MRTL
MC790P	Plastic MRTL
MC791F	Commercial MRTL
MC791P	Plastic MRTL
MC792F	Commercial MRTL
MC792P	Plastic MRTL
MC793F	Commercial mW MRTL
MC793P	Plastic mW MRTL
MC794P	Plastic MRTL
MC796F	Commercial MRTL
MC796P	Plastic MRTL
MC797F	Commercial MRTL
MC797P	Plastic MRTL
MC798F	Commercial mW MRTL
MC798P	Plastic mW MRTL

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DEVICE TYPE	FAMILY
MC799F	Commercial MRTL
MC799G	Commercial MRTL
MC799P	Plastic MRTL
MC800F,G	MRTL
MC801G	↓
MC802G	
MC803F,G	
MC804F,G	
MC805F,G	
MC806F,G	
MC807F,G	↓
MC808F,G	mW MRTL
MC809F,G	↓
MC810F,G	
MC811F,G	
MC812F,G	
MC813F,G	
MC814F,G	MRTL
MC815F,G	MRTL
MC815P	Plastic MRTL
MC816F,G	MRTL
MC816P	Plastic MRTL
MC817F	mW MRTL
MC817P	Plastic mW MRTL
MC818F,G	mW MRTL
MC818P	Plastic mW MRTL
MC819F	mW MRTL
MC819P	Plastic mW MRTL
MC820F,G	mW MRTL
MC821F,G	↓
MC822F,G	Plastic mW MRTL
MC822P	MRTL
MC824F	Plastic MRTL
MC824P	MRTL
MC825F	Plastic MRTL
MC825P	MRTL
MC826F,G	Plastic MRTL
MC826P	MRTL
MC827F,G	mW MRTL
MC828F,G	
MC829F,G	MRTL
MC830F,G,L,P	MDTL
MC831F,G,L,P	↓
MC832F,G,L,P	
MC833F,G,L,P	
MC834F,L,P	
MC835F,L,P	MDTL
MC836F,L,P	↓
MC837F,L,P	
MC838F,L,P	
MC839F,L,P	
MC840F,L,P	
MC841F,L,P	
MC842F,L,P	
MC843G	
MC844F,G,L,P	
MC845F,G,L,P	
MC846F,G,L,P	
MC847F,L,P	
MC848F,G,L,P	
MC849F,G,L,P	
MC850F,G,L,P	
MC851F,G,L,P	
MC852F,L,P	
MC853F,L,P	
MC855F,L,P	
MC856F,L,P	
MC857F,L,P	
MC858F,L,P	
MC860F,L,P	
MC861F,G,L,P	↓
MC862F,G,L,P	
MC863F,G,L,P	
MC864P	Plastic mW MRTL
MC867P	↓
MC870P	
MC871F	MRTL
MC871P	Plastic MRTL
MC874G	MRTL
MC875F	MRTL

DEVICE TYPE	FAMILY
MC875P	Plastic MRTL
MC876F	mW MRTL
MC876P	Plastic mW MRTL
MC877P	Plastic MRTL
MC878F	mW MRTL
MC878P	Plastic mW MRTL
MC879P	Plastic MRTL
MC880P	Plastic MRTL
MC881G	mW MRTL
MC882G	mW MRTL
MC883F	MRTL
MC883P	Plastic MRTL
MC884F	MRTL
MC884P	Plastic MRTL
MC885F	MRTL
MC885P	Plastic MRTL
MC886F	MRTL
MC886P	Plastic MRTL
MC887P	Plastic MRTL
MC888F	MRTL
MC888P	Plastic MRTL
MC889F	MRTL
MC889P	Plastic MRTL
MC890F	MRTL
MC890P	Plastic MRTL
MC891F	MRTL
MC891P	Plastic MRTL
MC892F	MRTL
MC892P	Plastic MRTL
MC893F	mW MRTL
MC893P	Plastic mW MRTL
MC894P	Plastic MRTL
MC896F	MRTL
MC896P	Plastic MRTL
MC897F	MRTL
MC897P	Plastic MRTL
MC898F	mW MRTL
MC898P	Plastic mW MRTL
MC899F,G	MRTL
MC899P	Plastic MRTL
MC900F,G	MRTL
MC901G	↓
MC902G	
MC903F,G	
MC904F,G	
MC905F,G	
MC906F,G	
MC907F,G	
MC908F,G	mW MRTL
MC909F,G	↓
MC910F,G	
MC911F,G	
MC912F,G	
MC913F,G	
MC914F,G	MRTL
MC915F,G	↓
MC916F,G	
MC917F	mW MRTL
MC918F,G	↓
MC919F	
MC920F,G	↓
MC921F,G	
MC922F,G	
MC924F	MRTL
MC925F	↓
MC926F,G	
MC927F,G	
MC928F,G	mW MRTL
MC929F,G	MRTL
MC930F,G,L	MDTL
MC931F,G,L	↓
MC932F,G,L	
MC933F,G,L	
MC934F,L	
MC935F,L	
MC936F,L	
MC937F,L	
MC938F,L	
MC939F,L	
MC940F,L	↓

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DEVICE TYPE	FAMILY
MC941F,L MC942F,L MC943G MC944F,G,L MC945F,G,L MC946F,G,L MC947F,L MC948F,G,L MC949F,G,L MC950F,G,L	MDTL
MC951F,G,L MC952F,L MC953F,L MC955F,L MC956F,L MC957F,L MC958F,L MC960F,L MC961F,G,L MC962F,G,L	
MC963F,G,L MC971F MC974G MC975F MC976F MC978F MC981G MC982G MC983F MC984F	MRTL mW MRTL MRTL
MC985F MC986F MC988F MC989F MC990F MC991F MC992F MC993F MC996F MC997F	mW MRTL MRTL MRTL
MC998F MC999F,G MC1001P MC1002P MC1003P MC1004P MC1005P MC1006P MC1007P MC1008P	mW MRTL MRTL MECL II
MC1009P MC1010P MC1011P MC1012P MC1013P MC1014P MC1015P MC1016P MC1017P MC1018P	
MC1019P MC1020P MC1021P MC1022P MC1023F,P MC1024P MC1025P MC1026P MC1027F,P MC1028P	
MC1029P MC1030P MC1031P MC1032P MC1033P MC1034F,P MC1035P MC1036F,P MC1037F,P MC1038P	

DEVICE TYPE	FAMILY
MC1039P MC1040F,P MC1042P MC1043F,P MC1044P MC1046P MC1047P MC1048P MC1070F,P	MECL II
MC1141G MC1142G MC1150L MC1151L MC1160G MC1161G MC1170L MC1201F,L MC1202F,L	MOS MECL II
MC1203F,L MC1204F,L MC1205F,L MC1206F,L MC1207F,L MC1208F,L MC1209F,L MC1210F,L MC1211F,L MC1212F,L	
MC1213F,L MC1214F,L MC1215F,L MC1216F,L MC1217F,L MC1218F,L MC1219F,L MC1220F,L MC1221F,L MC1222F,L	
MC1224F,L MC1225F,L MC1226F,L MC1228L MC1229F,L MC1230F,L MC1231F,L MC1233F,L MC1235F,L MC1238F,L	
MC1239L MC1240L MC1247F,L MC1248F,L MC1270L MC1303L MC1304P,PQ MC1305P,PQ MC1306P MC1307P	Linear Consumer Product
MC1326P,PQ MC1328G,P,PQ MC1330P MC1335P MC1350P MC1351P,PQ MC1352P MC1355P,PQ MC1357P,PQ MC1410G	High-Frequency Circuit
MC1414L MC1430F,G,L MC1431F,G,L MC1433F,G,L MC1435F,G,L MC1436G MC1437L MC1438R MC1439G,L MC1440F,G,L	Sense Amplifier Operational Amplifier Special-Purpose Circuit Operational Amplifier Sense Amplifier

DEVICE TYPE	FAMILY
MC1441F,L MC1445F,G,L MC1446L MC1454G MC1456CG,G MC1463G,R MC1466L MC1469G,R MC1488L MC1489L	Sense Amplifier High-Frequency Circuit Sense Amplifier Low-Frequency Circuit Operational Amplifier Regulator ↓ Special-Purpose Circuit Special-Purpose Circuit
MC1495F,L MC1510G MC1514L MC1520F,G MC1530F,G MC1531F,G MC1533F,G,L MC1535F,G MC1536G MC1537L	Multiplier, Modulator, Det High-Frequency Circuit Sense Amplifier Operational Amplifier Operational Amplifier ↓
MC1538R MC1539G,L MC1540F,G,L MC1541F,L MC1543L MC1545F,G,L MC1546L MC1550F,G MC1552G MC1553G	Special-Purpose Circuit Operational Amplifier Sense Amplifier ↓ High-Frequency Circuit Sense Amplifier High-Frequency Circuit ↓
MC1554G MC1556G MC1563G,R MC1566L MC1569G,R MC1580L MC1581L MC1582L MC1583L MC1584L	Low-Frequency Circuit Operational Amplifier Regulator ↓ Special-Purpose Circuit ↓
MC1590G MC1595F,L MC1596G MC1660S,L MC1661S,L MC1662S,L MC1663S,L MC1664S,L MC1665S,L MC1666S,L	High-Frequency Circuit Multiplier, Modulator, Det Multiplier, Modulator, Det MECL III ↓
MC1667S,L MC1668S,L MC1669S,L MC1670S,L MC1671S,L MC1709F,G,L MC1709CF,G,L MC1710F,G,L MC1710CF,G,L MC1711F,G,L	↓ Operational Amplifier Operational Amplifier Sense Amplifier ↓
MC1711CF,G,L MC1712F,G,L MC1712CF,G,L MC1741F,G,L MC1741CF,G,L MC1800F,L,P MC1801F,L,P MC1802F,L,P MC1803F,L,P MC1804F,L,P	Operational Amplifier ↓ MDTL ↓
MC1805F,L,P MC1806F,L,P MC1807F,L,P MC1808F,L,P MC1809F,L,P MC1810F,L,P MC1811F,L,P MC1812F,L,P MC1813L,P MC1814F,L,P	↓

DEVICE TYPE	FAMILY
MC1815F,L,P MC1816F,L,P MC1818F,L,P MC1900F,L MC1901F,L MC1902F,L MC1903F,L MC1904F,L MC1905F,L MC1906F,L	MDTL ↓
MC1907F,L MC1908F,L MC1909F,L MC1910F,L MC1911F,L MC1912F,L MC1914F,L MC1915F,L MC1916F,L MC1918F,L	↓
MC2000F,L,P MC2001F,L,P MC2002F,L,P MC2003F,L,P MC2004F,L,P MC2005F,L,P MC2006F,L,P MC2007F,L,P MC2008F,L,P MC2009F,L,P	MTTL II ↓
MC2010F,L,P MC2011F,L,P MC2012F,L,P MC2013F,L,P MC2023F,L,P MC2024F,L,P MC2025F,L,P MC2026F,L,P MC2028F,L,P MC2050F,L,P	↓
MC2051F,L,P MC2052F,L,P MC2053F,L,P MC2054F,L,P MC2055F,L,P MC2056F,L,P MC2057F,L,P MC2058F,L,P MC2059F,L,P MC2060F,L,P	↓
MC2061F,L,P MC2062F,L,P MC2063F,L,P MC2065F,L,P MC2073F,L,P MC2074F,L,P MC2075F,L,P MC2076F,L,P MC2078F,L,P MC2100F,L	↓
MC2101F,L MC2102F,L MC2103F,L MC2104F,L MC2105F,L MC2106F,L MC2107F,L MC2109F,L MC2110F,L MC2111F,L	↓
MC2112F,L MC2113F,L MC2123F,L MC2124F,L MC2125F,L MC2126F,L MC2128F,L MC2150F,L MC2151F,L MC2152F,L	↓

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DEVICE TYPE	FAMILY
MC2153F,L MC2154F,L MC2155F,L MC2156F,L MC2157F,L MC2159F,L MC2160F,L MC2161F,L MC2162F,L MC2163F,L	MTTL II
MC2165F,L MC2173F,L MC2174F,L MC2175F,L MC2176F,L MC2178F,L MC2501L MC2502L MC2503L MC2597G	MOS
MC2598G MC3000F,L,P MC3001F,L,P MC3002F,L,P MC3003F,L,P MC3004F,L,P MC3005F,L,P MC3006F,L,P MC3007F,L,P MC3008F,L,P	MTTL III
MC3009F,L,P MC3010F,L,P MC3011F,L,P MC3012F,L,P MC3015F,L,P MC3016F,L,P MC3018F,L,P MC3019F,L,P MC3020F,L,P MC3021F,L,P	
MC3022F,L,P MC3023F,L,P MC3024F,L,P MC3025F,L,P MC3026F,L,P MC3028F,L,P MC3029F,L,P MC3030F,L,P MC3031F,L,P MC3032F,L,P	
MC3033F,L,P MC3034F,L,P MC3050F,L,P MC3051F,L,P MC3052F,L,P MC3053F,L,P MC3054F,L,P MC3055F,L,P MC3060F,L,P MC3061F,L,P	
MC3062F,L,P MC3100F,L MC3101F,L MC3102F,L MC3103F,L MC3104F,L MC3105F,L MC3106F,L MC3107F,L MC3108F,L	
MC3109F,L MC3110F,L MC3111F,L MC3112F,L MC3115F,L MC3116F,L MC3118F,L MC3119F,L MC3120F,L MC3121F,L	

DEVICE TYPE	FAMILY
MC3122F,L MC3123F,L MC3124F,L MC3125F,L MC3126F,L MC3128F,L MC3129F,L MC3130F,L MC3131F,L MC3132F,L	MTTL III
MC3133F,L MC3134F,L MC3150F,L MC3151F,L MC3152F,L MC3153F,L MC3154F,L MC3155F,L MC3160F,L MC3161F,L	
MC3162F,L MC4000F,L,P MC4001L,P MC4002F,L,P MC4004F,L,P MC4005F,L,P MC4006F,L,P MC4007L,P MC4008F,L,P MC4010F,L,P	MTTL Complex Functions
MC4012F,L,P MC4015L,P MC4023F,L,P MC4024F,L,P MC4026F,L,P MC4027F,L,P MC4028F,L,P MC4029F,L,P MC4030F,L,P MC4031F,L,P	
MC4032F,L,P MC4038P MC4039P MC4040P MC4041P MC4042F,L,P MC4043F,L,P MC4044F,L,P MC4304F,L MC4305F,L	
MC4324F,L MC4326F,L MC4327F,L MC4328F,L MC4329F,L MC4330F,L MC4331F,L MC4332F,L MC4344F,L MC5400F	MTTL
MC5400L MC5401F MC5401L MC5402F MC5402L MC5403L MC5404F MC5404L MC5405L	
MC5410F MC5410L MC5420F MC5420L MC5430F MC5430L MC5440F MC5440L MC5442L MC5443L MC5444L	

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DEVICE TYPE	FAMILY
MC5446L MC5447L MC5450F MC5450L MC5451F MC5451L MC5453F MC5453L MC5454F MC5454L	MTTL
MC5460F MC5460L MC5472F MC5472L MC5473F MC5473L MC5479F MC5479L MC5480L MC5483L	
MC5490F,L MC5491AL MC5492F,L MC5493L MC5495F,L MC7400F MC7400L,P MC7401F MC7401L,P MC7402F	
MC7402L,P MC7403L,P MC7404F MC7404L,P MC7405L,P MC7410F MC7410L,P MC7420F MC7420L,P MC7430F	
MC7430L,P MC7440F MC7440L,P MC7441AL,P MC7442L,P MC7443L,P MC7444L,P MC7446L,P MC7447L,P MC7450F	
MC7450L,P MC7451F MC7451L,P MC7453F MC7453L,P MC7454F MC7454L,P MC7460F MC7460L,P MC7472F	
MC7472L,P MC7473F MC7473L,P MC7475P MC7476P MC7479F MC7479L,P MC7480L,P MC7483L,P MC7490F,L,P	
MC7491AL,P MC7492F,L,P MC7493L,P MC7495F,L,P MC8300L,P MC8301L,P MC8304L,P MC8309L,P MC8312L,P MC8601F,L,P MC9300L	MTTL Complex Functions

DEVICE TYPE	FAMILY
MC9301L MC9304L MC9309L MC9312L MC9601F,L MC9701P MC9704P MC9707P MC9709P MC9713P	MTTL Complex Functions Plastic MRTL
MC9714P MC9715P MC9718P MC9719F MC9719P MC9720P MC9721F MC9721P MC9722P MC9760P	Plastic mW MRTL Commercial MRTL Plastic MRTL Plastic mW MRTL Commercial mW MRTL Plastic mW MRTL Plastic mW MRTL Plastic MRTL
MC9801P MC9804P MC9807P MC9809P MC9813P MC9814P MC9815P MC9818P MC9819F MC9819P	Plastic mW MRTL MRTL Plastic MRTL
MC9820P MC9821F MC9821P MC9822P MC9860P MC9919F MC9921F MC15482F,L MC17482F,L,P MC25482F,L	Plastic mW MRTL mW MRTL Plastic mW MRTL Plastic mW MRTL Plastic MRTL MRTL mW MRTL MTTL
MC27482F,L,P MC54107L MC74107L,P MCE930F MCE932F MCE933F MCE936F MCE944F MC4945F MCE946F	MDTL
MCE948F MCE962F MCH1002P MCH2005F MCH2870CR,MR MCH5890 MFC4000 MFC4010 MFC4040 MFC4050	Special-Purpose Circuit Operational Amplifier Microwave Device Linear Consumer Product Linear Consumer Product Digital Consumer Product Linear Consumer Product
MFC4060 MFC6000 MFC6010 MFC6020 MFC6030 MFC6040 MFC8000P MFC8001P MFC8002P MFC8010	Digital Consumer Product Linear Consumer Product
MFC8020 MFC8030 MFC8040 MFC9000 MFC9010 XC157 XC170 XC171 XC177	Multi-Gate Array Memory Memory Multi-Gate Array

DIGITAL INTEGRATED CIRCUITS

Motorola offers a wide selection of digital integrated circuits from a variety of logic families, including MECL, MHTL, MTTL, MDTL, MRTL, and MOS, plus complex functions for custom applications. Devices are available in a broad selection of packages. Refer to the last page of the Digital device listing for package information.

MECL

MC300 Series (-55 to +125°C)
MC350 Series (0 to +75°C)

MECL non-saturating integrated logic circuits offer high fan-in and fan-out capabilities with propagation delay typically 8.0 ns per logic decision. Current drain is constant regardless of logic state or operating frequency, thereby minimizing noise generation. Because of common mode rejection of power supply variations, system designs will operate with power supply variations of ±20%. MECL circuits in this series are compatible with the higher-speed MECL II circuits.

FUNCTIONS AND CHARACTERISTICS (V_{CC} = 0, V_{EE} = -5.2 V, T_A = 25°C)

Function	Type ①		DC Output Loading Factor Each Output	Propagation Delay t_{pd} ns typ	Total Power Dissipation mW typ/pkg	Case
	-55 to +125°C	0 to +75°C				
5-Input OR/NOR Gate	MC301	MC351	25	7.5	37	602B,606
R-S Flip-Flop	MC302	MC352A	25	11	42	602B,606
R-S Flip-Flop w/o Buffered Outputs	—	MC352	25	11	40	602B,606
Half-Adder	MC303	MC353	25	7.5	63	602B,606
Bias Driver	MC304	MC354	25	—	18	602B,606
5-Input Gate Expander	MC305	MC355	—	4.5	—	602B,606
3-Input OR/NOR Gate	MC306	MC356	25	7.5	37	602B,606
3-Input OR/NOR Gate	MC307	MC357	25	7.5	15	602B,606
AC-Coupled J-K Flip-Flop	MC308	MC358A	25	8.5	87	602B,606
Dual 2-Input NOR Gate	MC309	MC359	25	7.0	54	602B,606
Dual 2-Input NOR Gate	MC310	MC360	25	7.0	54	602B,606
Dual 2-Input NOR Gate	MC311	MC361	25	7.0	41	602B,606
Dual 3-Input NOR Gate (With Internal Bias)	MC312A	MC362A	25	7.5	70	602B,606
Dual 3-Input NOR Gate	MC312	MC362	25	7.5	54	604,607
Quad 2-Input NOR Gate	MC313F	MC363F	25	7.0	125	607
AC-Coupled J-K Flip-Flop	MC314	MC364	25	12	118	602B, 606
Line Driver	MC315	MC365	—	14	180②– 270③	602B, 606
Lamp Driver	MC316	MC366	—	—	135	602B, 606
Level Translator — MECL to Saturated Logic	MC317	MC367	7 (DTL)	27.5	63	602B, 606
Level Translator — Saturated Logic to MECL	MC318	MC368	25 (MECL)	17	105	602B, 606
Dual 4-Input Clock Driver/High-Speed Gate	—	MC369F	100	3.0	250	607
Dual 2-Input Clock Driver/High-Speed Gate	—	MC369G	100	3.0	250	602B

① G suffix denotes Metal Can. F suffix denotes Flat Package. (i.e., MC301G = Metal Can, MC301F = Flat Package.)
② With 93-ohm load for MC315 (each side)
③ With 50-ohm load for MC365 (each side)

MECL II

MC1000 Series (0 to +75°C)
MC1200 Series (−55 to +125°C)

MECL II high-speed non-saturating integrated logic circuits provide propagation delay times typically 4.0 ns per logic decision. Noise immunity of 175 mV is specified over the temperature range. Current drain is constant regardless of logic state or operating frequency, thereby minimizing noise generation. Because of common-mode rejection of power supply variations, system designs will operate with power supply variations of ±20%.

FUNCTIONS AND CHARACTERISTICS (V_{CC} = 0, V_{EE} = −5.2 V, T_A = 25°C

Function	Type		DC Output Loading Factor Each Output	Propagation Delay t_{pd} ns typ	Total Power Dissipation mW typ	Case ①
	−55 to +125°C	0 to +75°C				
Single 6-Input Gate, 3 OR Outputs w/Pulldowns 3 NOR Outputs w/Pulldowns	MC1201F,L	MC1001P	25	4.0	115	605, 607, 632
Single 6-Input Gate, 3 OR Outputs w/Pulldowns 3 NOR Outputs w/o Pulldowns	MC1202F,L	MC1002P			80	
Single 6-Input Gate, 3 OR Outputs w/o Pulldowns 3 NOR Outputs w/o Pulldowns	MC1203F,L	MC1003P			40	
Dual 4-Input Gate, 2 OR Outputs w/Pulldowns 2 NOR Outputs w/Pulldowns	MC1204F,L	MC1004P			95	
Dual 4-Input Gate, 2 OR Outputs w/Pulldowns 2 NOR Outputs w/o Pulldowns	MC1205F,L	MC1005P			65	
Dual 4-Input Gate, 2 OR Outputs w/o Pulldowns 2 NOR Outputs w/o Pulldowns	MC1206F,L	MC1006P			45	
Triple 3-Input Gate, 3 NOR Outputs w/Pulldowns	MC1207F,L	MC1007P	25	4.0	110	
Triple 3-Input Gate, 1 NOR Outputs w/Pulldowns 2 NOR Outputs w/o Pulldowns	MC1208F,L	MC1008P			75	
Triple 3-Input Gate, 3 NOR Outputs w/o Pulldowns	MC1209F,L	MC1009P			60	
Quad 2-Input Gate, 4 NOR Outputs w/Pulldowns	MC1210F,L	MC1010P		4.5	115	
Quad 2-Input Gate, 2 NOR Outputs w/Pulldowns 2 NOR Outputs w/o Pulldowns	MC1211F,L	MC1011P			95	
Quad 2-Input Gate, 4 NOR Outputs w/o Pulldowns	MC1212F,L	MC1012P			65	
85 MHz AC Coupled J-K Flip-Flop	MC1213F,L	MC1013P		6.0	125	
Dual R-S Flip-Flop (Positive Clock)	MC1214F,L	MC1014P			140	
Dual R-S Flip-Flop (Negative Clock)	MC1215F,L	MC1015P				
Dual R-S Flip-Flop (Single Rail)	MC1216F,L	MC1016P				
Level Translator (Saturated Logic to MECL)	MC1217F,L	MC1017P	25 (MECL)	15	105	
Level Translator (MECL to Saturated Logic)	MC1218F,L	MC1018P	7 (DTL)	19	55	
Full Adder	MC1219F,L	MC1019P	25	3.0 or 8.0*	145	
Quad Line Receiver	MC1220F,L	MC1020P		4.0	115	
Full Subtractor	MC1221F,L	MC1021P		4.0 or 11*	145	
Type D Flip-Flop	MC1222F,L	MC1022P		8.0	110	
Dual 4-Input OR/NOR Clock Driver	–	MC1023F,P		2.0	250	
Dual 2-Input Expandable Gate	MC1224F,L	MC1024P		4.0	95	
Dual 4 and 5-Input Expander	MC1225F,L	MC1025P	–	–	–	
Dual 3-4-Input Transmission Line and Clock Driver	MC1226F,L	MC1026P	25	2.0	140	
120-MHz AC Coupled J-K Flip-Flop	–	MC1027F,P		4.0	250	
Dual 4-Channel Data Selector	MC1228L	MC1028P		5.0	170	612,620
Data Distributor	MC1229F,L	MC1029P		4.0	160	605, 607, 632
Quad Exclusive OR Gate	MC1230F,L	MC1030P		5.0	130	605, 607, 632

① Type numbers with F suffix use Case 607, Type numbers with L suffix use Case 632 or 620 as indicated.
Type numbers with P suffix use Case 605 or 612 as indicated.
*Propagation delay time is dependent on data path, see data sheet for details.

MECL II (continued)

Function	Type -55 to +125°C	Type 0 to +75°C	DC Output Loading Factor Each Output	Propagation Delay t_{pd} ns typ	Total Power Dissipation mW typ	Case ①
Quad Exclusive NOR Gate	MC1231F,L	MC1031P	25	5.0	130	605, 607, 632
100-MHz AC Coupled Dual J-K Flip-Flop	–	MC1032P		4.5	180	612
Dual R-S Flip-Flop (Single Rail, Negative Clock)	MC1233F,L	MC1033P		6.0	140	605, 607, 632
Type D Flip-Flop	–	MC1034F,P		4.0	185	
Dual Schmitt Trigger/Triple Differential Amplifier	MC1235F,L	MC1035P		5.0	140	
16-Bit Coincident Memory	–	MC1036F,P	5	17	250	
16-Bit Coincident Memory w/o Pulldowns	–	MC1037F,P	5	17	250	
8-Channel Data Selector	MC1238F,L	MC1038P	25	7.0 or 18*	150	
Quad Level Translator (MECL to Saturated Logic)	MC1239L	MC1039P	7 (DTL)	12	200	612,620
Quad Latch	MC1240L	MC1040F,P	25	8.0	250	605, 607, 632
Dual Binary to One-Of-Four Decoder	–	MC1042P		6.5	245	612
3-Bit Binary to One-Of-Eight Line Decoder	–	MC1043F,P		6.0 or 11*	210	605, 607, 632
Binary to One-Of-Ten Line Decoder	–	MC1044P		6.0	245	612
8-Bit Parity Checker and Generator	–	MC1046P		13 or 14*	205	605, 607, 632
Quad 2-Input AND Gates	MC1247F,L	MC1047P		5.0	130	
Quad 2-Input NAND Gates	MC1248F,L	MC1048P		5.0	130	
Quad Latch	MC1270L	MC1070F,P		8.0	200	

① Type numbers with F suffix use Case 607, Type numbers with L suffix use Case 632 or 620 as indicated.
Type numbers with P suffix use Case 605 or 612 as indicated.

*Propagation delay time is dependent on data path, see data sheet for details.

MECL III

MC1600 Series (0 to +75°C)

The MECL III family of non-saturating integrated logic circuits is designed for very high speed digital system operation. Gate circuits are capable of subnanosecond speeds with local loading and of driving terminated lines with 1.5-ns rise times and 1.1-ns propagation delays. Flip-flop toggle frequencies are greater than 300 MHz. MECL III circuit design is similar to that employed in the MECL II family, however more advanced processing techniques are used and unused inputs may be left open.

FUNCTIONS AND CHARACTERISTICS (V_{CC} = 0, V_{EE} = -5.2 V, T_A = 25°C)

Function	Type Case 617 ① 0 to +75°C	DC Output Loading Factor* Each Output High Z	DC Output Loading Factor* Each Output Low Z	Propagation Delay 50-ohm Load t_{pd}, ns typ	Total Power Dissipation P_D, mW typ
Dual 4-Input OR/NOR Gate (High Z)	MC1660S	70	7	1.1	120
Dual 4-Input OR/NOR Gate (Low Z)	MC1661S	70	7	1.1	120
Quad 2-Input NOR Gate (High Z)	MC1662S	70	7	1.1	240
Quad 2-Input NOR Gate (Low Z)	MC1663S	70	7	1.1	240
Quad 2-Input OR Gate (High Z)	MC1664S	70	7	1.1	240
Quad 2-Input OR Gate (Low Z)	MC1665S	70	7	1.1	240
Dual Clocked R-S Flip-Flop (High Z)	MC1666S	70	7	1.8	220
Dual Clocked R-S Flip-Flop (Low Z)	MC1667S	70	7	1.8	250
Dual Clocked Latch (High Z)	MC1668S	70	7	1.8	220
Dual Clocked Latch (Low Z)	MC1669S	70	7	1.8	250
Master-Slave Type D Flip-Flop (High Z)	MC1670S	70	7	1.8	210
Master-Slave Type D Flip-Flop (Low Z)	MC1671S	70	7	1.8	220

① All devices are also available in the 16-lead dual in-line ceramic package (Case 620). Add L suffix to type number.

*DC Loading factors are based on: 1. Full load output current, I_L = -25 mAdc max 2. Maximum input current, I_{in} = 350 μAdc (High Z) 3.1 mAdc (Low Z)

MHTL

MC660 Series (−30 to +75°C)

MHTL integrated circuits are designed to meet the requirements of industrial applications. Noise immunity is 5.0 V minimum, providing error-free operation in high noise environments far beyond the tolerance of other integrated circuit families.

FUNCTIONS AND CHARACTERISTICS (V_{CC} = 15 V ± 1.0 Vdc, T_A = 25°C)

Function	Type ① −30 to +75°C	Cases	Output Loading Factor Each Output	Propagation Delay t_{pd} ns typ	Power Dissipation P_D mW typ/pkg
Expandable Dual 4-Input Gate (active pullup)	MC660	605,632	10	110	88/26 ②
Expandable Dual 4-Input Gate (passive pullup)	MC661	605,632	10	125	88/26 ②
Expandable Dual 4-Input Line Driver	MC662	605,632	30	140	180/26 ②
Dual J-K Flip-Flop	MC663	605,632	9	3.0 MHz ③	200
Master-Slave R-S Flip-Flop	MC664	605,632	8	3.0 MHz ③	160
Triple Level Translator	MC665	605,632	MDTL = 8 MTTL III = 5.5 MRTL = 5	40	83 (MDTL) 104 (MRTL)
Triple Level Translator	MC666	605,632	10	75	105
Dual Monostable Multivibrator	MC667	605,632	10	140	240
Quad 2-Input Gate (passive pullup)	MC668	605,632	10	125	176/52 ②
Dual 4-Input Expander	MC669	605,632	—	—	—
Triple 3-Input Gate (passive pullup)	MC670	605,632	10	125	132/39 ②
Triple 3-Input Gate (active pullup)	MC671	605,632	10	110	132/39 ②
Quad 2-Input Gate (active pullup)	MC672	605,632	10	110	176/52 ②
Dual 2-Input AND-OR-INVERT Gate	MC673	605,632	10	110	160/50 ②
Dual 2-Input AND-OR-INVERT Gate	MC674	605,632	10	125	160/50 ②
Dual Pulse Stretcher	MC675	605,632	10	150 (pins 1,6) 110 (pins 5,6)	180
Hex Inverter With Strobe (active pullup)	MC677	612,620	10	110	246/96 ②
Hex Inverter With Strobe (without output resistors)	MC678	612,620	10	125	192/96 ②
Dual Lamp Driver	MC679	605,632	125	0.5 μs typ	250/30 ②

① L suffix denotes Dual In-Line Ceramic Package, P denotes Dual In-Line Plastic Package (i.e., MC660L = Dual In-Line Ceramic, MC660P = Dual In-In Line Plastic Package).

② Inputs High/Input Low ③ f_{Tog}

MTTL

MC5400 Series (−55 to +125°C)

MC7400 Series (0 to +70°C)

MC5400/MC7400 series MTTL integrated circuits are designed for general purpose digital applications. The family has a medium operating speed (15-30 MHz clock rate), good external noise immunity, high fan-out, and the capability of driving capacitive loads of up to 600 pF.

FUNCTIONS AND CHARACTERISTICS (V_{CC} = 5.0 V, T_A = 25°C)

Function	Type ①				Output Loading Factor Each Output	Propagation Delay t_{pd} ns typ	Power Dissipation mW typ/pkg
	−55 to +125°C	Case	0 to +70°C	Case			
Quad 2-Input NAND Gate	MC5400F,L	609, 632	MC7400F,L,P	609,632,605	10	10	40
Quad 2-Input NAND Gate (Open Collector Output)	MC5401F,L	609, 632	MC7401F,L,P	609,632,605	10	35	40
Quad 2-Input NOR Gate	MC5402F,L	609, 632	MC7402F,L,P	609,632,605	10	10	48
Quad 2-Input "NAND" GATE (With Open Collector)	MC5403L	632	MC7403L,P	632,605	10	35	40

① F suffix denotes Flat Package. L suffix denotes Dual In-Line Ceramic Package. P suffix denotes Dual In-Line Plastic Package.

MTTL (continued)

Function	Type ①				Output Loading Factor Each Output	Propagation Delay t_{pd} ns typ	Power Dissipation mW typ/pkg
	-55 to +125°C	Case	0 to +70°C	Case			
Hex Inverter	MC5404F,L	609, 632	MC7404F,L,P	609,632,605	10	13	60
Hex Inverter	MC5405L	632	MC7405L,P	632, 605	10	35	60
Triple 3-Input NAND Gate	MC5410F,L	609, 632	MC7410F,L,P	609,632,605	10	10	30
Dual 4-Input NAND Gate	MC5420F,L	609, 632	MC7420F,L,P	609,632,605	10	10	20
8-Input NAND Gate	MC5430F,L	609, 632	MC7430F,L,P	609,632,605	10	10	10
Dual 4-Input NAND Buffer	MC5440F,L	609, 632	MC7440F,L,P	609,632,605	30	13	50
BCD-to-Decimal Decoder and High-Level Driver	–	–	MC7441AL,P	620, 612	–	–	105
BCD-to-Decimal Decoder	MC5442L	620	MC7442L,P	620, 612	10	22/23#	140
Excess Three-to-Decimal Decoder	MC5443L	620	MC7443L,P	620, 612	10	22/23#	140
Excess Three Gray-to-Decimal Decoder	MC5444L	620	MC7444L,P	620, 612	10	22/23#	140
BCD-to-Seven Segment Decoder/Driver	MC5446L	620	MC7446L,P	620, 612	BI/RBO 5	–	265
BCD-to-Seven Segment Decoder/Driver	MC5447L	620	MC7447L,P	620, 612	BI/RBO 5	–	265
Expandable Dual 2-Wide 2-Input AND-OR-INVERT Gate	MC5450F,L	609, 632	MC7450F,L,P	609,632,605	10	13	28
Dual 2-Wide 2-Input AND-OR-INVERT Gate	MC5451F,L	609, 632	MC7451F,L,P	609,632,605	10	13	28
Expandable 4-Wide 2-Input AND-OR-INVERT Gate	MC5453F,L	609, 632	MC7453F,L,P	609,632,605	10	13	22
4-Wide 2-Input AND-OR-INVERT Gate	MC5454F,L	609, 632	MC7454F,L,P	609,632,605	10	13	22
Dual 4-Input Expander for AND-OR-INVERT Gates	MC5460F,L	609, 632	MC7460F,L,P	609,632,605	–	5.0	8.0
J-K Flip-Flop	MC5472F,L	609, 632	MC7472F,L,P	609,632,605	10	30	40
Dual J-K Flip-Flop	MC5473F,L	609, 632	MC7473F,L,P	609,632,605	10	30	80
Quad Latch	–	–	MC7475P	612	10	30	160
Dual J-K Flip-Flop	–	–	MC7476P	612	10	30	80
Dual Type D Flip-Flop	MC5479F,L	609, 632	MC7479F,L,P	609,632,605	10	16	84
Gated Full Adder	MC5480L	632	MC7480L,P	632, 605	S, $\overline{S}$ = 10 C_{n+1} = 5 A*, B*, = 3	10/55*	105
4-Bit Binary Full Adder	MC5483L	620	MC7483L,P	620, 612	S = 10 C4 = 5	35	390
Decade Counter	MC5490F,L	607, 632	MC7490F,L,P	607,632,605	10	20/bit	160
8-Bit Shift Register	MC5491AL	632	MC7491AL,P	632, 605	10	25	175
Divide-by-Twelve Counter	MC5492F,L	607, 632	MC7492F,L,P	607,632,605	10	60	160
4-Bit Binary Counter	MC5493L	632	MC7493L	632	10	20/bit	160
4-Bit Shift Register	MC5495F,L	607, 632	MC7495F,L,P	607,632,605	10	25	250
2-Bit Full Adder	MC15482F,L	609, 632	MC17482F,L,P	609,632,605	10	15/12*	165
2-Bit Full Adder	MC25482F,L	609, 632	MC27482F,L,P	609,632,605	10	25/12*	165
Dual J-K Flip-Flop	MC54107L	632	MC74107L,P	632, 605	10	30	80

① F suffix denotes Flat Package. L suffix denotes Dual In-Line Ceramic Package. P suffix denotes Dual In-Line Plastic Package.
*Add delay/Carry delay. # 2 Logic Levels/3 Logic Levels.

MTTL I

MC400 Series (0 to +75°C)
MC500 Series (−55 to +125°C)

MTTL I high fan-out, high noise immunity, saturating logic circuits are designed for general purpose digital applications. Gate propagation delay time is typically 10 ns. Flip-flop clock frequency is 20 MHz maximum.

MTTL I — FUNCTIONS AND CHARACTERISTICS (V_{CC} = 5.0 V, T_A = 25°C)

Function	Type ① Case 609, 605, 632 0 to +75°C	Type ① Case 609, 632 -55 to +125°C	Output Loading Factor Each Output MC400 Series	Output Loading Factor Each Output MC500 Series	Propagation Delay t_{pd} ns typ	Power Dissipation mW typ/pkg
Dual 4-Input NAND Gate	MC400 MC450	MC500 MC550	12 6	15 7	10	30
Expandable 4-Wide 2-2-2-3-Input AND-OR-INVERT Gate	MC401 MC451	MC501 MC551	12 6	15 7	12	30
8-Input NAND Gate	MC402 MC452	MC502 MC552	12 6	15 7	12	15
2-Wide 3-Input AND-OR-INVERT Gate with Gated Complement	MC403 MC453	MC503 MC553	12 6	15 7	11	35
Expandable 3-Wide 3-Input AND-OR-INVERT Gate	MC404 MC454	MC504 MC554	12 6	15 7	12	25
Expandable 2-Wide 4-Input AND-OR-INVERT Gate	MC405 MC455	MC505 MC555	12 6	15 7	12	20
Expandable 8-Input NAND Gate	MC406 MC456	MC506 MC556	12 6	15 7	18	15
Line Driver	MC407 MC457	MC507 MC557	12 6	15 7	25 @ 1000 pF Load	60
Quad 2-Input NAND Gate	MC408 MC458	MC508 MC558	12 6	15 7	10	60
4-Wide 3-2-2-3 Input Expander for AND-OR-INVERT Gates	MC409 MC459	MC509 MC559	12 6	15 7	–	–
Dual 4-Input Expander for AND-OR-INVERT Gates	MC410 MC460	MC510 MC560	12 6	15 7	–	–
Dual 4-Input Expander for NAND Gates	MC411 MC461	MC511 MC561	12 6	15 7	–	–
Triple 3-Input NAND Gate	MC412 MC462	MC512 MC562	12 6	15 7	10	45
R-S Flip-Flop	MC413 MC463	MC513 MC563	12 6	15 7	20/15*	30
Gated R-S Flip-Flop	MC414 MC464	MC514 MC564	12 6	15 7	20/7.5*	30
AND J-K Flip-Flop	MC415 MC465	MC515 MC565	12 6	15 7	13/25*	40
OR J-K Flip-Flop	MC416 MC466	MC516 MC566	12 6	15 7	13/25*	50
AND Input J-K Flip-Flop	MC417 MC467	MC517 MC567	12 6	15 7	20	95
Type D Flip-Flop	MC418 MC468	MC518 MC568	12 6	15 7	20	95
Triple 2-Input Buss Driver	MC419 MC469	MC519 MC569	– –	– –	50/15*	54
Expandable Dual 2-Wide 2-Input AND-OR-INVERT Gate	MC420 MC470	MC520 MC570	12 6	15 7	12	40
AC Coupled R-S Flip-Flop	MC421 MC471	MC521 MC571	12 6	15 7	18	30
Dual Type D Flip-Flop	MC422 MC472	MC522 MC572	12 6	15 7	16	84
Dual J-K Flip-Flop (separate clock)	MC423 MC473	MC523 MC573	13 7	16 8	10/12*	110
Dual J-K Flip-Flop (common clock)	MC424 MC474	MC524 MC574	13 7	16 8	10/12*	110
Hex Inverter	MC425 MC475	MC525 MC575	12 6	15 7	10	90
Dual 3-Input Pulse Shaper/Delay AND Gate	MC426 MC476	MC526 MC576	13 7	16 8	15	60
OR Expandable Dual 4-Input AND Gate	MC427 MC477	MC527 MC577	12 6	15 7	10	38
Dual 2-Wide 2-3 Input OR Expander	MC428 MC478	MC528 MC578	– –	– –	–	15

① F suffix denotes Flat Package, L suffix denotes dual in-line Ceramic Package, P suffix denotes dual in-line Plastic Package, (i.e., MC401F = Flat Package, MC401L = Ceramic Package, MC401P - Plastic Package.)

*t_{pd+}/t_{pd-}

MTTL II

MC2000 Series (0 to +75°C)
MC2100 Series (−55 to +125°C)

MTTL II high fan-out, high noise immunity, saturating logic circuits are designed for high-speed general purpose digital applications. Gate propagation delay time is typically 6.0 ns. Flip-flop clock frequency is 30 MHz maximum.

FUNCTIONS AND CHARACTERISTICS (V_{CC} = 5.0 V, T_A = 25°C)

Function	Type ① Case 605, 609, 632 0 to +75°C	Type ① Case 609, 632 −55 to +125°C	Output Loading Factor Each Output MC2000 Series	Output Loading Factor Each Output MC2100 Series	Propagation Delay t_{pd} ns typ	Power Dissipation mW typ/pkg
Expandable 2-Wide 4-Input AND-OR-INVERT Gate	MC2000 MC2050	MC2100 MC2150	9 5	11 6	7.0	27
Quad 2-Input NAND Gate	MC2001 MC2051	MC2101 MC2151	9 5	11 6	6.0	88
4-Wide 3-2-2-3 Input Expander for AND-OR-INVERT Gates	MC2002 MC2052	MC2102 MC2152	9 5	11 6	–	28
Dual 4-Input NAND Gate	MC2003 MC2053	MC2103 MC2153	9 5	11 6	6.0	44
Expandable 4-Wide 2-2-2-3 Input AND-OR-INVERT Gate	MC2004 MC2054	MC2104 MC2154	9 5	11 6	7.0	36
8-Input NAND Gate	MC2005 MC2055	MC2105 MC2155	9 5	11 6	8.0	22
Dual 4-Input Expander for AND-OR-INVERT Gates	MC2006 MC2056	MC2106 MC2156	9 5	11 6	–	14
Triple 3-Input NAND Gate	MC2007 MC2057	MC2107 MC2157	9 5	11 6	6.0	66
Hex Inverter	MC2008 MC2058	– –	9 5	– –	6.0	132
AND J-K Flip-Flop	MC2009 MC2059	MC2109 MC2159	9 5	11 6	f = 30 MHz	40
OR J-K Flip-Flop	MC2010 MC2060	MC2110 MC2160	9 5	11 6	f = 30 MHz	50
Expandable 8-Input NAND Gate	MC2011 MC2061	MC2111 MC2161	9 9	11 6	11	22
Expandable 3-Wide 3-Input AND-OR-INVERT Gate	MC2012 MC2062	MC2112 MC2162	9 5	11 6	6.0	39
Expandable Dual 2-Wide 2-Input AND-OR-INVERT Gate	MC2013 MC2063	MC2113 MC2163	9 5	11 6	7.0	58
Quad 2-Input Lamp/ Line Driver	– MC2065	– MC2165	– –	– –	20	105
Dual J-K Flip-Flop (separate clock)	MC2023 MC2073	MC2123 MC2173	9 5	11 6	f = 70 MHz	110
Dual J-K Flip-Flop (common clock)	MC2024 MC2074	MC2124 MC2174	9 5	11 6	f = 70 MHz	110
AND J-K Flip-Flop	MC2025 MC2075	MC2125 MC2175	9 5	11 6	f = 50 MHz	50
OR J-K Flip-Flop	MC2026 MC2076	MC2126 MC2176	9 5	11 6	f = 50 MHz	60
OR J-K Flip-Flop	MC2028 MC2078	MC2128 MC2178	9 5	11 6	f = 35 MHz	60

① F suffix denotes Flat Package, L denotes Dual In-Line Ceramic Package, P denotes Plastic Package, (i.e., MC2000F = Flat Package, MC2100L = Dual In-Line Ceramic, MC2000P = Plastic Package.)

MTTL III

MC3000 Series (0 to +75°C)

MC3100 Series (−55 to +125°C)

MTTL III integrated circuits are designed for general purpose digital applications. The family has a high operating speed (30-50 MHz clock rate), good external noise immunity, high fan-out, and the capability of driving lines up to 600 pF capacitance.

FUNCTIONS AND CHARACTERISTICS (V_{CC} = 5.0 V, T_A = 25°C)

Function	Type ①		Output Loading Factor Each Output	Propagation Delay t_{pd} ns typ	Power Dissipation mW typ/pkg
	Case 605, 607, 632 0 to +75°C	Case 607, 632 -55°C to +125°C			
Quad 2-Input NAND Gate	MC3000	MC3100	10	6.0	88
Quad 2-Input AND Gate	MC3001	MC3101	10	9.0	112
Quad 2-Input NOR Gate	MC3002	MC3102	10	6.0	122
Quad 2-Input OR Gate	MC3003	MC3103	10	9.0	150
Quad 2-Input NAND Gate (Open Collector)	MC3004	MC3104	10	8.0	88
Triple 3-Input NAND Gate	MC3005	MC3105	10	6.0	66
Triple 3-Input AND Gate	MC3006	MC3106	10	9.0	84
Triple 3-Input NAND Gate (Open Collector)	MC3007	MC3107	10	8.0	66
Hex Inverter	MC3008	MC3108	10	6.0	140
Hex Inverter	MC3009	MC3109	10	8.0	90
Dual 4-Input NAND Gate	MC3010	MC3110	10	6.0	44
Dual 4-Input AND Gate	MC3011	MC3111	10	9.0	56
Dual 4-Input NAND Gate (Open Collector)	MC3012	MC3112	10	8.0	44
8-Input NAND Gate	MC3015	MC3115	10	8.0	22
8-Input NAND Gate	MC3016	MC3116	10	8.0	22
4-Wide 3-2-2-3 Input Expander For AND-OR-INVERT Gates	MC3018	MC3118	**	Δt_{pd1} = 0.4 Δt_{pd0} = 0.05	40
Triple 3-Input Expander For AND-OR Gates	MC3019	MC3119	**	Δt_{pd1} = 0.4 Δt_{pd0} = 0.05	25
Expandable Dual 2-Wide 2-Input AND-OR-INVERT Gate	MC3020	MC3120	10	6.0	62.5
Quad 2-Input Exclusive OR Gate	MC3021	MC3121	8	14	100
Quad 2-Input Exclusive NOR Gate	MC3022	MC3122	8	14	85
Dual 2-Wide 2-Input AND-OR-INVERT Gate	MC3023	MC3123	10	6.0	62.5
Dual 4-Input NAND Buffer Gate	MC3024	MC3124	30	6.0	90
Dual 4-Input NAND Power Gate	MC3025	MC3125	20	6.0	70
Dual 4-Input AND Power Gate	MC3026	MC3126	20	9.0	90
Dual 3-Input 3-Output AND Series Terminated Line Driver	MC3028	MC3128	*	9.0	56
Dual 3-Input 3-Output NAND Series Terminated Line Driver	MC3029	MC3129	*	6.0	44
Dual 4-Input Expander for AND-OR-INVERT Gates	MC3030	MC3130	**	Δt_{pd} = 1.0	15
Expandable 4-Wide 2-2-2-3 Input AND-OR Gate	MC3031	MC3131	10	10	87.5
Expandable 4-Wide 2-2-2-3 Input AND-OR-INVERT Gate	MC3032	MC3132	10	7.0	40
4-Wide 2-2-2-3 Input AND-OR-INVERT Gate	MC3033	MC3133	10	7.0	40
Expandable 2-Wide 4-Input AND-OR-INVERT Gate	MC3034	MC3134	10	7.0	30
AND J-K Flip-Flop	MC3050	MC3150	10	f = 40 MHz	80
AND Input J-K Flip-Flop	MC3051	MC3151	10	f = 50 MHz	50
AND Input JJ-$\overline{K}\overline{K}$ Flip-Flop	MC3052	MC3152	10	f = 40 MHz	75
Double-Edge-Triggered Master-Slave Type D Flip-Flop	MC3053	MC3153	10	—	100
OR Input J-K Flip-Flop	MC3054	MC3154	10	20	95
AND Input J-K Flip-Flop	MC3055	MC3155	10	10	80
Dual Type D Flip-Flop	MC3060	MC3160	10	f = 30 MHz	120
Dual J-K Flip-Flop	MC3061	MC3161	10	f = 50 MHz	100
Dual J-K Flip-Flop	MC3062	MC3162	10	f = 50 MHz	100

① F suffix denotes Flat Package, L suffix denotes Dual In-Line Ceramic Package, P suffix denotes Plastic Package, (i.e., MC3000F = Flat Package, MC3000L = Ceramic Package, MC3000P = Plastic Package).

*Direct Output = 10 minus the number of resistor-terminated outputs being used.

**Full output loading factor of the expandable gate is maintained.

MTTL COMPLEX FUNCTIONS

The MTTL complex functions are designed for digital applications in the medium to high-speed range. Each device is compatible with many or all of the families of MTTL and MDTL devices, as indicated in the table.

These MTTL devices provide significant reduction in package count and increased logic per function over devices in the basic MTTL and MDTL families.

FUNCTIONS AND CHARACTERISTICS (V_{CC} = 5.0 V, T_A = 25°C)

Function	Type ① −55 to +125°C	Case	Type ① 0 to +75°C	Case	Output Loading Factor Each Output	Propagation Delay t_{pd} ns typ	Power Dissipation P_D mW typ/pkg	Code ②
Dual 4-Channel Data Selector	–	–	MC4000F,L,P	607,632,605	10	18/11*	150	A
BCD-to-Binary/Binary-to-BCD Number Converter	–	–	MC4001L,P	620,612	Open Collector I_{OL} = 16 mA	Address Time <45 ns	300	A
Dual Data Distributor	–	–	MC4002F,L,P	607,632,605	10	10.5	175	A
16-Bit Scratch Pad Memory Cell	MC4304F,L	607,632	MC4004F,L,P	607,632,605	I_{OL} = 40 mA Open Collector	Write mode: 25 Sense mode: 15	250	B
16-Bit Scratch Pad Memory Cell	MC4305F,L	607,632	MC4005F,L,P	607,632,605	I_{OL} = 20 mA	Write mode: 25 Sense mode: 15	250	B
Binary to One-of-Eight Line Decoder	–	–	MC4006F,L,P	607,632,605	10	14	100	A
Dual Binary to One-of-Four Line Decoder	–	–	MC4007L,P	620,612	10	14	125	A
8-Bit Parity Tree	–	–	MC4008F,L,P	607,632,605	10	15 to 30	150	A
Dual 4-Bit Parity Tree	–	–	MC4010F,L,P	607,632,605	10	9.5 to 22	125	A
4-Bit Shift Register	–	–	MC4012F,L,P	607,632,605	10	22/bit	180	A
Quad Type D Flip-Flop	–	–	MC4015L,P	620,612	10	16	190	A
4-Bit Universal Counter	–	–	MC4023F,L,P	607,632,605	10	16/bit	200	A
Dual Voltage-Controlled Multivibrator	MC4324F,L	607,632	MC4024F,L,P	607,632,605	7	25 MHz‡	150	A
Full Adder	MC4326F,L	607,632	MC4026F,L,P	607,632,605	15/12**	25/13#	90	B
Full Adder	MC4327F,L	607,632	MC4027F,L,P	607,632,605	7/6**	25/13#	90	B
Adder (Dependent Carry)	MC4328F,L	607,632	MC4028F,L,P	607,632,605	15/12**	25/13#	125	B
Adder (Dependent Carry)	MC4329F,L	607,632	MC4029F,L,P	607,632,605	7/6**	25/13#	125	B
Adder (Independent Carry)	MC4330F,L	607,632	MC4030F,L,P	607,632,605	15/12**	25/13#	125	B
Adder (Independent Carry)	MC4331F,L	607,632	MC4031F,L,P	607,632,605	7/6**	25/13#	125	B
Carry Decoder	MC4332F,L	607,632	MC4032F,L,P	607,632,605	–	Δt_{pd} = 4.0/decoder	20	B
Inverting/Non-Inverting One-of-Eight Decoder	–	–	MC4038P	612	Open Collector I_{OL} = 20 mA	Address Time <45 ns	240	A
Seven-Segment Character Generator	–	–	MC4039P	612			240	A
Binary to Two-of-Eight Decoder	–	–	MC4040P	612			200	A
Single-Error Hamming Code Detector and Generator	–	–	MC4041P	612			250	A
Quad Predriver	–	–	MC4042F,L,P	607,632,605	I_{OL} = 50 mA Open Collector	15	120	A
Dual Line Selector	–	–	MC4043F,L,P	607,632,605	I_{OL} = 400 mA Pulsed	20	70	A
Phase-Frequency Detector	MC4344F,L	607,632	MC4044F,L,P	607,632,605	10	9.0	85	A
			0 to +70°C					
BCD-to-Decimal Decoder and High-Level Driver	–	–	MC7441AL,P	620,612	–	–	105	C
BCD-to-Decimal Decoder	MC5442L	620	MC7442L,P	620,612	10	2 Logic Levels = 22 3 Logic Levels = 23	140	C
Excess Three-to-Decimal Decoder	MC5443L	620	MC7443L,P	620,612	10	2 Logic Levels = 22 3 Logic Levels = 23	140	C
Excess Three Gray-to-Decimal Decoder	MC5444L	620	MC7444L,P	620,612	10	2 Logic Levels = 22 3 Logic Levels = 23	140	C
BCD-to-Seven Segment Decoder/Driver	MC5446L	620	MC7446L,P	620,612	BI/RBO = 5	–	265	C
BCD-to-Seven Segment Decoder/Driver	MC5447L	620	MC7447L,P	620,612	BI/RBO = 5	–	265	C
Quad Latch	–	–	MC7475P	612	10	30	160	C
Gated Full Adder	MC5480L	632	MC7480L,P	632,605	Sum, $\overline{Sum}$ = 10 C_{n+1} = 5 A*, B* = 3	10/55#	105	C
4-Bit Binary Full Adder	MC5483L	620	MC7483L,P	620,612	S = 10 C4 = 5	35	390	C
Decade Counter	MC5490F,L	607,632	MC7490F,L,P	607,632,605	10	20/bit	160	C
8-Bit Shift Register	MC5491AL	632	MC7491AL,P	632,605	10	25	175	C
Divide-by-Twelve Counter	MC5492F,L	607,632	MC7492F,L,P	607,632,605	10	60	160	C
4-Bit Binary Counter	MC5493L	632	MC7493L	632	10	20/bit	160	C
4-Bit Shift Register	MC5495F,L	607,632	MC7495F,L,P	607,632,605	10	25	250	C
			0 to +75°C					
Universal 4-Bit Shift Register	MC9300L	620	MC8300L,P	620,612	6	25	300	A
BCD-to-Decimal Decoder	MC9301L	620	MC8301L,P	620,612	10	22	125	A
Dual Full Adder	MC9304L	620	MC8304L,P	620,612	$\overline{C}_{o1}$, $\overline{C}_{o2}$ = 7 S1, $\overline{S}$2 = 10 $\overline{S}$1, S2 = 9	8.0 to 28	110	A
Dual 4-Channel Data Selector	MC9309L	620	MC8309L,P	620,612	Z, W = 10 $\overline{Z}$, $\overline{W}$ = 9	9.0 to 24	150	A
8-Channel Data Selector	MC9312L	620	MC8312L,P	620,612	$\overline{Z}$ = 20/10† $\overline{Z}$ = 18/9†	9.0 to 24	135	A
Retriggerable Monostable Multivibrator	MC9601F,L	607,632	MC8601F,L,P	607,632,605	MC9601 = 6 MC8601 = 8	25	75	A

① F suffix denotes ceramic flat package, L suffix denotes ceramic dual in-line package, P suffix denotes plastic dual in-line package.

② Code A denotes devices compatible with all MTTL and MDTL families.
B denotes devices compatible with MTTL I and MTTL II devices.
C denotes devices compatible with MTTL MC5400/7400 Series devices.

**MC4300 Series/MC4000 Series

‡Maximum Operating Frequency

*Control line/Data line
#Add delay/Carry delay
†High/Low

MTTL (continued)

Function	Type ① −55 to +125°C	Case	Type ① 0 to +70°C	Case	Output Loading Factor Each Output	Propagation Delay t_{pd} ns typ	Power Dissipation P_D mW typ/pkg	Code ②
2 Bit Full Adder	MC15482F,L	609,632	MC17482F,L,P	609,632,605	10	15/12#	165	C
2-Bit Full Adder	MC25482F,L	609,632	MC27482F,L,P	609,632,605	10	15/12#	165	C

① F suffix denotes ceramic flat package, L suffix denotes ceramic dual in-line package, P suffix denotes plastic dual in-line package.
② Code A denotes devices compatible with all MTTL and MDTL families.
B denotes devices compatible with MTTL I and MTTL II devices.
C denotes devices compatible with MTTL MC5400/7400 Series devices.
#Add delay/Carry delay

MDTL

MC830 Series (0 to +75°C)
MC930 Series (−55 to +125°C)

MDTL integrated circuits provide an excellent balance of speed, power dissipation, and noise immunity for general purpose digital applications. Additional logic power is provided by the "Wired-OR" capability of the basic MDTL gate.

FUNCTIONS AND CHARACTERISTICS (V_{CC} = 5.0 Vdc, T_A = 25°C)

Function	Type ① 0 to +75°C	Case	Type ① −55 to +125°C	Case	Output Loading Factor Each Output	Propagation Delay t_{pd} ns typ	Total Power Dissipation mW typ/pkg
Expandable Dual 4-Input NAND Gate	MC830	605,607,632	MC930	607,632	8	30	22
Expandable Dual 3-2 Input NAND Gate	MC830	603	MC930	603	8	30	22
Clocked Flip-Flop	MC831	603,605,607,632	MC931	603,607,632	7	40	55
Expandable Dual 4-Input Buffer	MC832	605,607,632	MC932	607,632	25	35	85
Expandable Dual 3-2 Input Buffer	MC832	603	MC932	603	25	35	85
Dual 4-Input Expander	MC833	605,607,632	MC933	607,632	–	–	–
Dual 4-3 Input Expander	MC833	603	MC933	603	–	–	–
Hex Inverter	MC834	605,607,632	MC934	607,632	8	30	66
Hex Inverter (without output resistors)	MC835	605,607,632	MC935	607,632	8	30	42
Hex Inverter	MC836	605,607,632	MC936	607,632	8	30	66
Hex Inverter	MC837	605,607,632	MC937	607,632	7	25	90
Decade Counter	MC838	605,607,632	MC938	607,632	8	30 MHz ③	150
Divide-by-Sixteen Counter	MC839	605,607,632	MC939	607,632	8	30 MHz ③	150
Hex Inverter (without input diodes)	MC840	605,607,632	MC940	607,632	8	30	66
Hex Inverter (without output resistors and input diodes)	MC841	605,607,632	MC941	607,632	8	30	42
Type D Flip-Flop Plus 2-Wide 2-Input AND-OR-INVERT Gate	MC842	605,607,632	MC942	607,632	9/11 ②	40	110
4-Input AND Driver with NOR Strobe	MC843	603	MC943	603	250 mA	80	50
Expandable Dual 4-Input Power Gate	MC844	605,607,632	MC944	607,632	27	30	65
Expandable Dual 3-2 Input Power Gate	MC844	603	MC944	603	27	30	65
Clocked Flip-Flop	MC845	603,605,607,632	MC945	603,607,632	12/10 ②	40	60
Quad 2-Input NAND Gate	MC846	605,607,632	MC946	607,632	8	30	44
Quad Inverter	MC846	603	MC946	603	8	30	44
Quad 2-Input Gate Expander	MC847	605,607,632	MC947	607,632	–	–	–
Clocked Flip-Flop	MC848	603,605,607,632	MC948	603,607,632	11/9 ②	40	70
Quad 2-Input NAND Gate (2 k pullup resistor)	MC849	605,607,632	MC949	607,632	7	25	66
Quad Inverter (2 k pullup resistor)	MC849	603	MC949	603	7	25	60
Pulse Triggered Binary	MC850	603,605,607,632	MC950	603,607,632	10/8 ②	15	50
Monostable Multivibrator	MC851	603,605,607,632	MC951	603,607,632	10	40	30
Dual J-K Flip-Flop (common clock and C_D, separate S_D)	MC852	605,607,632	MC952	607,632	12/10 ②	40	120
Dual J-K Flip-Flop (separate clock and S_D, no C_D)	MC853	605,607,632	MC953	607,632	12/10 ②	40	120
Dual J-K Flip-Flop (common clock and C_D, separate S_D, 2 k pullup resistor)	MC855	605,607,632	MC955	607,632	11/9 ②	40	140
Dual J-K Flip-Flop (separate clock and S_D, no C_D, 2 k pullup resistor)	MC856	605,607,632	MC956	607,632	11/9 ②	40	140
Quad 2-Input Buffer	MC857	605,607,632	MC957	607,632	25	35	170
Quad 2-Input NAND Power Gate	MC858	605,607,632	MC958	607,632	27	30	130
Dual Pulse Triggered Binary	MC860	605,607,632	MC960	607,632	10/8 ②	15	100
Expandable Dual 4-Input NAND Gate (2 k pullup resistor)	MC861	605,607,632	MC961	607,632	7	25	33

① F suffix denotes Ceramic Flat Package, G suffix denotes Metal Can, L suffix denotes Dual In-Line Ceramic Package, P suffix denotes Dual In-Line Plastic Package (i.e., MC830G = Metal Can, MC830F = Flat Package, MC830L = Dual In-Line Ceramic Package, MC830P = Plastic Package)

② Fan-out for MC830 series type / Fan-out for MC930 series type.

③ Maximum counting frequency.

MDTL (continued)

Function	Type ① 0 to +75°C	Case	Type ① -55 to +125°C	Case	Output Loading Factor Each Output	Propagation Delay t_{pd} ns typ	Total Power Dissipation mW typ/pkg
Expandable Dual 3-2 Input NAND Gate (2 k pullup resistor)	MC861	603	MC961	603	7	25	33
Triple 3-Input NAND Gate	MC862	605,607	MC962	607,632	8	30	33
Dual 2-Input NAND Gate plus Inverter	MC862	603	MC962	603	8	30	30
Triple 3-Input NAND Gate (2 k pullup resistor)	MC863	605,607	MC963	607,632	7	25	50
Dual 2-Input NAND Gate plus Inverter (2 k pullup resistor)	MC863	603	MC963	603	7	25	45
Dual 6-Input NAND Gate	MC1800	605,607,632	MC1900	607,632	8	30	22
Dual 5-Input NAND Gate (2 k pullup resistor)	MC1801	605,607,632	MC1901	607,632	7	25	33
Expandable 8-Input NAND Gate	MC1802	605,607,632	MC1902	607,632	8	30	11
Expandable 8-Input NAND Gate (2 k pullup resistor)	MC1803	605,607,632	MC1903	607,632	7	25	16.5
10-Input NAND Gate	MC1804	605,607,632	MC1904	607,632	8	30	11
10-Input NAND Gate (2 k pullup resistor)	MC1805	605,607,632	MC1905	607,632	7	25	16.5
Quad 2-Input AND Gate	MC1806	605,607,632	MC1906	607,632	8	35	72
Quad 2-Input AND Gate (2 k pullup resistor)	MC1807	605,607,632	MC1907	607,632	7	30	85
Quad 2-Input OR Gate	MC1808	605,607,632	MC1908	607,632	8	35	97
Quad 2-Input OR Gate (2 k pullup resistor)	MC1809	605,607,632	MC1909	607,632	7	30	115
Quad 2-Input NOR Gate	MC1810	605,607,632	MC1910	607,632	8	30	60
Quad 2-Input NOR Gate (2 k pullup resistor)	MC1811	605,607,632	MC1911	607,632	7	25	72
Quad 2-Input Exclusive OR Gate	MC1812	605,607,632	MC1912	607,632	8	40	120
Quad Latch	MC1813	612,620	—	—	7	35	220
Quad Latch	MC1814	605,607,632	MC1914	607,632	7	35	220
Parallel Gated Clocked Flip-Flop	MC1815	605,607,632	MC1915	607,632	12/10 ②	40	65
Parallel Gated Clocked Flip-Flop	MC1816	605,607,632	MC1916	607,632	11/9 ②	40	75
Quad 2-Input NAND Gate (without output resistor)	MC1818	605,607,632	MC1918	607,632	8	30	32

① F suffix denotes Ceramic Flat Package, G suffix denotes Metal Can, L suffix denotes Dual In-Line Ceramic Package, P suffix denotes Dual In-Line Plastic Package. (i.e., MC830G = Metal Can, MC830F = Flat Package, MC830L = Dual In-Line Ceramic Package, MC830P = Plastic Package)

② Fan-out for MC830 series type / Fan-out for MC930 series type.

③ Maximum counting frequency.

MDTL

MCE930 Series (−55 to +125°)

The Dielectrically Isolated MDTL family is intended for use in military and space applications that require a high degree of reliability under severe radiation environments. In addition to dielectric isolation, this family of devices utilizes nichrome resistors throughout. A post-metalization passivation process further enhances the radiation resistance qualities of the family and very small high frequency transistor structures are used throughout.

FUNCTIONS AND CHARACTERISTICS (V_{CC} = 5.0 Vdc, T_A = 25°C)

Function	Type Case 607 -55 to +125°C	Output Loading Factor Each Output	Total Power Dissipation mW typ/pkg
Expandable Dual 4-Input NAND Gate	MCE930	8	22
Expandable Dual 4-Input Buffer	MCE932	25	85
Dual 4-Input Expander	MCE933	—	—
Hex Inverter	MCE936	8	66
Expandable Dual 4-Input NAND Power Gate	MCE944	27	65
Clocked Flip-Flop	MCE945	10	60
Quad 2-Input NAND Gate	MCE946	8	44
Clocked Flip-Flop	MCE948	9	70
Triple 3-Input NAND Gate	MCE962	8	33

MRTL

MC700 Series (+15 to +55°C)
MC800 Series (0 to +75 and 0 to +100°C)
MC900 Series (−55 to +125°C)

Medium-power MRTL integrated circuits provide a broad line of low-cost, multi-function, digital circuits. Typical gate speed is 12 ns, with power dissipation averages of 19 mW (input high) and 5.0 mW (inputs low) per logic node. Devices from the MC700 Series have loading factors normalized for compatibility with the low-power mW MRTL devices for ease in mixing the two power levels in a system.

FUNCTIONS AND CHARACTERISTICS

(V_{CC} = 3.0 V ±10% for MC900 Series and MC800F, G Series; 3.6 V ±10% for MC800P Series and MC700 Series, T_A = 25°C)

Function	Type ① MC700 Series +15 to +55°C	Case	Type ① MC800 Series 0 to +75°C	Case	Type ① MC800 Series 0 to +100°C	Case	Type ① MC900 Series −55 to +125°C	Case	Output Loading Factor Each Output: With mW MRTL	Output Loading Factor Each Output: With MRTL	Propagation Delay t_{pd} ns typ	Total Power Dissipation mW typ: MC700 and MC800P Series	Total Power Dissipation mW typ: MC800F,G and MC900 Series
Buffer	MC700	601,606			MC800	601,606	MC900	601,606	80	25	20	25/50 ②	16/45 ②
Counter Adapter	MC701	601			MC801	601	MC901	601	16	5	22	80	55
R-S Flip-Flop	MC702	601			MC802	601	MC902	601	13	4	14	32	22
3-Input NOR Gate	MC703	601,606			MC803	601,606	MC903	601,606	16	5	12	28/7.5 ②	19/5.0 ②
Half Adder	MC704	601,606			MC804	601,606	MC904	601,606	16	5	14	65	45
Half-Shift Register	MC705	601,606			MC805	601,606	MC905	601,606	13	4	22	75	53
Half-Shift Register (w/o inverter)	MC706	601,606			MC806	601,606	MC906	601,606	13	4	22	52	36
4-Input NOR Gate	MC707	601,606			MC807	601,606	MC907	601,606	16	5	12	30/7.5 ②	19/5.0 ②
Dual 2-Input NOR Gate	MC714	601,606			MC814	601,606	MC914	601,606	16	5	12	50/15 ②	38/10 ②
Dual 3-Input NOR Gate	MC715	603,605,606	MC815	605	MC815	603,606	MC915	603,606	16	5	12	55/15 ②	38/10 ②
J-K Flip-Flop			MC816	605	MC816	601,606	MC916	601,606	–	3	30	91/79 ③	62/54 ③
J-K Flip-Flop	MC723	601,605,606							10	–	30	91/79 ③	–
Quad 2-Input NOR Gate	MC724	605,607	MC824	605	MC824	607	MC924	607	16	5	12	100/30 ②	76/20 ②
Dual 4-Input NOR Gate	MC725	605,607	MC825	605	MC825	607	MC925	607	16	5	12	60/15 ②	38/10 ②
J-K Flip-Flop	MC726	603,605,606	MC826	605	MC826	603,606	MC926	603,606	16	5	35	100/86 ③	130/65 ③
Quad Inverter	MC727	603,606			MC827	603,606	MC927	603,606	16	5	12	87/30 ②	76/20 ②
5-Input NOR Gate	MC729	601,606			MC829	603,606	MC929	601,606	16	5	12	33/7.5 ②	19/5.0 ②
Quad Exclusive OR Gate	MC771	605,607	MC871	605	MC871	607	MC971	607	16	5	12	28	72
J-K Flip-Flop	MC774	601			MC874	601	MC974	601	16	5	35	100/86 ③	130/65 ③
Dual Half-Adder	MC775	605,607	MC875	605	MC875	607	MC975	607	16	5	20	120	90
Binary Up Counter	MC777	605	MC877	605					10	3	–	180	–
1 J-K Flip-Flop, 1 Expander, 2 Buffers	MC779	605	MC879	605					–	–	–	141/124 ④	–
Decade Up Counter	MC780	605	MC880	605					10	3	–	250	–
Dual Half-Shift Register	MC783	605,607	MC883	605	MC883	607	MC983	607	13	4	22	140	110
Dual Half-Shift Register (w/inverter)	MC784	605,607	MC884	605	MC884	607	MC984	607	13	4	22	100	75
Quad 2-Input Expander	MC785	605,607	MC885	605	MC885	607	MC985	607	–	–	12	20/– ②	17/– ②
Dual 4-Input Expander	MC786	605,607	MC886	605	MC886	607	MC986	607	–	–	12	20/– ②	17/– ②
1 J-K Flip-Flop, 1 Inverter, 2 Buffers	MC787	605	MC887	605					–	–	–	138/132 ④	–
Dual 3-Input Buffer, non-inverting	MC788	605,607	MC888	605	MC888	607	MC988	607	80	25	24	145/56 ②	128/42 ②
Hex Inverter	MC789	605,607	MC889	605	MC889	607	MC989	607	16	5	12	130/15 ②	76/20 ②
Dual J-K Flip-Flop	MC790	605,607	MC890	605	MC890	607	MC990	607	10	3	35	182/158 ③	124/108 ③
Dual J-K Flip-Flop	MC791	605,607	MC891	605	MC891	607	MC991	607	16	5	40	190/160 ③	155/130 ③
Triple 3-Input NOR Gate	MC792	605,607	MC892	605	MC892	607	MC992	607	16	5	12	82/24 ②	57/15 ②
Serial-Parallel Shift Register	MC794	605	MC894	605					16	5	55	225	–
Dual Full Adder	MC796	605,607	MC896	605	MC896	607	MC996	607	16	5	60	225	190
Dual Full Subtractor	MC797	605,607	MC897	605	MC897	607	MC997	607	16	5	60	225	190
Dual Buffer	MC799	603,605,606	MC899	605	MC899	603,606	MC999	603,606	80	25	15	50/90 ②	32/90 ②
Dual 4-Channel Data Selector	MC9701	612	MC9801	612					16	5	25	100	–
4-Bit Parallel Full Adder	MC9704	612	MC9804	612					6	2	125	265	–
Dual 4-Channel Data Distributor	MC9707	612	MC9807	612					16	5	25	150	–
Quad Schmitt Trigger	MC9709	605	MC9809	605					16	5	30	95	–
Quad 2-Input AND Gate	MC9713	605	MC9813	605					16	5	28	100	–
Quad 2-Input NAND Gate	MC9714	605	MC9814	605					16	5	14 ⑤	145	–
Quad 2-Input OR Gate	MC9715	605	MC9815	605					16	5	14 ⑤	28/100 ②	–
Hex Expander	MC9719	605,607	MC9819	605	MC9819	607	MC9919	607	–	–	12	13/– ②	13/– ②
BCD-to-Decimal Decoder/Driver	MC9760	612	MC9860	612					–	–	–	115	–

① G Suffix denotes Metal Can, F suffix denotes Flat Package, P suffix denotes Plastic Package.
② Inputs High/Inputs Low
③ Only Clock Inputs High/Inputs Low
④ Only Clock Input High on flip-flop, other element Inputs High/Inputs Low
⑤ Operating Frequency (MHz)

mW MRTL

MC708 Series (+15 to +55°C)
MC808 Series (0 to +75°C)
MC908 Series (−55 to +125°C)

Low-power mW MRTL integrated circuits are designed for use where minimal system power consumption is desired. Typical gate speed is 27 ns, with typical power dissipation of 6.5 mW (input high) and 0.5 mW (inputs low) per logic node. Devices from the MC708 Series can be mixed with devices from the medium-power MC700 Series which has loading factors normalized for compatibility.

FUNCTIONS AND CHARACTERISTICS

(V_{CC} = 3.0 V ±10% for MC908 Series, 3.6 V ±10% for MC808 Series and MC708 Series; T_A = 25°C)

Function	Type ① MC708 Series +15 to +55°C	Type ① MC808 Series 0 to +75°C	Case	Type ① MC908 Series −55 to +125°C	Case	Output Loading Factor Each Output All Series	Propagation Delay t_{pd} ns typ	Total Power Dissipation mW typ/pkg MC708 Series & MC808 Series	Total Power Dissipation mW typ/pkg MC908 Series
Half Adder	MC708	MC808	601, 606	MC908	601, 606	4	60	19/12.5 ②	14/8.5 ②
2-Input Buffer	MC709	MC809	601, 606	MC909	601, 606	30	57	7.0/23 ②	5.5/16 ②
Dual 2-Input NOR Gate	MC710	MC810	601, 606	MC910	601, 606	4	27	10/2.5 ②	8.0/1.0 ②
4-Input OR/NOR Gate	MC711	MC811	601, 606	MC911	601, 606	4	60	8.0/5.5 ②	6.0/3.5 ②
Half Adder	MC712	MC812	601, 606	MC912	601, 606	4	66	15.5/10.5 ②	11.5/5.5 ②
Type D Flip-Flop	MC713	MC813	601, 606	MC913	601, 606	3	75	24/17.5 ③	17.5/13 ③
Quad 2-Input NOR Gate	MC717	MC817	605, 607	MC917	607	4	27	20/5.0 ②	16/2.5 ②
Dual 3-Input NOR Gate	MC718	MC818	603,605,606	MC918	603, 606	4	27	12/2.5 ②	9.5/1.0 ②
Dual 4-Input NOR Gate	MC719	MC819	605, 607	MC919	607	4	27	13/2.5 ②	11/1.0 ②
J-K Flip-Flop	MC720	MC820	601, 606	MC920	601, 606	2	50	20.5/14.5 ④	15.5/10 ④
Dual 2-Input Gate Expander	MC721	MC821	601, 606	MC921	601, 606	—	27	3.0/— ②	3.0/— ②
J-K Flip-Flop	MC722	MC822	603,605,606	MC922	603, 606	4	70	24/20 ④	17.5/13 ④
5-Input NOR Gate	MC728	MC828	601, 606	MC928	601, 606	4	27	7.5/1.0 ②	6.5/0.5 ②
Dual Exclusive OR/NOR Gate	MC764	MC864	605			4	—	25	—
Quad Latch	MC767	MC867	612			9	50	110	—
BCD-To-Decimal Decoder	MC770	MC870	612			7	36	100/— ②	—
Dual J-K Flip-Flop	MC776	MC876	605, 607	MC976	607	2	50	41/29 ④	31/20 ④
Dual Type D Flip-Flop	MC778	MC878	605, 607	MC978	607	3	60	48/35 ③	35/26 ③
Dual Buffer	MC781	MC881	601	MC981	601	30	57	14/46 ②	11/32 ②
J-K Flip-Flop	MC782	MC882	601	MC982	601	2	80	23/21 ④	15/13 ④
Triple 3-Input NOR Gate	MC793	MC893	605, 607	MC993	607	4	27	18/3.5 ②	14/2.0 ②
Dual 2-Input Buffer	MC798	MC898	605, 607	MC998	607	30	57	14/46 ②	11/32 ②
Hex Inverter	MC9718	MC9818	605			4	27	7.0/3.0 ②	—
Hex Expander	MC9720	MC9820	605				12	30/— ②	—
Quad 2-Input Expander	MC9721	MC9821	605, 607	MC9921	607	—	27	20/— ②	20/— ②
Dual J-K Flip-Flop	MC9722	MC9822	605			4	75	24/— ④	—

①G suffix denotes Metal Can, F suffix denotes Flat Package, P suffix denotes Plastic Package.
②Inputs High/Inputs Low unless otherwise noted. ③ Direct Set and Direct Clear Low, All other Inputs High/All Inputs Low.
④Only Clock Input High/All INputs Low

DIGITAL INTEGRATED CIRCUITS

MOS

Function	Temperature	Type	Case	Comments
P-Channel MOS				
Triple 66-Bit Dynamic Shift Register	0 to +75°C	MC1141G	602A	Operating frequency = 10 kHz to 1.0 MHz, power dissipation = 1.0 mW/bit @ 1.0 MHz.
200-Bit Dynamic Shift Register	0 to +55°C	MC1142G	619-02	Operating frequency = 10 kHz to 1.0 MHz, power dissipation = 1.0 mW/bit @ 1.0 MHz.
8-Channel Multiplex Switch	0 to +75°C	MC1150L	620	High on/off resistance ratio, zero offset voltage, all channel blanking.
2-of-8 Channel Multiplex Switch	0 to +75°C	MC1151L	620	High on/off resistance ratio, zero offset voltage, all channel blanking.
Dual 100-Bit Static Shift Register	-55 to +85°C	MC1160G	602A	Operating frequency = DC to 2.0 MHz, non-inverting buffered outputs, independent input/output lines.
Dual 50-Bit Static Shift Register	-55 to +85°C	MC1161G	602A	Operating frequency = DC to 2.0 MHz, non-inverting buffered outputs, independent input/output lines.
64-Bit Random Access Memory	0 to +75°C	MC1170L	637	Binary addressing, enable line for address expansion, single-phase clock.
Low-Power Complementary MOS				
Quad 2-Input NOR Gate	-55 to +125°C	MC2501L	632	Quiescent power dissipation = 10 nW typ, noise immunity = 45% of V_{DD} typ.
Dual 4-Input NOR Gate	-55 to +125°C	MC2502L	632	Quiescent power dissipation = 10 nW typ, noise immunity = 45% of V_{DD} typ.
Dual Type D Flip-Flop	-55 to +125°C	MC2503L	632	Quiescent power dissipation = 50 nW typ, noise immunity = 45% of V_{DD} typ, toggle rate = 4.0 MHz.
Dual 2-Input NAND Gate	-55 to +125°C	MC2597G	602A	Quiescent power dissipation = 100 nW typ, noise immunity = 4.5 V typ @ V_{DD} = 10 V.
Type D Flip-Flop	-55 to +125°C	MC2598G	602A	Quiescent power dissipation = 100 nW typ, noise immunity = 4.5 typ @ V_{DD} = 10 V, toggle rate = 2.0 MHz typ.

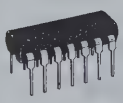
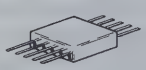
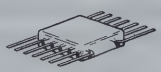
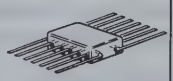
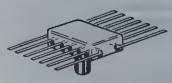
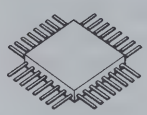
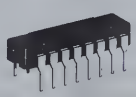
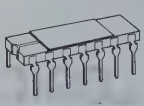
SPECIAL LOGIC PRODUCTS for CUSTOM APPLICATIONS

Function	Type	Comments
12-Gate Array	XC157	Twelve gates with custom second layer of metalization completing the circuit to obtain desired function. Compatible with MDTL and all MTTL lines.
25-Gate Array	XC177	Twenty-five gates with two custom layers of metalization required to complete the circuit and obtain the desired function. Compatible with MDTL and all MTTL lines.
128-Bit Read Only Memory	XC170	Bipolar read only memory organized as 16 eight-bit words. Compatible with MDTL and all MTTL lines. Open collectors at buffered output bit lines. Truth table specified by user.
128-Bit Read Only Memory	XC171	Same as XC170 except 2.0 kilohm pullup resistors on the collector outputs.

CONSUMER PRODUCTS

Function	Temperature	Type	Case	Comments
Toggle Flip-Flop	0 to +75°C	MFC4040	206A	Divide-by-two units for frequency-divider applications. Ideal for electronic organs.
Dual Toggle Flip-Flop	0 to +75°C	MFC6020	643	

DIGITAL IC PACKAGES

					
CASE 206A	**CASE 601** TO-99 Suffix G after type number	**CASE 602A** Suffix G after type number	**CASE 602B** Suffix G after type number	**CASE 603** TO-100 Suffix G after type number	**CASE 604** Suffix G after type number
					
PLASTIC PACKAGE **CASE 605** TO-116 Suffix P after type number	**CASE 606** TO-91 Suffix F after type number	**CASE 607** TO-86 Suffix F after type number	**CASE 609** TO-85 Suffix F after type number	PLASTIC PACKAGE **CASE 612** Suffix P after type number	**CASE 617** Suffix S after type number
					
CASE 618 Suffix F after type number	**CASE 619-02** Suffix G after type number	CERAMIC PACKAGE **CASE 620** Suffix L after type number	CERAMIC PACKAGE **CASE 632** TO-116 Suffix L after type number	CERAMIC PACKAGE **CASE 637** Suffix L after type number	**CASE 643**

LINEAR integrated circuits offer the design engineer a variety of functions for analog applications. This line includes devices for military, industrial, and consumer applications. Devices are available in a broad selection of operating characteristics and packaging. Refer to the last page of the Linear device listing for package information.

At a Glance — MILITARY and INDUSTRIAL DEVICES

OPERATIONAL AMPLIFIERS

TYPE			SPECIFICATIONS TYPICAL AT T_A = +25°C						
-55 to +125°C	0 to +75°C	Case	A_{VOL}, V/V	V_o, V_{pk}	I_b, μA	$\|V_{io}\|$ mV	dV_{out}/dt, V/μs	f_C, MHz	Comments
MC1520	–	602A,606	1,500	±4.0	0.8	5.0	5.0	10	Z_o = 50 ohms
MC1530	MC1430	602B,606,632	5,000	±5.2	3.0	1.0	1.0	5.0	Z_o = 25 ohms
MC1531	MC1431	602B,606,632	3,500	±5.2	0.025	3.0	1.0	5.0	Z_o = 25 ohms
MC1533	MC1433	602B,606,632	60,000	±13	0.5	1.0	0.8	0.5	V_{io} Adjustable
MC1535	MC1435	602B,607,632	7,000	±2.5	1.2	1.0	0.7	2.0	Dual Op-Ampl.
MC1536	MC1436	601	500,000	±23	0.008	2.0	2.0	1.0	Internally Compensated
MC1537	MC1437	632	45,000	±14	0.2	1.0	0.25	1.0	Dual MC1709
MC1539	MC1439	601,632	120,000	±13	0.2	1.0	4.2	1.0	dV_{out}/dt = 34 @ A_V = 100
MC1556	MC1456, C	601	200,000	±13	0.008	2.0	2.5	1.0	Internally Compensated
MC1558	MC1458	601	200,000	±14	0.2	1.0	0.8	1.1	Dual MC1741,C
MC1709	MC1709C	601,606,632	45,000	±14	0.2	1.0	0.25	0.7	
MC1712	MC1712C	601,606,632	3,600	±5.0	2.0	1.1	1.5	9.0	
MC1741	MC1741C	601,606,632	200,000	±14	0.2	1.0	0.8	1.0	Internally Compensated
MCH2870M	MCH2870C	614	200,000	±13	0.2	1.0	0.8	1.1	Load current up to ±300 mA – Hybrid, Hi-gain, Internally Compensated

Definitions: A_{VOL} Open-Loop Voltage Gain; V_o Output Voltage Swing; I_b Input Bias Current; $|V_{io}|$ Input Offset Voltage; dV_{out}/dt Slew Rate; f_C Unity Gain Crossover Frequency

LINEAR/DIGITAL INTERFACE CIRCUITS

TYPE				Typ – Input Threshold (V_{th}, mVdc)	Voltage Gain – Typ (A_V, V/V)	Response Time – Typ (t_R, ns)	Comments
Temperature Range							
-55 to +125°C	Case	0 to +75°C	Case				
MC1514	632	MC1414	632	21.5/18.5 ①	1700†	40	A dual differential comparator for level detection, low-level sensing, and memory applications.
MC1540	602B, 606, 632	MC1440	602B, 606, 632	17	85	20	Designed to detect bipolar differential signals derived by a core memory with cycle times as short as 0.5 μs
MC1541	607, 632	MC1441	607, 632	17	75	30/15 ②	A dual-channel gated sense amplifier with separate wide-band differential input amplifiers.
MC1543	632	–	–	20	–	10/3.0 ②	A MECL dual core-memory sense amplifier; adjustable threshold with excellent threshold stability.
MC1546	620	MC1446	620	0.5 ③	600	60/40 ②	A four-channel plated wire sense amplifier designed to convert ±3.0 mV (or ±4.0 mV) signals from plated wire memories to MTTL logic levels.
MC1710	601, 606, 632	MC1710C	601, 606, 632	0	1700†	40	A differential comparator providing high accuracy and fast response time.
MC1711	603, 606, 632	MC1711C	603, 606, 632	0	1500†	40	A dual differential comparator providing high accuracy and fast response time.

① -55°C/+125°C ② Diff. Mode/Com. Mode †A_{VOL} ③ Input Offset Voltage, mV typ

MILITARY and INDUSTRIAL DEVICES (continued)

LINEAR/DIGITAL INTERFACE CIRCUITS (continued)

LINE DRIVER/RECEIVER SERIES			
TYPE	Temperature	Case	Comments
MC1488	0 to +75°C	632	EIA RS-232C Interface Circuit – Quad MDTL Line Driver
MC1489	0 to +75°C	632	EIA RS-232C Interface Circuit-Quad MDTL Line Receiver

			Impedance-typ (kΩ @ 10 MHz)		t_{pd}	Common-Mode Voltage		
			Z_{in}	Z_{out}	ns, max	CMV_{in} (V-min)	CMV_{out} (V-min)	Comments
MC1580	-55 to +125°C	632	5.0	5.0	18	±4.0	+3.0/-9.0	Dual line driver/receiver; bias driver for MECL, interfacing for MDTL, MRTL and MTTL
MC1581	-55 to +125°C	632	8.0	-	20	+9.0/-3.0	-	Dual MECL line receiver
MC1582	-55 to +125°C	632	–	7.0	20	-	+9.0/-3.0	Dual MDTL and MTTL line driver
MC1583	-55 to +125°C	632	12 ①	–	40	±4.0	–	Dual saturated logic receiver (open-collector)
MC1584	-55 to +125°C	632	7.0	–	37	+4.0	-	Dual MDTL and MTTL receiver (active pullup)

HIGH-FREQUENCY CIRCUITS

TYPE		Case	V^+, V^- (Vdc)	Bandwidth (MHz)	$V_{o\ p\text{-}p\ se}$ (Vdc)	$\lvert Z_{in}\rvert$ kΩ/kHz	$\lvert Z_o\rvert$ Ω/kHz	$A_{V(se)}$ (dB)	A_p at 60 MHz (dB)	Diff. Input and Output	AGC
–55 to +125°C	0 to +70°C										
MC1510	MC1410	601	±6.0	dc to 40	4.5	6.0/20	35/20	40 (fixed)	–	Yes	No
MC1545	MC1445	602A, 602 632	±5.0	dc to 75	2.5	10/50	25/50	18 (fixed)	–	Yes	Yes
MC1550	–	602B, 606	+6.0	50	6.0	1.8/1.0 M	100 k/1.0 M	26 (AGC = 0)	25	No	Yes
MC1552	–	602B	+6.0	40 @ A_V = 34 dB 35 @ A_V = 40 dB	4.2	10/100	16/100	30 – 40 (fixed)	–	No	No
MC1553	–	602B	+6.0	35 @ A_V = 46 dB 15 @ A_V = 52 dB	4.2	10/100	16/100	46 – 52 (fixed)	–	No	No
MC1590	–	601	+12	100 @ A_V = 4 dB 60 @ A_V = 25 dB	7.0	3.0/1.0 M	100 k/1.0 M	44 (AGC = 0)	45	Yes	Yes

LOW-FREQUENCY CIRCUITS

TYPE		Case	Output Power (W – Typ)	Voltage Gain – Typ (A_V, V/V)	Total Harmonic Distortion (% – Typ)	Comments
–55 to +125°C	0 to 70°C					
MC1554	MC1454	602B	1.0	10, 18, 36	0.4	A power amplifier device capable of single or split supply operation.

MULTIPLIERS, MODULATORS, AND DETECTORS

TYPE		Case	Linearity Error (Typ)	Typ – Input Voltage Range (Vdc)	Comments
–55 to +125°C	0 to +70°C				
MC1595	–	632	X Input = 0.5% Y Input = 1.0%	±10	Applications include multiply, divide, square root, mean square, phase detector, frequency doubler, balanced modulator/demodulator, electronic gain control.
–	MC1495	632	X Input = 1.0% Y Input = 2.0%	±10	
			Typ – Carrier Suppression (dB) @ f (MHz)	Typ – Common Mode Rejection (CM_{rej}, dB)	
MC1596	MC1496	602A, 632	65 @ 0.5 50 @ 10	85	Balanced modulator/demodulator designed for use where the output voltage is a product of an input voltage (signal) and a switching function (carrier).

① f = 5.0 MHz

MILITARY and INDUSTRIAL DEVICES (continued)

REGULATORS

TYPE			V_{in} Range (Vdc)		Input-Output Diff. (Vdc)		V_o Range (Vdc)		TC_{V_o} (%/°C - Typ)	V_{ref} (Vdc)		I_b (mAdc - Max)	I_{out} (mAdc - Max)	P_D (W – Max)		Reg_{Line} (Max $\frac{\%V_o}{V_{in}}$)	Reg_{Load} (%V_o - Max)
–55 to +125°C	0°C to +70°C	Case	Min	Max	Min	Max	Min	Max		Min	Max			T_C +25°C	T_A +25°C		
POSITIVE VOLTAGE REGULATORS																	
–	MC1469	602A, 614	9.0	35	3.0	40	2.5	32	±0.002	3.2	3.8	12	200 500	1.8 17.5	0.68 3.0	0.030	0.13 0.05
MC1569	–	602A, 614	8.5	40	2.7	35	2.5	37	±0.002	3.4	3.6	9.0	200 500	1.8 17.5	0.68 3.0	0.015	0.13 0.05
–	MFC 4060*	206A	8.0	35	–	3.0	5.0	32	±3.0**	3.8	4.8	–	200	–	1.0	0.03	0.2
–	MFC 6030*	643	8.0	35	–	3.0	5.0	32	±3.0**	3.8	4.8	–	200	–	1.0	0.03	0.2
NEGATIVE VOLTAGE REGULATORS																	
–	MC1463	602A, 614	–9.0	–35	–3.0	40	–3.8	–32	±0.002	–3.2	–3.8	14	200 500	1.8 9.0	0.68 2.4	0.030	0.13 0.05
MC1563	–	602A, 614	–8.5	–40	–2.7	35	–3.6	–37	±0.002	–3.4	–3.6	11	200 500	1.8 9.0	0.68 2.4	0.015	0.13 0.05
MULTI-PURPOSE REGULATORS																	
–	MC1466	632	①②	①②	①	①	0	①	0.01	17.3	19.7	12	①	①	①	0.03	0.03% +3 mV 0.2% +1 mA ③
MC1566	–								0.006	18	19	8.5				0.01	0.01% +1 mV 0.1% +1 mA ③

*Temperature Range of –10 to +75°C
**mV/°C

① Limited only by the characteristics of the external series pass transistor, may be hundreds of volts or many amperes.

② An auxiliary voltage (27 Vdc nom), isolated from both the unregulated dc input voltage and Gnd, is required to bias the IC.

③ Current Load Regulation (max).

MICROWAVE DEVICES

INDUCTORS TYPE	Peak Temperature (Mounting – Max)	Inductance (nH – Typ)	Q (Typ)	Frequency (MHz – Typ) Test	Frequency (MHz – Typ) Self-Reson.	Comments
MCH5800	+300°C	28	19	200	1800	Thin-film chip inductors for use in UHF and hybrid circuits (tuning and biasing applications).
MCH5801	+300°C	35	21	200	1700	
MCH5802	+300°C	115	27	200	1030	
MCH5803	+300°C	150	25	100	920	
MCH5804	+300°C	195	29	100	810	
MCH5805	+300°C	230	30	100	740	

RESISTORS TYPE	R(nom) (Ohms)	Temperature Coefficient (PPM/°C)	P_D (mW-max)	Comments
MCH5862	5.0	50	125	Unencapsulated beam-lead resistor chips designed for hybrid applications at frequencies up to and including microwave wave lengths.
MCH5867	50	50	125	
MCH5871	250	50	125	
MCH5872	500	50	125	
MCH5875	1500	50	125	
MCH5880	5000	50	125	
MCH5883	10,000	50	125	

DUPLEXER TYPE	Temperature	Case	Input Power (Watts-Max)	Isolation (dB-Typ)	Insertion Loss (dB-Typ)	Comments
MCH5890†	0 to +120°C	631	40	25***	0.1***	This solid-state three-port network functions as a single-pole double-throw switch connecting an antenna to a transmitter or receiver.

*** Transmit-Mode, P_{in} = 10 W, I_b = 10 to 20 mA, f = 460 MHz †Hybrid

MILITARY and INDUSTRIAL DEVICES (continued)

MICROWAVE DEVICES (continued)

CAPACITORS		V_{bd}	$C_{(nom)}$	TC(max)	
Type	Temperature	(Volts)	(pF)	(PPM/°C)	Comments
MCH5901	-55 to +150°C	100	1.8 ±20%	100	Unencapsulated beam-lead capacitor chips designed for use in UHF and microwave hybrid circuits as coupling or blocking capacitors.
MCH5902	-55 to +150°C	100	2.5 ±10%	100	
MCH5903	-55 to +150°C	100	3.2 ±10%	100	
MCH5904	-55 to +150°C	100	4.0 ±10%	100	
MCH5905	-55 to +150°C	100	4.8 ±10%	100	
MCH5907	-55 to +150°C	100	6.6 ±10%	100	
MCH5908	-55 to +150°C	100	8.0 ±10%	100	
MCH5909	-55 to +150°C	100	9.6 ±10%	100	
MCH5910	-55 to +150°C	100	11.2 ±10%	100	
MCH5911	-55 to +150°C	100	13 ±10%	100	
MCH5912	-55 to +150°C	100	15.6 ±10%	100	
MCH5914	-55 to +150°C	100	23 ±10%	100	
MCH5915	-55 to +150°C	100	27.5 ±10%	100	
MCH5916	-55 to +150°C	100	33 ±10%	100	
MCH5917	-55 to +150°C	100	40 ±10%	100	
MCH5918	-55 to +150°C	100	48 ±10%	100	
MCH5919	-55 to +150°C	100	57 ±10%	100	

SPECIAL-PURPOSE CIRCUITS

POWER DRIVERS			BV_{CEO}	I_{out} – Typ	h_{FE} – Typ	t_{on}/t_{off}	Comments
TYPE	Temperature	Case	(Vdc – Typ)	(A)		(ns – Typ)	
MCH1002	-30 to +75°C	625	40	0.5	–	115/260 typ	Dual hybrid power drivers
MCH2005	-55 to +125°C	628	30	–	1000	350/450 max	Darlington hybrid power driver

POWER BOOSTER							
TYPE		Case	Impedance-Typ		BW	Current Gain	Output
Temp -55 to +125°C	Temp 0 to +75°C		Input (MΩ)	Output (Ω)	(MHz-Typ)	Typ	Current (mAdc-Max)
MC1538	MC1438	614	0.4	10	1.5	3,000	300

Comments

A high current gain amplifier (70 dB) with unity voltage gain capability.

At a Glance – CONSUMER DEVICES

HIGH-FREQUENCY CIRCUITS

TYPE	Temperature	Case	Small-Signal Voltage Gain (A_V,dB – Typ)	Supply Drain Current (mA – Typ)	Noise Figure (dB – Typ)	Comments
MC1330	0 to +75°C	626	34 ③	15	–	Low-level video detector for color and monochrome TV receivers: replaces 3rd IF, detector, video and AFC buffers.
MC1350	0 to +75°C	626	50 ①	14	9.0 @ 60 MHz	IF amplifier featuring wide-range AGC.
MC1352	0 to +75°C	605	53 ①	27	8.5 @ 60 MHz	TV video IF amplifier with AGC and keyer circuit.
MC1550	–55 to +125°C	602B, 606	25 @ 60 MHz ②	1.5	5.0 @ 60 MHz	Constant input impedance over entire AGC range, RF-IF amplifier for communications equipment.
MFC4010	–10 to +75°C	206	70	3.0	1.0 mV ④ @ 20 Hz to 20 kHz	Designed for AM/IF and low-level audio applications.
MFC8030	0 to +75°C	644	40 @ 10 MHz	Variable	7.0	Differential cascode amplifier, ideal general-purpose differential building block.

① Power gain ② Transducer power gain ③ Conversion gain ④ Output noise voltage

CONSUMER DEVICES (continued)

HIGH FREQUENCY CIRCUITS (continued)

TYPE	Temperature	Case	Typical BV_{CEO} (Vdc)	DC Current Gain (h_{FE}, Min)	Max Base Differential Voltage ($\lvert\Delta V_{BE}\rvert$, mV)	Max Base Differential Current ($\lvert\Delta I_B\rvert$, μA)	Comments
MFC8000	−10 to +75°C	644	40	75	15	1.0	Dual differential amplifiers; designed for the input stage of stereo power amplifiers.
MFC8001	−10 to +75°C	644	50	75	15	1.0	
MFC8002	−10 to +75°C	644	60	75	15	1.0	

SOUND IF AMPLIFIERS						
TYPE	Temperature	Case	Small-Signal Voltage Gain (A_v, dB – Typ)	Supply Drain Current (mA – Typ)	AM Rejection (dB – Typ)	Comments
MC1351	0 to +75°C	605, 647	65 ①	31	45	TV sound IF amplifier with quadrature detector and audio preamplifier
MC1357	0 to +75°C	646, 647	60 ①	15	45	TV sound IF with quadrature detector or FM radio IF amplifier

FM IF AMPLIFIERS						
TYPE	Temperature	Case	Small-Signal Voltage Gain (A_v, dB – Typ)	Supply Drain Current (mA – Typ)	Noise Figure (dB – Typ)	Comments
MFC6010	0 to +75°C	643	40 @ 10.7 MHz	7.0	7.0 (R_S = 750Ω)	FM limiting IF amplifier designed for 10.7 MHz IF applications.

TYPE	Temperature	Case	Supply Voltage Range (Vdc)	Input Signal 3 dB Limiting (μV[rms] – Typ)	AM Rejection (dB – Typ)	Comments
MC1355	0 to +75°C	605, 647	8–18	175	60	Four-stage limiting FM amplifier

LOW-FREQUENCY CIRCUITS

AUDIO POWER AMPLIFIER CIRCUITS						
TYPE	Temperature	Case	Output Power (W – Min)	Input Sensitivity @ Full P_{out} (mV – Max)	THD @ ½ Rated Pwr (% – Typ)	Comments
MC1306	0 to +75°C	626	0.2	270/360 ②	0.5	Complementary power amplifier and preamplifier
MC1316	0 to +75°C	656	2.0	–	2.0	Audio power amplifier with separate preamplifier; A_V Range 16 to 200.
MFC4000	−10 to +75°C	206	0.25	–	0.7	Designed for the output stage of battery-powered portable radios.
MFC6000	−10 to +75°C	643	0.25	–	0.8	Audio amplifier for battery-powered portable radios (output stage)
MFC8010	0 to +55°C	644	1.0	10	1.0	Provides the complete audio system in TV, radio, and phonograph equipment, includes preamplifier.
MFC9000	0 to +75°C	641	4.0	15	1.0	Four-watt audio amplifier, drives 8 or 16-Ω loads, includes preamplifier.
MFC9010	0 to +75°C	641	2.0	15	1.0	Two-watt audio amplifier/amplifier included

DRIVER AND AUDIO PREAMPLIFIER CIRCUITS						
TYPE	Temperature	Case	Open-Loop Voltage Gain (dB – Typ)	Power Supply Voltage (Vdc – Max)	Output Swing (V[rms] – Typ)	Comments
MC1303	0 to +75°C	632	10,000*	±15	5.5	Dual monolithic stereo preamplifier, channel separation of 60 dB min at 10 kHz.
MFC4050	0 to +75°C	206A	42	18	30**	Audio driver designed for driving Class A PNP power output stage of up to 4 watts of audio power.
MFC8020	−10 to +75°C	644	80	35	9.0/V^+ = 32 Vdc	Class B audio driver designed as a preamplifier and driver circuit for complementary output transistors, will drive ≦ 15 W.
MFC8040	0 to +75°C	644	90	33	7.0/V^+ = 30 Vdc	Low noise audio preamplifier, input noise level of 1.0 μV typical

① IF voltage gain ② A_{VOL}, preamplifier/power amplifier *V/V **mA(rms) output current

CONSUMER DEVICES (continued)

REGULATORS

TYPE 0°C to +70°C	Case	V_{in} Range (Vdc)		Input-Output Diff. (Vdc)		V_o Range (Vdc)		TC_{V_o} (%/°C - Typ)	V_{ref} (Vdc)		I_b (mAdc - Max)	I_{out} (mAdc - Max)	P_D (W – Max)		Reg_{Line} (Max $\frac{\%V_o}{V_{in}}$)	Reg_{Load} (%V_o - Max)
		Min	Max	Min	Max	Min	Max		Min	Max			T_C +25°C	T_A +25°C		
POSITIVE VOLTAGE REGULATORS																
MC1469	602A, 614	9.0	35	3.0	40	2.5	32	±0.002	3.2	3.8	.12	200 500	1.8 17.5	0.68 3.0	0.030	0.13 0.05
MFC 4060*	206A	8.0	35	–	3.0	5.0	32	±3.0**	3.8	4.8	–	200	–	1.0	0.03	0.2
MFC 6030*	643	8.0	35	–	3.0	5.0	32	±3.0**	3.8	4.8	–	200	–	1.0	0.03	0.2
NEGATIVE VOLTAGE REGULATORS																
MC1463	602A, 614	–9.0	–35	–3.0	40	–3.8	–32	±0.002	–3.2	–3.8	14	200 500	1.8 9.0	0.68 2.4	0.030	0.13 0.05
MULTI-PURPOSE REGULATORS																
MC1466	632	①②	①②	①	①	0	①	0.01	17.3	19.7	12	①	①	①	0.03	0.03% +3 mV 0.2% +1 mA ③

*Temperature Range of –10 to +75°C
**mV/°C

① Limited only by the characteristics of the external series pass transistor, may be hundreds of volts or many amperes.

② An auxiliary voltage (27 Vdc nom), isolated from both the unregulated dc input voltage and Gnd, is required to bias the IC.

③ Current Load Regulation (max).

SPECIAL-PURPOSE CIRCUITS

STEREO DEMODULATORS			Power Supply Voltage Range (Vdc – Typ)	THD – Typ (%)	P_D – Max (mW)	Comments
TYPE	Temperature	Case				
MC1304	0 to +75°C	605, 647	8.0-14	0.5	625	An FM multiplex stereo demodulator; derives the left and right channel audio information from the detected composite signal. MC1305 permits use of external stereo-channel separation control.
MC1305	0 to +75°C	605, 647	8.0-14	0.5	625	
MC1307	0 to +75°C	605, 647	8.0-14	0.5	625	Thrifty version of MC1304, without audio mute and stereo switch capabilities.

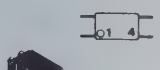
CHROMA DEMODULATORS			Output Voltage Swing (V_{p-p} – Typ)	Output Differential Voltage (Vdc – Typ)	Output Voltage Temperature Coefficient (mV/°C – Typ)	Comments
TYPE	Temperature	Case				
MC1326	0 to +75°C	605, 647	10	0.3	3.0	Dual doubly balanced chroma demodulator with RGB matrix and chroma driver stages.
MC1328	0 to +75°C	603, 605, 647	10	0.3	3.0	Dual doubly balanced chroma demodulator.

TUNING INDICATOR			Drain Current (mA – Typ)	Saturation Voltage (Vdc – Typ)	Noise Inhibit (Vdc – Typ)	Threshold		Comments
TYPE	Temperature	Case				Lamp On Min/Max (Vdc)	Lamp Off Min/Max (Vdc)	
MC1335	0 to +75°C	626	5.5	0.85	1.9	5.8/ 6.2	5.1/ 6.9	Designed for FM radios and fine tuning of color TV sets.

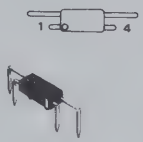
ELECTRONIC ATTENUATOR			Voltage Gain (dB – Typ)	Attenuation Range (dB – Typ)	THD (% – Typ)	Power Supply Voltage Range (Vdc)	Comments
TYPE	Temperature	Case					
MFC6040	0 to +75°C	643	13	90	0.6†	9.0 to 18	Ideal for dc volume control and AGC audio amplifier applications.

†At Unity Gain

LINEAR IC PACKAGES



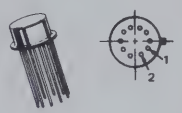
CASE 206
No Suffix



CASE 206A
No Suffix



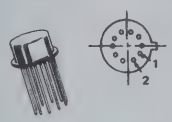
CASE 601 (TO-99)
Suffix G after type number



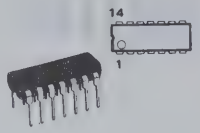
CASE 602A
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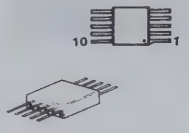
CASE 602B
Suffix G after type number



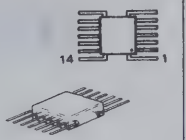
CASE 603
Suffix G after type number



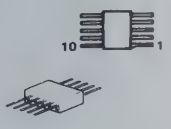
CASE 605 (TO-116)
Suffix P after type number



CASE 606 (TO-91)
Suffix F after type number



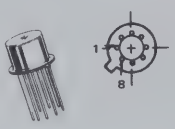
CASE 607 (TO-86)
Suffix F after type number



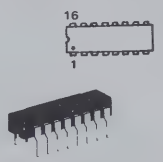
CASE 608
Suffix F after type number



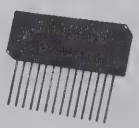
CASE 614
Suffix R after type number



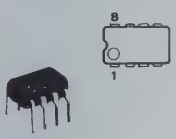
CASE 619
Suffix G after type number



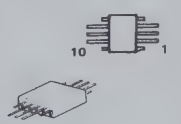
CASE 620
Suffix L after type number



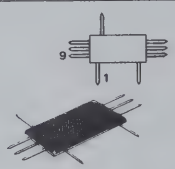
CASE 625
Suffix P after type number



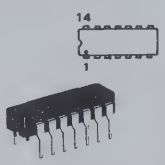
CASE 626
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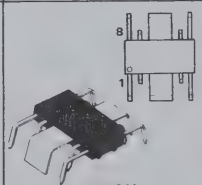
CASE 628 (TO-91)
Suffix F after type number



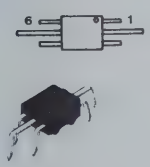
CASE 631
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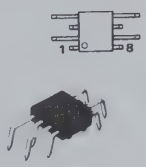
CASE 632 (TO-116)
Suffix L after type number



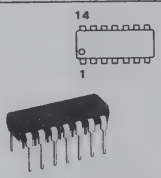
CASE 641
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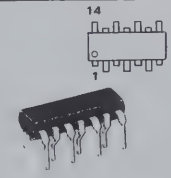
CASE 643
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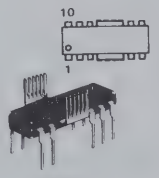
CASE 644
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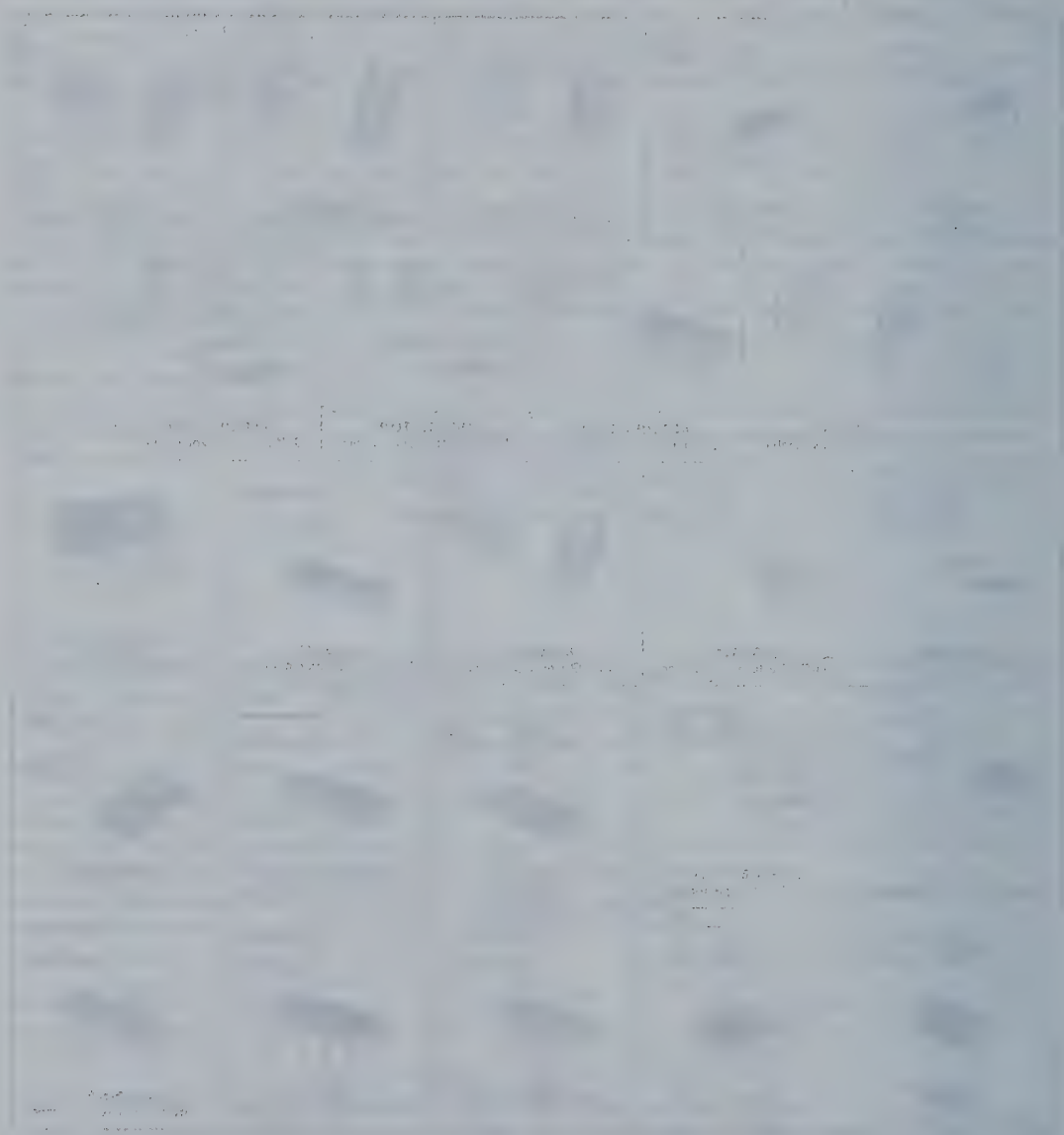
CASE 646 (TO-116)
Suffix P after type number



CASE 647
Suffix PQ after type number



CASE 656
Suffix P after type number



OUTLINE DIMENSIONS

MOTOROLA CASE NUMBER CROSS REFERENCE

Case 1	TO-3
Case 3	TO-3*
Case 3A	TO-3*
Case 4	TO-41
Case 4-04	TO-41
Case 5	TO-36
Case 6	—
Case 7	TO-68
Case 8	—
Case 9	TO-61
Case 11	TO-3
Case 11A	TO-3*
Case 12	TO-3*
Case 17	—
Case 19	—
Case 20	TO-72
Case 21	TO-17
Case 22	TO-18
Case 22A	TO-18*
Case 23	TO-107
Case 24	TO-102
Case 25	—
Case 26	TO-46
Case 27	TO-52
Case 28	—
Case 29	TO-92
Case 29A	—
Case 31	TO-5
Case 32	See Case 654-01
Case 32A	See Case 654-03
Case 32B	See Case 654-05
Case 32C	See Case 654-04
Case 33	See Case 610-02
Case 33A	See Case 610A
Case 34	—
Case 34A	TO-12
Case 35	See Case 655
Case 36	TO-60
Case 39	TO-37
Case 41	—
Case 42	DO-5
Case 43	DO-21
Case 44	DO-4
Case 45	—
Case 45A	—
Case 46	—
Case 47	—
Case 47A	—
Case 47B	—
Case 48	—
Case 49	—
Case 51	DO-7
Case 52	DO-13
Case 53	—
Case 54	TO-3*
Case 55	—
Case 56	DO-4
Case 56A	DO-4
Case 56B	—
Case 57	—
Case 58	—
Case 59	DO-41
Case 60	—
Case 61	TO-41
Case 62	—
Case 63	—
Case 64	TO-48
Case 70	—
Case 77-01	—
Case 77-02	—
Case 79	TO-39
Case 80-02	TO-66
Case 81	DO-31
Case 81A-01	—
Case 81A-02	—
Case 82	—
Case 83	TO-86
Case 85	—
Case 85L	—
Case 86	—
Case 86L	—
Case 87	—
Case 87L	—
Case 88	—
Case 88L	—
Case 90	—
Case 91	—
Case 92	—
Case 94	—
Case 100	—
Case 105	—
Case 106	—
Case 107	—
Case 108	—
Case 109	—
Case 110	—
Case 111	—
Case 112	—
Case 113	—
Case 114	—
Case 115	—
Case 116	—
Case 117	—
Case 118	—
Case 119	—
Case 120	—
Case 121	—
Case 122	—
Case 123	—
Case 124	—
Case 125	—
Case 126	—
Case 127	—
Case 128	—
Case 129	—
Case 130	—
Case 131	—
Case 132	—
Case 133	—
Case 134	—
Case 135	—
Case 136	—
Case 137	—
Case 138	—
Case 139	—
Case 142	—
Case 143	TO-9
Case 144-02	—
Case 144A-02	—
Case 144B-02	—
Case 144C-01	—
Case 144D-01	—
Case 144D-02	—
Case 144D-03	—
Case 145-01	—
Case 145A-01	—
Case 145A-02	—
Case 145B-02	—
Case 145C-01	—
Case 145D-01	—
Case 146	DO-14
Case 149-02	TO-1
Case 152	—
Case 154	—
Case 154A	—
Case 155	—
Case 155A	—
Case 156	—
Case 156A	—
Case 157	—
Case 157A	—
Case 158	—
Case 159	—
Case 160	TO-59
Case 160A	TO-59
Case 161	TO-41

*Modified

MOTOROLA CASE NUMBER CROSS REFERENCE (continued)

Case 166	–
Case 167	–
Case 168	–
Case 169	–
Case 171	–
Case 172	–
Case 173	–
Case 174	–
Case 175	–
Case 177	TO-114
Case 178	–
Case 179	–
Case 180	–
Case 181	–
Case 182	–
Case 183	–
Case 184	–
Case 188	–
Case 189	–
Case 190	–
Case 197	–
Case 198	–
Case 199-01	–
Case 206	–
Case 206A	–
Case 208	–
Case 209	–
Case 210	–
Case 212	–
Case 226	–
Case 229-01	
Case 601	TO-99
Case 602A	–
Case 602B	–
Case 603	TO-100
Case 604	–
Case 605	TO-116
Case 606	TO-91
Case 607	TO-86
Case 608	TO-90
Case 609	TO-85
Case 610-02	TO-89
Case 610A	–
Case 612	–
Case 614	–
Case 617	–
Case 618	–
Case 619	–
Case 620	–
Case 625	–
Case 626	–
Case 628	TO-91
Case 631	–
Case 632	TO-116
Case 637	–
Case 641	–
Case 642	TO-76
Case 643	–
Case 644	–
Case 646	TO-116
Case 647	–
Case 654-01	–
Case 654-03	–
Case 654-04	–
Case 654-05	–
Case 655	TO-71
Case 656	–

REGISTERED CASE NUMBER CROSS REFERENCE

DO-4	Case 44
	Case 56
	Case 56A
DO-5	Case 42
DO-7	Case 51
DO-13	Case 52
DO-14	Case 146
DO-21	Case 43
DO-31	Case 81
DO-41	Case 59
TO-1	Case 149
TO-3	Case 1
	Case 11
TO-3*	Case 3
	Case 3A
	Case 11A
	Case 12
	Case 54
TO-5	Case 31
TO-9	Case 143
TO-12	Case 34A
TO-17	Case 21
TO-18	Case 22
TO-18*	Case 22A
TO-36	Case 5
TO-37	Case 39
TO-39	Case 79
TO-41	Case 4
	Case 4-04
	Case 61
	Case 161
TO-46	Case 26
TO-48	Case 64
TO-52	Case 27
TO-59	Case 160
	Case 160A
TO-60	Case 36
TO-61	Case 9
TO-66	Case 80
TO-68	Case 7
TO-71	Case 655
TO-72	Case 20
TO-76	Case 642
TO-85	Case 609
TO-86	Case 83
	Case 607
TO-89	Case 610-02
TO-90	Case 608
TO-91	Case 606
	Case 628
TO-92	Case 29
TO-99	Case 601
TO-100	Case 603
TO-102	Case 24
TO-107	Case 23
TO-114	Case 177
TO-116	Case 605
	Case 632
	Case 646

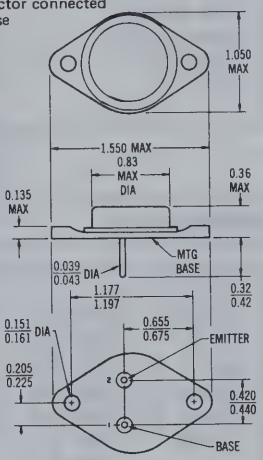
*Modified

CASE DIMENSIONS

Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

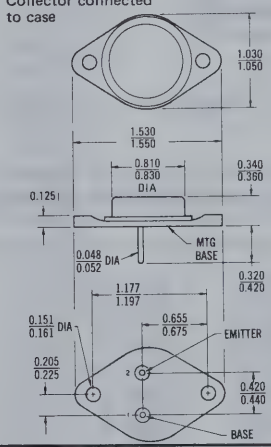
CASE 1 TO-3 Package

Collector connected to case



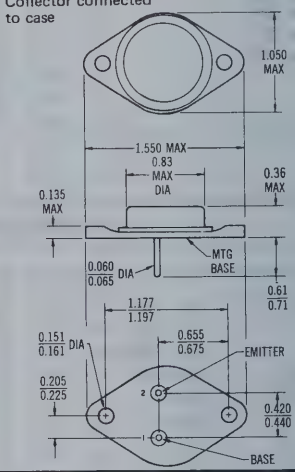
CASE 3 (TO-3 Except Pin Diameter)

Collector connected to case



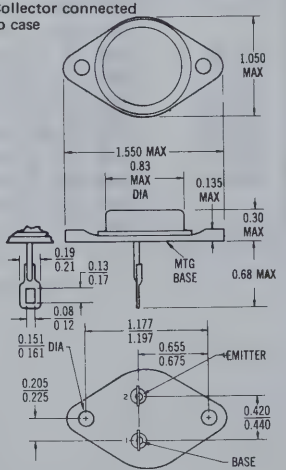
CASE 3A (TO-3 Except Pin Diameter)

Collector connected to case



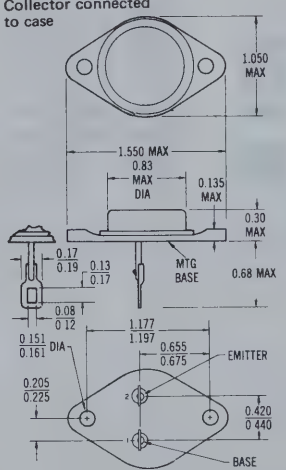
CASE 4 TO-41 Package

Collector connected to case



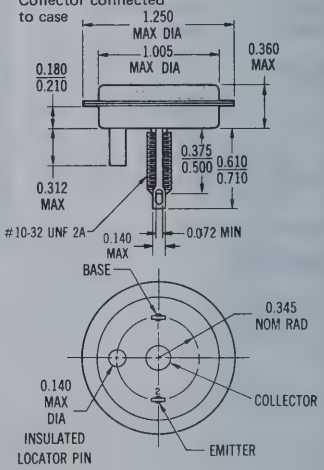
CASE 4-04 TO-41 Package

Collector connected to case



CASE 5 TO-36 Package

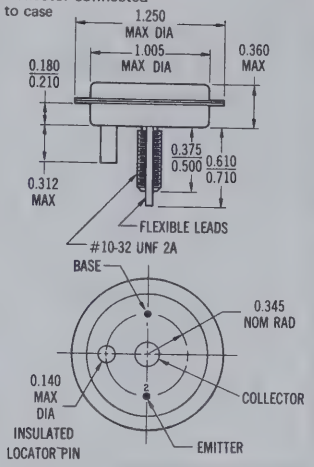
Collector connected to case



Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

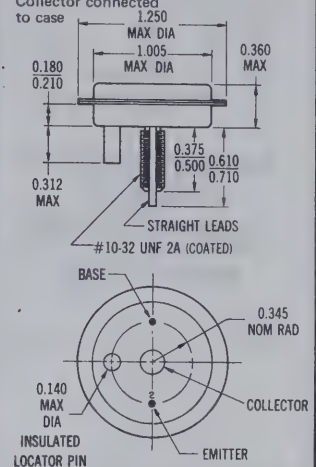
CASE 6

Collector connected to case



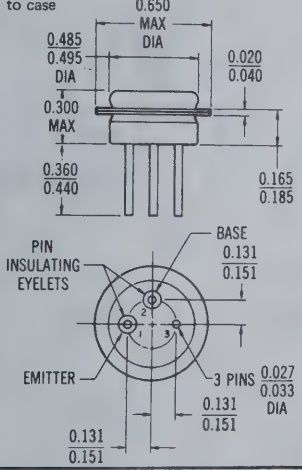
CASE 7 TO-68 Package

Collector connected to case

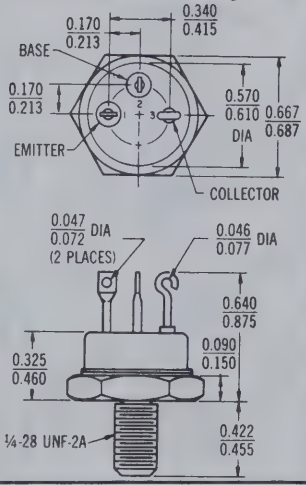


CASE 8

Collector connected to case

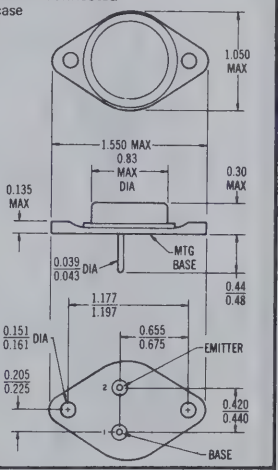


CASE 9 TO-61 Package



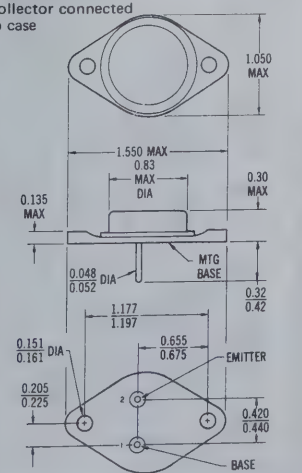
CASE 11 TO-3 Package

Collector connected to case



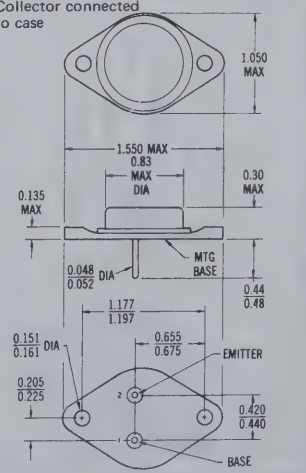
CASE 11A (TO-3 Except Pin Diameter)

Collector connected to case

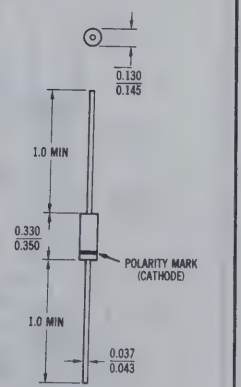


CASE 12 (TO-3 Except Pin Diameter)

Collector connected to case

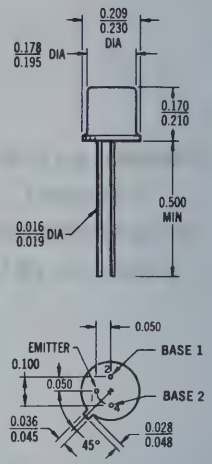


CASE 17

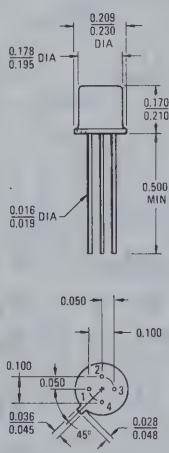


Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

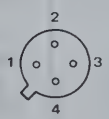
CASE 19



CASE 20 TO-72 Package



CASE 20 STYLES



Style 1
Pin 1. Source
2. Drain
3. Gate
4. Case

Style 2
Pin 1. Source
2. Gate
3. Drain
4. Substrate and Case

Style 3
Pin 1. Drain
2. Source
3. Gate
4. Case

Style 4
Pin 1. Source
2. Gate 1
3. Drain
4. Gate 2 – Substrate and Case

Style 5
Pin 1. Source
2. Gate
3. Drain
4. Case

Style 6
Pin 1. Drain
2. Source and Substrate
3. Gate
4. Source and Substrate

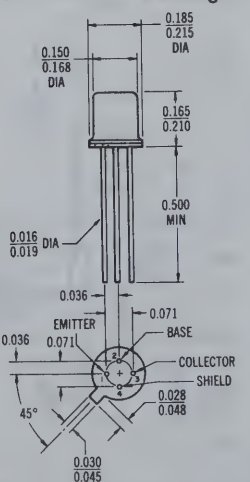
Style 7
Pin 1. Drain
2. Source
3. Gate
4. Case and Substrate

Style 8
Pin 1. Emitter 2
2. Base 1
3. Collector
4. Emitter 1, Base 2

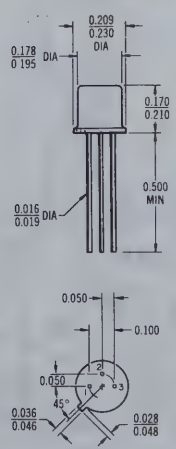
Style 9
Pin 1. Drain
2. Gate 2
3. Gate 1
4. Source, Substrate and Case

Style 10
Pin 1. Emitter
2. Base
3. Collector
4. Case

CASE 21 TO-17 Package



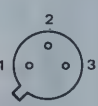
CASE 22 TO-18 Package



CASE 22 STYLES

Style 1
Pin 1. Emitter
2. Base
3. Collector

Style 2
Pin 1. Source Substrate, and Case
2. Gate
3. Drain



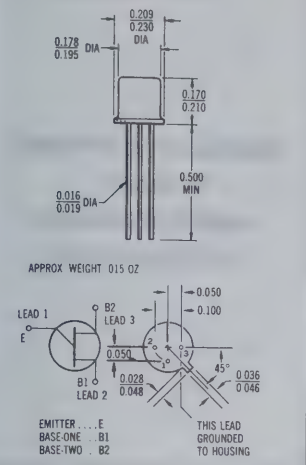
Style 3
Pin 1. Source
2. Drain
3. Gate

Style 4
Pin 1. Source
2. Drain
3. Gate and Case

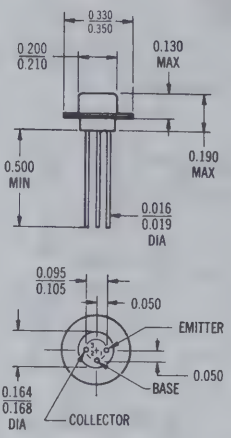
Style 5
Pin 1. Emitter
2. Base 1
3. Base 2

Style 6
Pin 1. Cathode
2. Gate
3. Anode

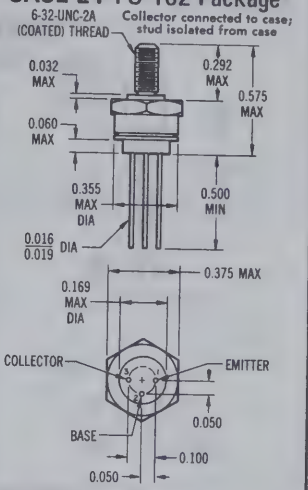
CASE 22A
(TO-18 Except Lead Position)



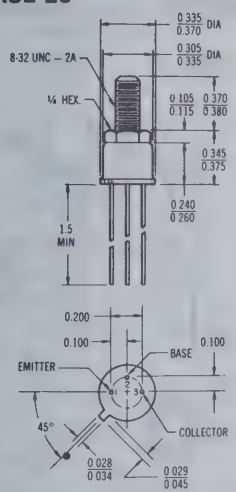
CASE 23 TO-107 Package



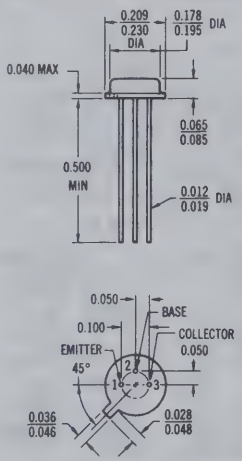
CASE 24 TO-102 Package



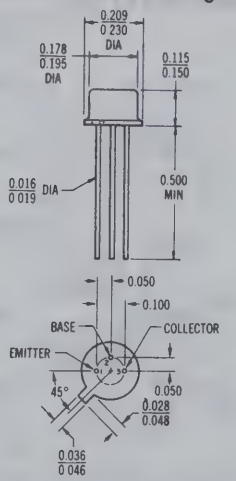
CASE 25



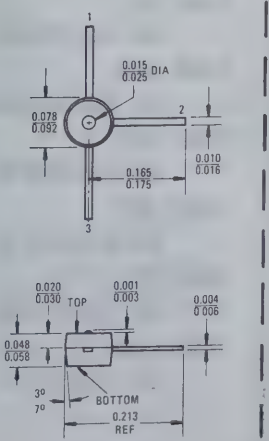
CASE 26 TO-46 Package



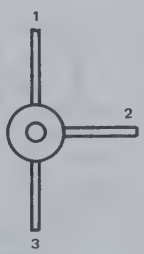
CASE 27 TO-52 Package



CASE 28



CASE 28 STYLES



Style 1
Pin 1. Base
2. Emitter
3. Collector

Style 2
Pin 1. Anode 2
2. Anode 1
3. Cathode (Common)

Style 3
Pin 1. Cathode 2
2. Cathode 1
3. Anode (Common)

Style 4
Pin 1. Cathode 1
2. Anode 2
3. Cathode 2, Anode 1

Style 5
Pin 1. Drain
2. Source
3. Gate

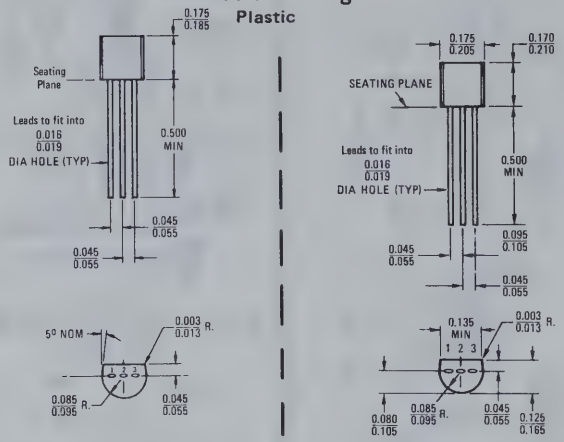
Style 6
Pin 1. Emitter
2. Collector
3. Base

Style 7
Pin 1. Base 1
2. Emitter
3. Base 2

CASE 29-01 CASE 29-02

TO-92 Package

Plastic



Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

CASE 29 STYLES



Style 1
Pin 1. Emitter
2. Base
3. Collector

Style 2
Pin 1. Base
2. Emitter
3. Collector

Style 3
Pin 1. Anode
2. Anode
3. Cathode

Style 4
Pin 1. Cathode
2. Cathode
3. Anode

Style 5
Pin 1. Drain
2. Source
3. Gate

Style 6
Pin 1. Gate
2. Source and Substrate
3. Drain

Style 7
Pin 1. Source
2. Drain
3. Gate

Style 8
Pin 1. Drain
2. Gate
3. Source and Substrate

Style 9
Pin 1. Base 1
2. Emitter
3. Base 2

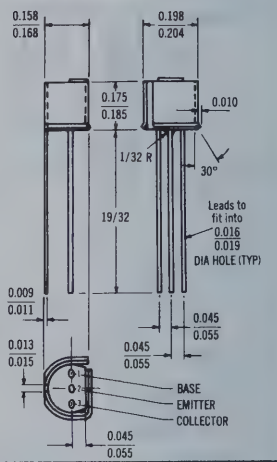
Style 10
Pin 1. Cathode
2. Gate
3. Anode

Style 11
Pin 1. Anode
2. Cathode and Anode
3. Cathode

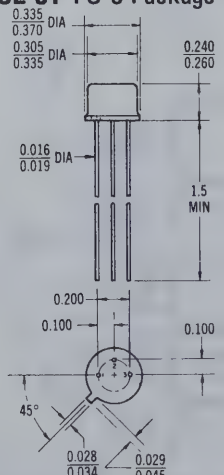
Style 12
Pin 1. Anode 1
2. Gate
3. Anode 2

Style 13
Pin 1. Anode 1
2. Gate
3. Cathode 2

CASE 29A PLASTIC TRANSISTOR WITH SHIELD



CASE 31 TO-5 Package



CASE 31 STYLES



Pin 1. Emitter
2. Base
3. Collector



Pin 1. Cathode
2. Gate
3. Anode

CASE 32
See Case 654-01

CASE 32A
See Case 654-03

CASE 32B
See Case 654-05

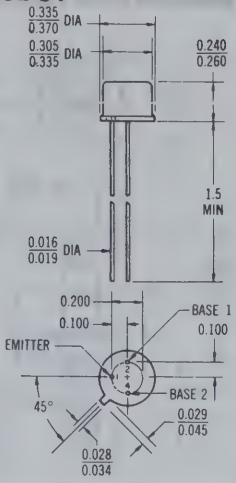
CASE 32C
See Case 654-04

CASE 33
See Case 610-02

CASE 33A
See Case 610A

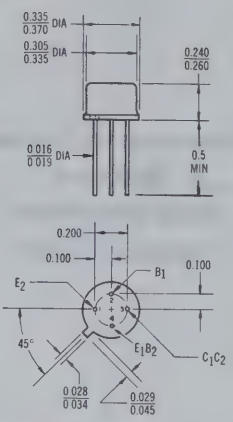
Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

CASE 34



CASE 34A TO-12 Package

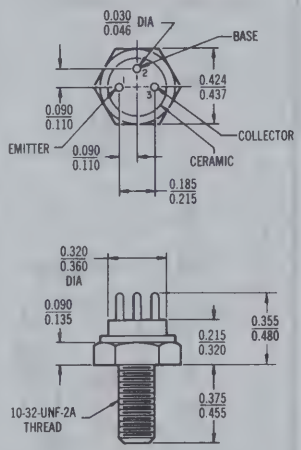
Collector connected to case



CASE 35

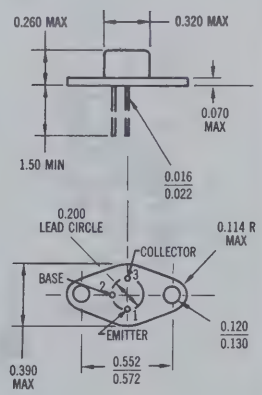
See Case 655

CASE 36 TO-60 Package



CASE 39 TO-37 Package

Collector connected to case

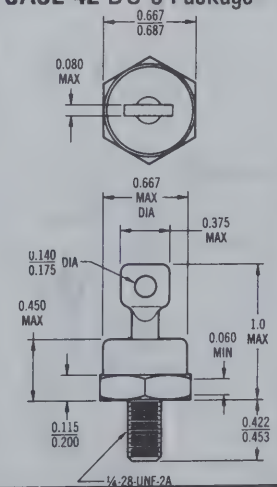


CASE 41

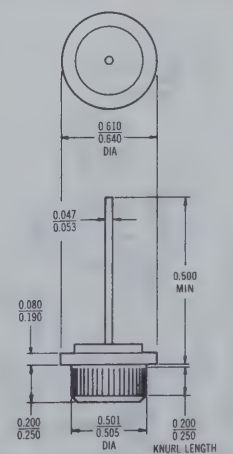


PKG.	OUTLINE DIMENSIONS (INCHES)			
	A MAX	B MAX	C ±0.002	D MIN
41-01	1.00	0.500	0.032	1.25
41-02	0.500	0.375	0.032	1.25
41-03	1.030	0.378	0.032	1.25
41-04	1.220	0.641	0.032	1.75
41-05	0.655	0.641	0.032	1.25
41-06	0.520	0.275	0.020	1.25
41-07	1.000	0.375	0.032	1.25
41-08	0.520	0.260	0.030	1.00
41-09	0.780	0.260	0.030	1.00
41-10	1.155	0.323	0.030	1.00

CASE 42 DO-5 Package

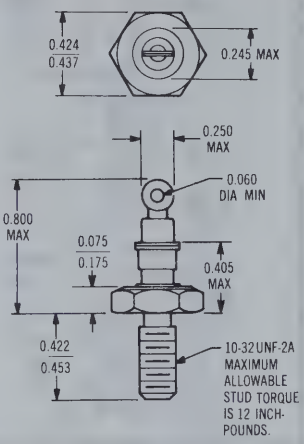


CASE 43 DO-21 Package

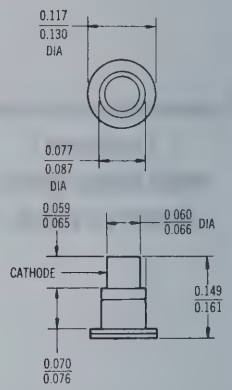


Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

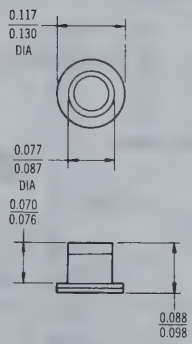
CASE 44 DO-4 Package



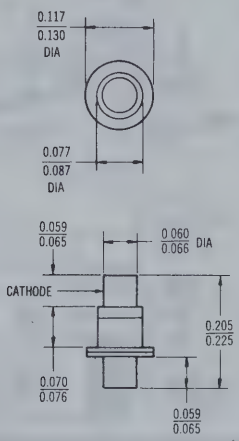
CASE 45



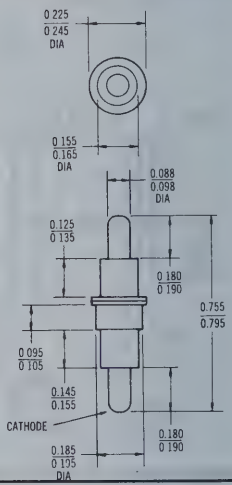
CASE 45A



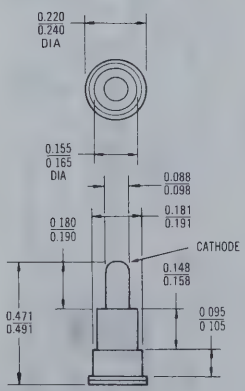
CASE 46



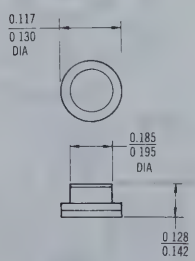
CASE 47



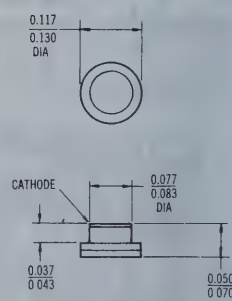
CASE 47A



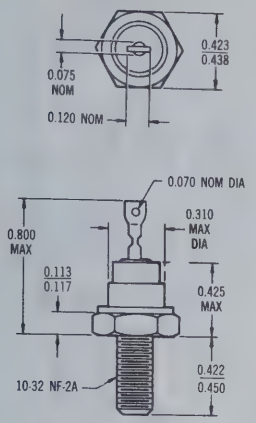
CASE 47B



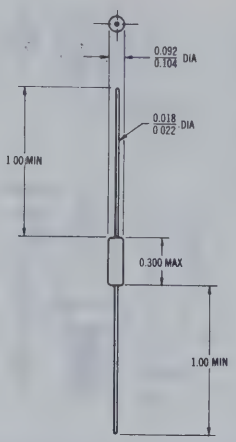
CASE 48



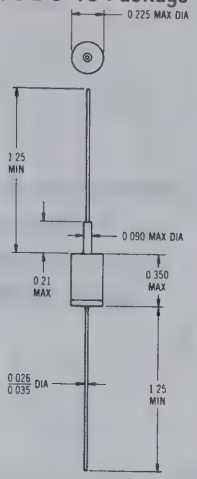
CASE 49



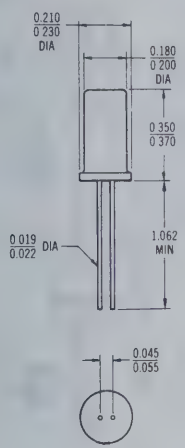
CASE 51 DO-7 Package



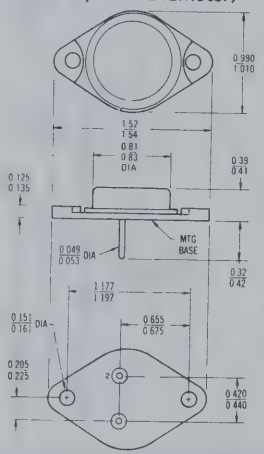
CASE 52 DO-13 Package



CASE 53



CASE 54
(TO-3 Except Pin Diameter)



CASE 54 STYLES

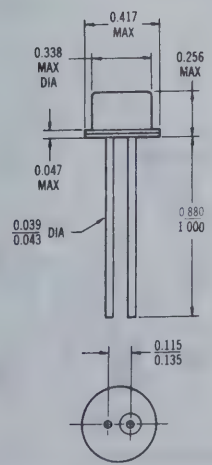
Style 1

Pin 1. Anode
2. Gate
Case. Cathode

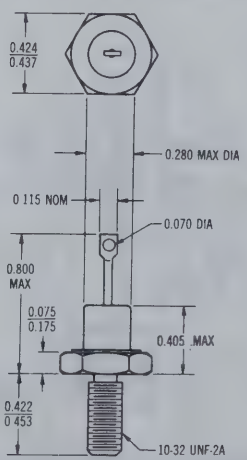
Style 2

Pin 1. Gate
2. Cathode
Case. Anode

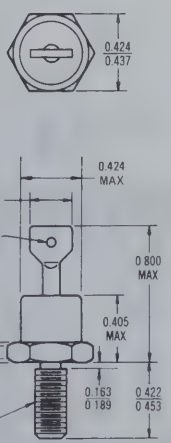
CASE 55



CASE 56 DO-4 Package

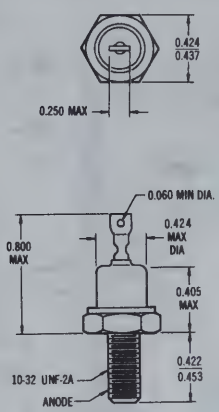


CASE 56A DO-4 Package

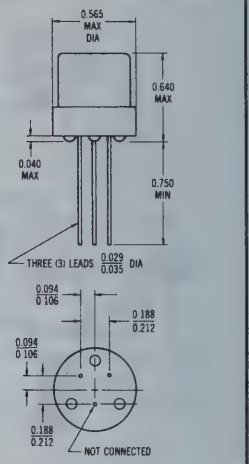


Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

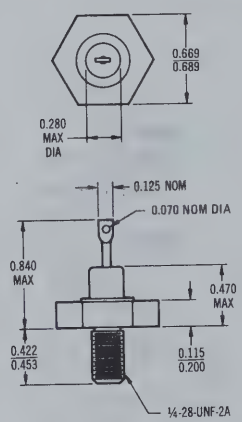
CASE 56B



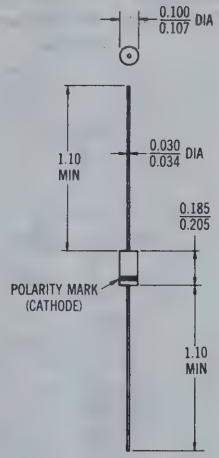
CASE 57



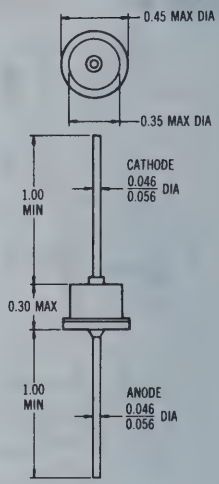
CASE 58



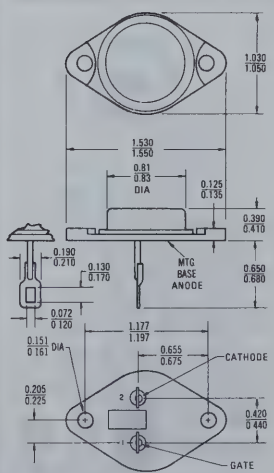
CASE 59 DO-41 Package



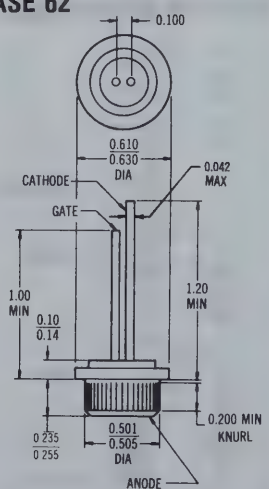
CASE 60



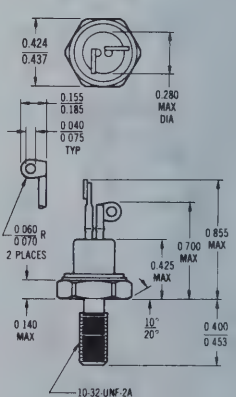
CASE 61 TO-41 Package



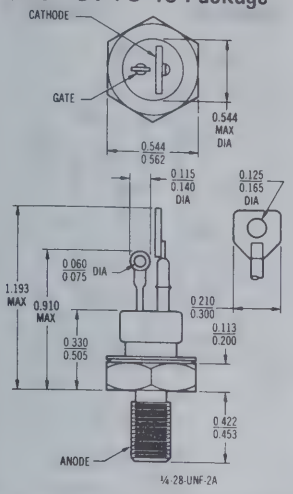
CASE 62



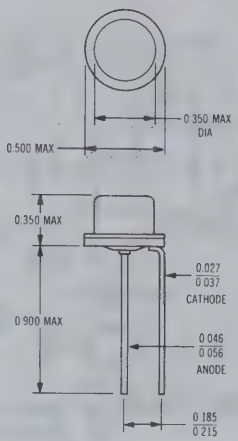
CASE 63



CASE 64 TO-48 Package

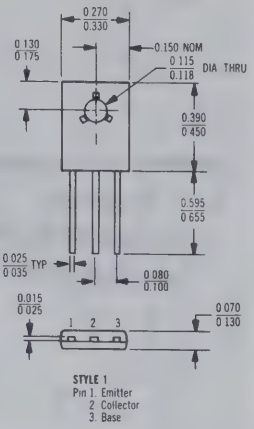


CASE 70

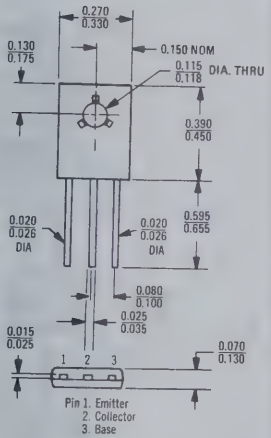


CASE 77-01

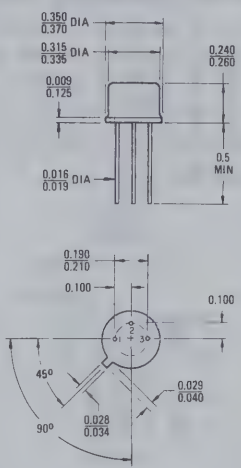
Plastic Transistor



CASE 77-02



CASE 79 TO-39 Package



CASE 79 STYLES

Style 1

Pin 1. Emitter
2. Base
3. Collector

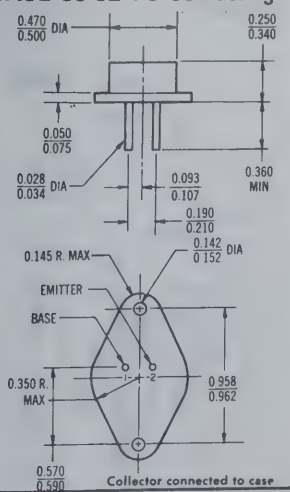
Style 2

Pin 1. Drain
2. Source
3. Gate

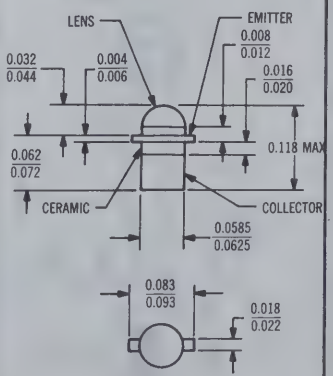
Style 3

Pin 1. Cathode
2. Gate
3. Anode

CASE 80-02 TO-66 Package



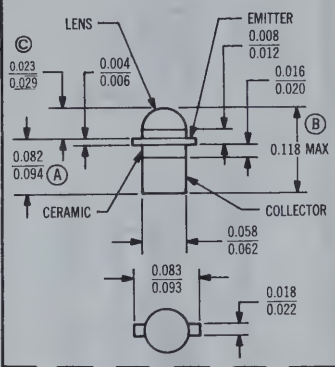
CASE 81 DO-31 Package



Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

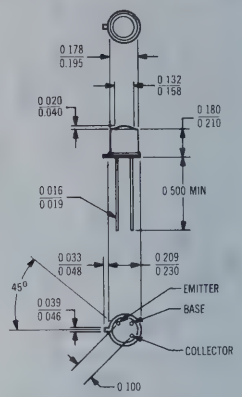
CASE 81A-01



CASE 81A-02

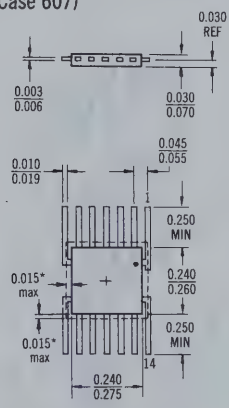
Ⓐ = 0.062/0.072
Ⓑ = 0.105 MAX
Ⓒ = 0.029 MAX

CASE 82



Leads are gold-plated kovar
Collector internally connected to case.
Package weight ≃ 0.45 grams

CASE 83 TO-86 Package
(Also Case 607)

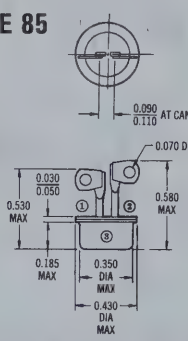


Lead 1 identified by color dot or by elbow on lead.
All leads electrically isolated from package.
*Tolerance for lid skewing, glass meniscus, and glass overrun.

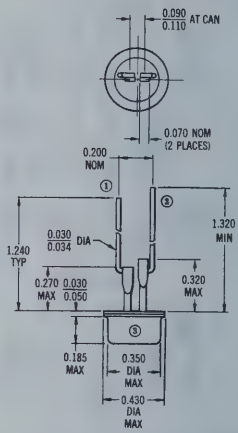
CASE 85,L thru 88,L STYLES

LEAD	STYLE 1 (Thyristors)	STYLE 2 (Triacs)
①	Gate	Gate
②	Cathode	Anode 1
③	Anode	Anode 2

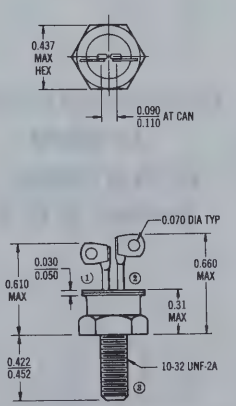
CASE 85



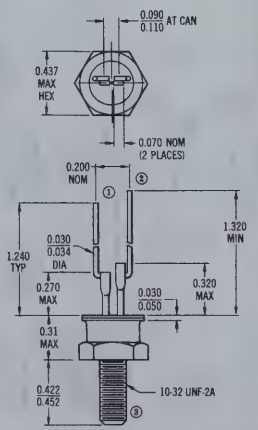
CASE 85L



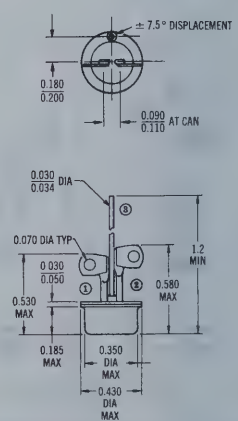
CASE 86



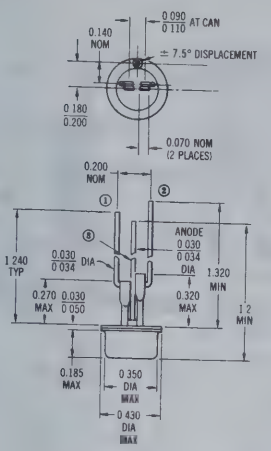
CASE 86L



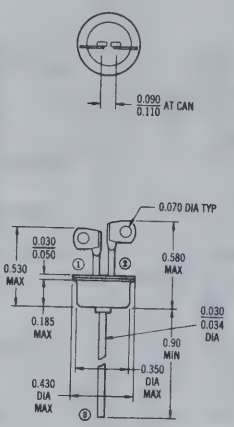
CASE 87



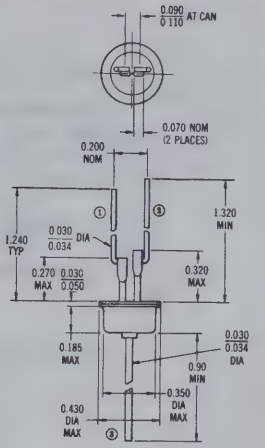
CASE 87L



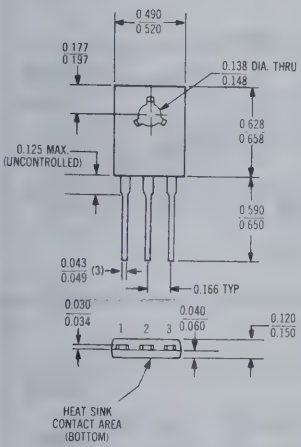
CASE 88



CASE 88L



CASE 90



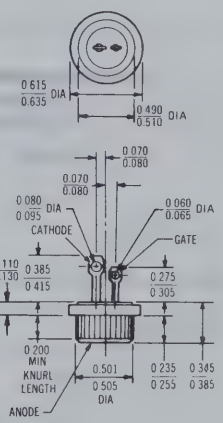
CASE 90 STYLES

Style 1
Pin 1. Cathode
2. Anode
3. Gate

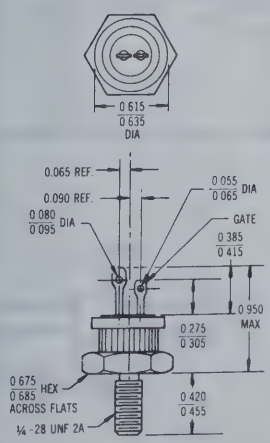
Style 2
Pin 1. Emitter
2. Collector
3. Base

Style 3
Pin 1. Cathode
2. Gate
3. Anode

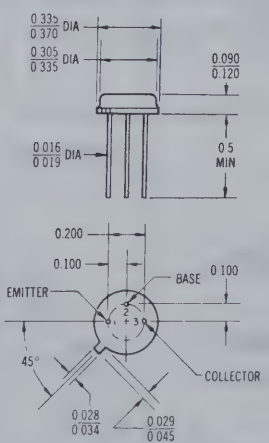
CASE 91



CASE 92

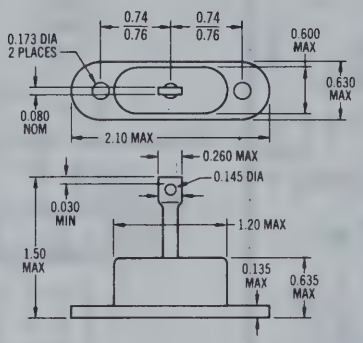


CASE 94

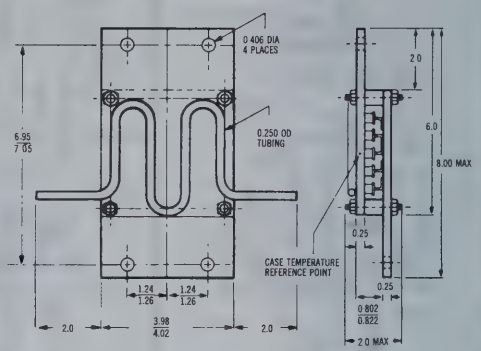


Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

CASE 100



CASE 105



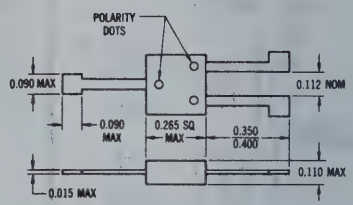
COLOR-CODED POLARITY DOTS:

Y = AC INPUT

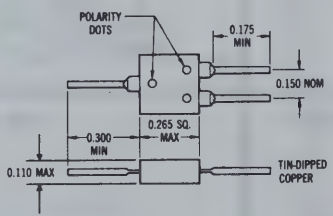
R = +DC OUTPUT

(NO MARK) = −DC OUTPUT

CASE 106

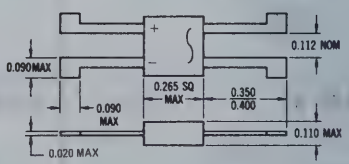


CASE 107

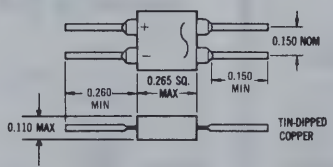


Leads formed to fit into a hole 0.037 min.

CASE 108

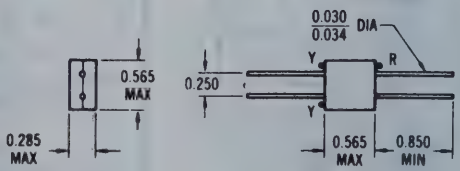


CASE 109

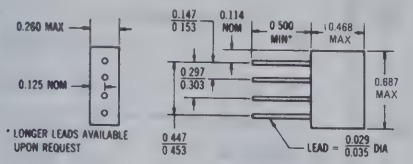


Leads formed to fit into a hole 0.037 min.

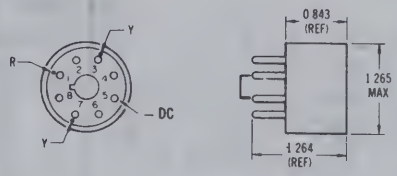
CASE 110



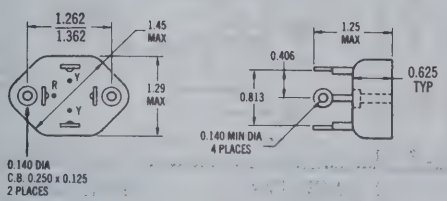
CASE 111



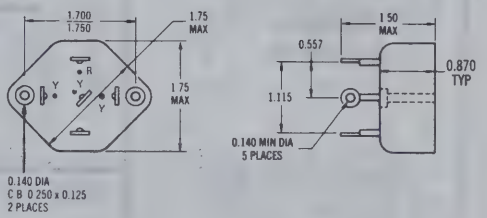
CASE 112



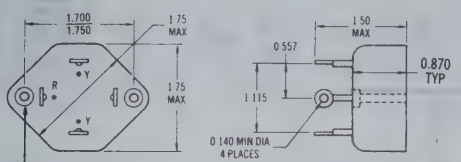
CASE 113



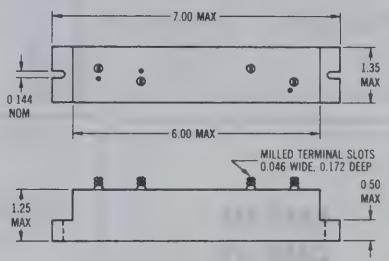
CASE 114



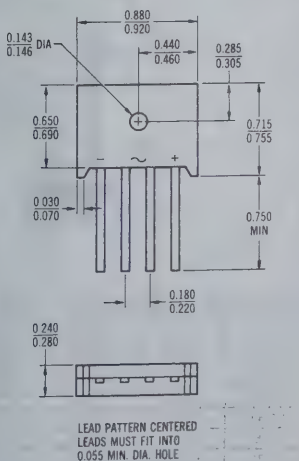
CASE 115



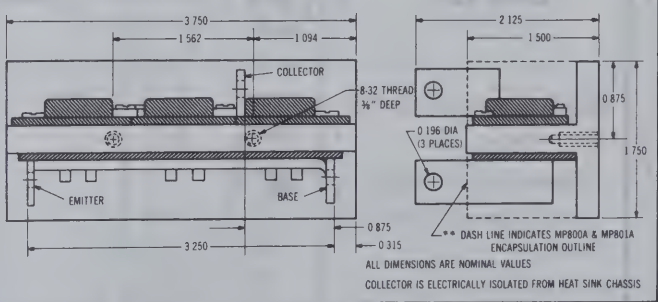
CASE 116



CASE 117

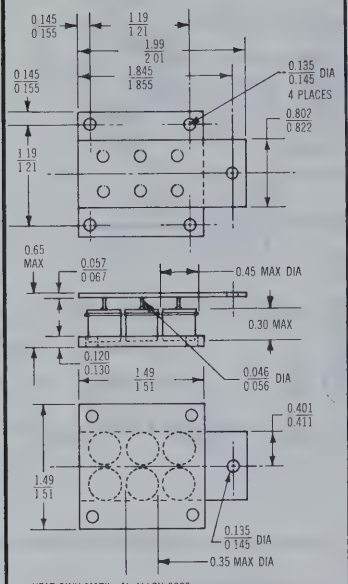


CASE 118



Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

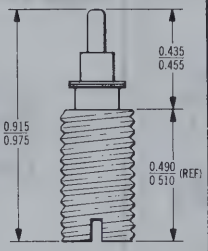
CASE 119



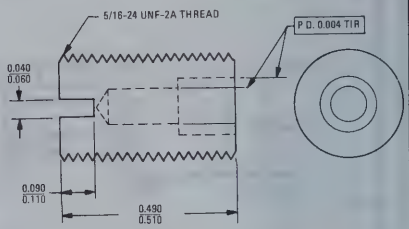
HEAT SINK MAT'L: AL ALLOY 3003 WITH NICKEL PLATING

WEIGHT 30 GRAMS (APPROX)

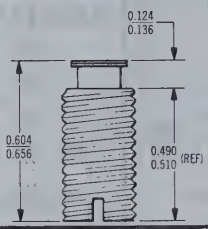
CASE 120



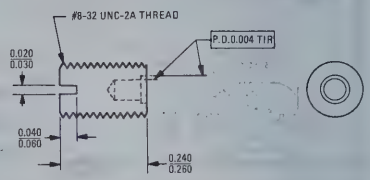
CASE 120,121 ADAPTER DETAIL



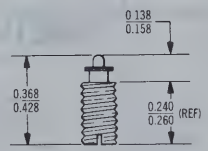
CASE 121



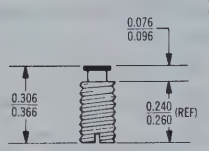
CASE 122,123,124 ADAPTER DETAIL



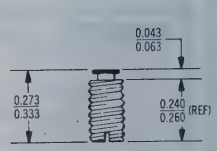
CASE 122



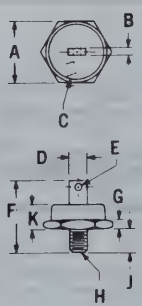
CASE 123



CASE 124

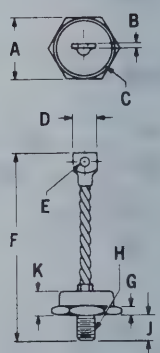


CASE 125
CASE 126
CASE 127
CASE 128



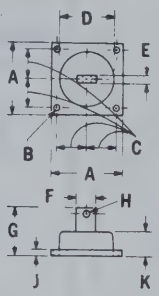
DIMENSION	CASE 125	CASE 126	CASE 127	CASE 128
A (hex)	1.250	1.75	2.00	2.250
B (max)	0.135	0.260	0.260	0.320
C (max dia)	1.20	1.72	1.94	2.20
D (max)	0.525	0.760	1.10	1.10
E (dia)	0.250	0.375	0.562	0.562
F (max)	2.25	3.0	3.50	3.72
G (typ)	0.125	0.375	0.375	0.375
H (thread)	10-32	¾-16 UNF	¾-16 UNF	¾-16 UNF
J (max)	0.500	1.00	1.00	1.00
K (max)	0.570	1.10	1.10	1.10

CASE 129
CASE 130
CASE 131
CASE 132



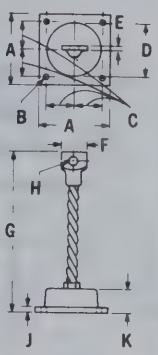
DIMENSION	CASE 129	CASE 130	CASE 131	CASE 132
A (hex)	1.250	1.75	2.00	2.250
B (max)	0.113	0.155	0.200	0.260
C (max dia)	1.20	1.72	1.94	2.20
D (max)	0.590	0.64	1.00	1.155
E (dia)	0.281	0.343	0.531	0.562
F (max)	6.25	8.10	8.10	8.10
G (typ)	0.125	0.375	0.375	0.375
H (thread)	10-32	¾-16 UNF	¾-16 UNF	¾-16 UNF
J (max)	0.500	1.00	1.00	1.00
K (max)	0.570	1.10	1.10	1.10

CASE 133
CASE 134
CASE 135
CASE 136



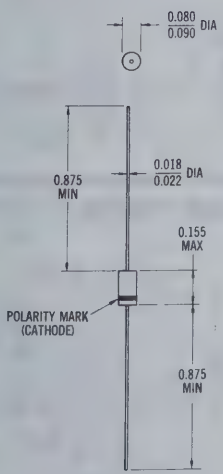
DIMENSION	CASE 133	CASE 134	CASE 135	CASE 136
A (typ)	2.25	3.00	3.00	3.25
B (dia)	0.203	0.281	0.281	0.281
C (max)	0.880	1.255	1.255	1.380
D (max dia)	1.720	2.100	2.200	2.885
E (max)	0.260	0.260	0.320	0.500
F (max)	0.760	1.100	1.100	1.30
G (max)	1.9	2.50	2.70	2.50
H (dia)	0.375	0.562	0.562	0.562
J (max)	0.260	0.260	0.260	0.260
K (max)	1.00	1.00	1.00	1.00

CASE 137
CASE 138
CASE 139

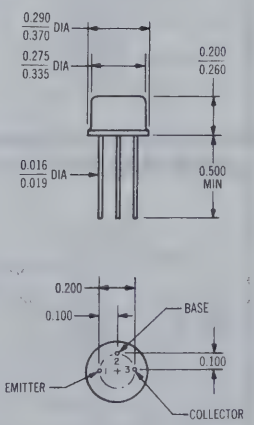


DIMENSION	CASE 137	CASE 138	CASE 139
A (typ)	2.25	3.00	3.00
B (dia)	0.203	0.281	0.281
C (max)	0.880	1.255	1.255
D (max dia)	1.720	2.100	2.20
E (max)	0.155	0.200	0.260
F (max)	0.64	1.00	1.155
G (max)	7.10	6.90	6.90
H (dia)	0.343	0.531	0.562
J (max)	0.260	0.260	0.260
K (max)	1.00	1.00	1.00

CASE 142



CASE 143 TO-9 Package



Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

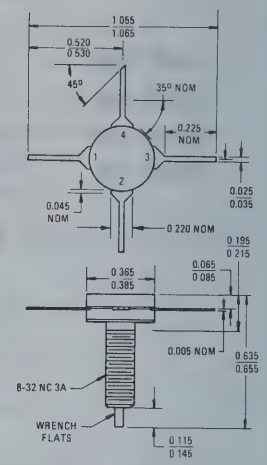
Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

CASE 144-02 thru CASE 145B-02 STYLES

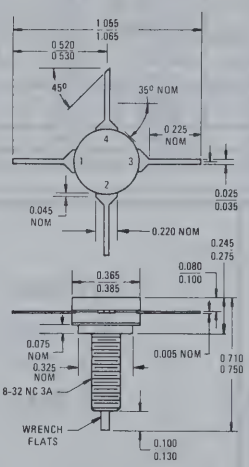
Style 1
Pin 1. Emitter
2. Base
3. Emitter
4. Collector

Style 2
Pin 1. Base
2. Emitter
3. Base
4. Collector

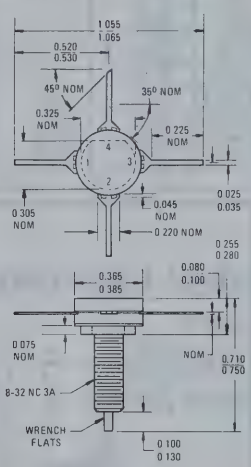
CASE 144-02



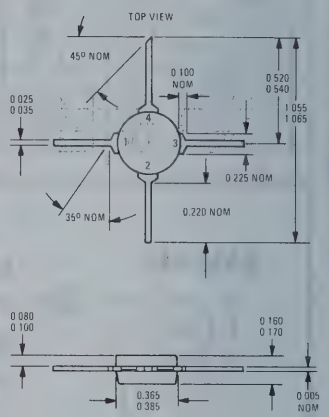
CASE 144A-02



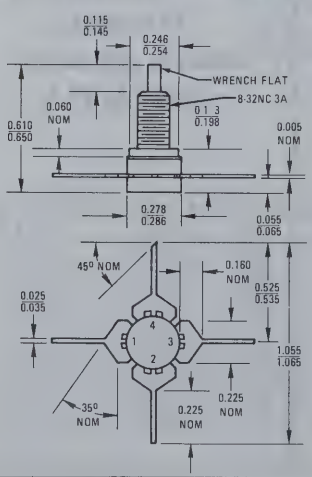
CASE 144B-02



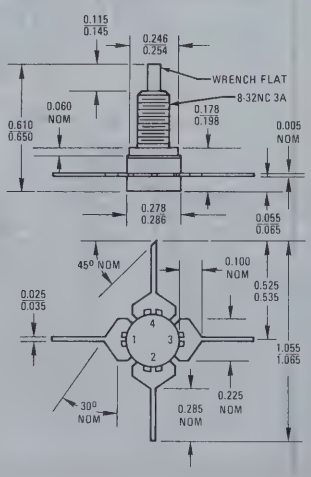
CASE 144C-01



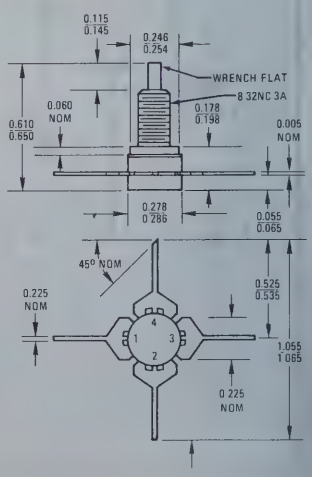
CASE 144D-01



CASE 144D-02

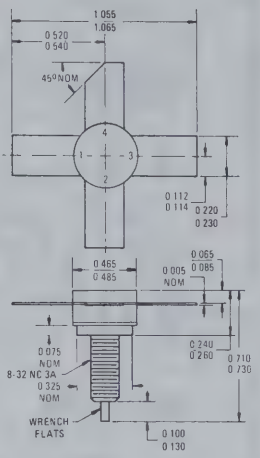


CASE 144D-03

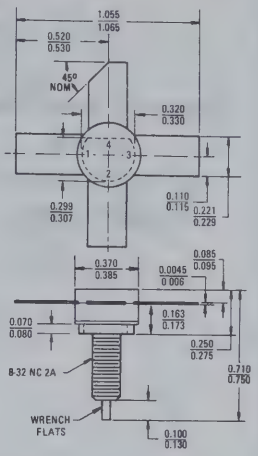


Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

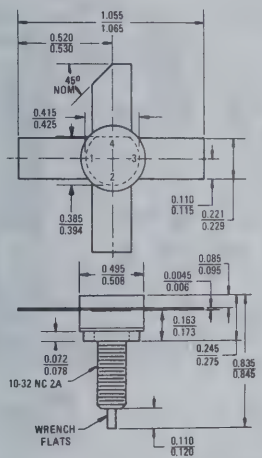
CASE 145-01



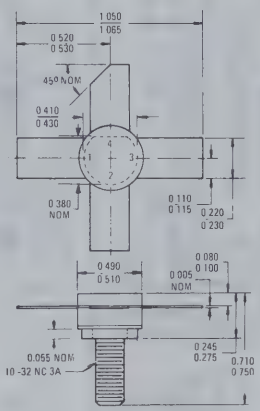
CASE 145A-01



CASE 145A-02

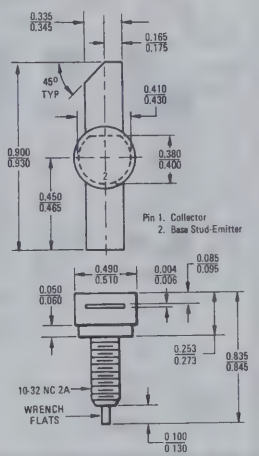


CASE 145B-02



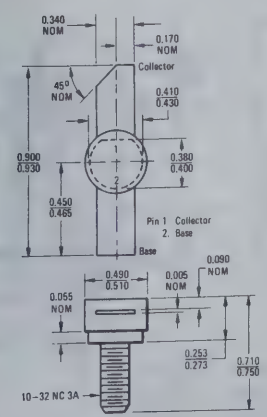
CASE 145C-01

Emitter Connected to Stud

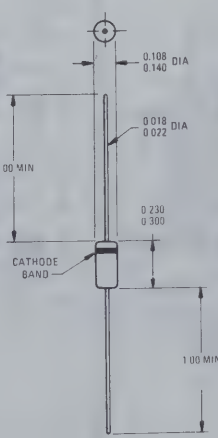


CASE 145D-01

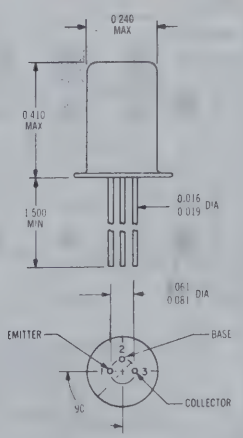
Emitter Connected to Stud



CASE 146 DO-14 Package

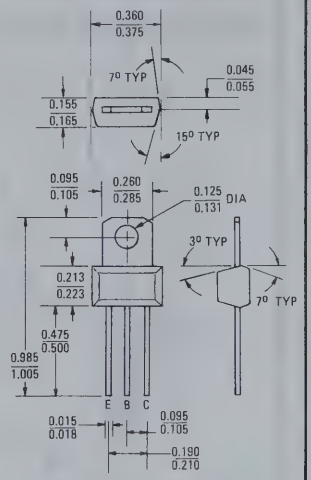


CASE 149-02 TO-1 Package

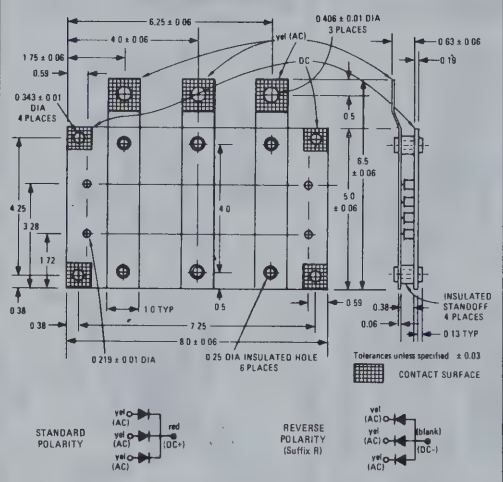


Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

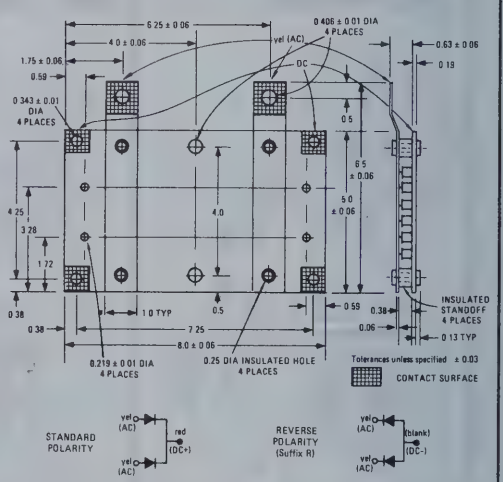
CASE 152 Collector connected to tab



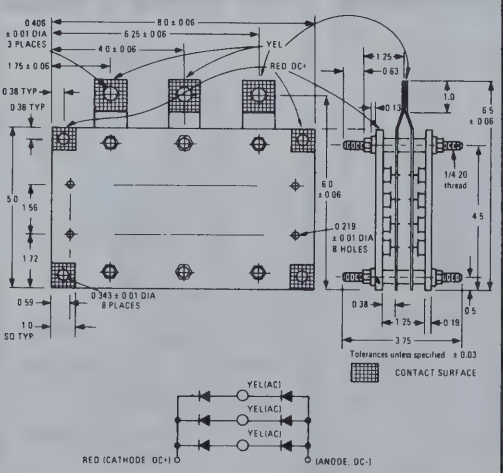
CASE 154



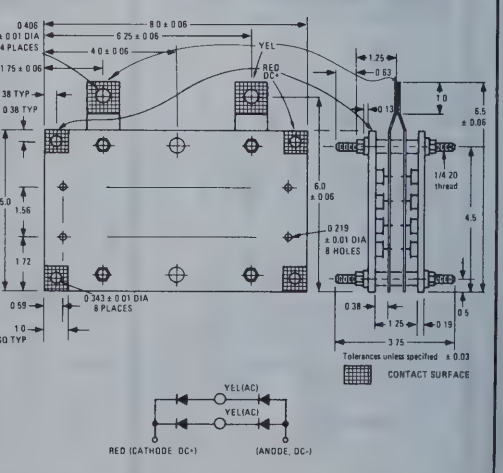
CASE 154A



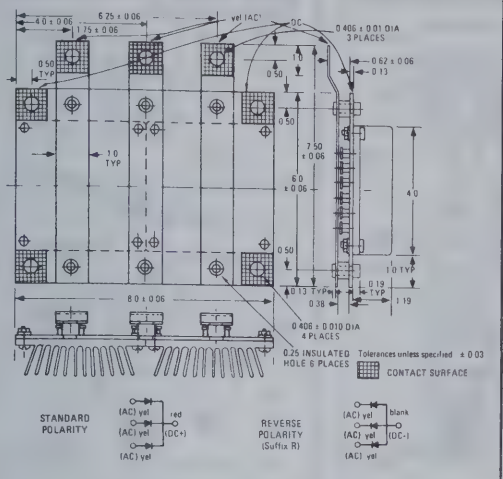
CASE 155



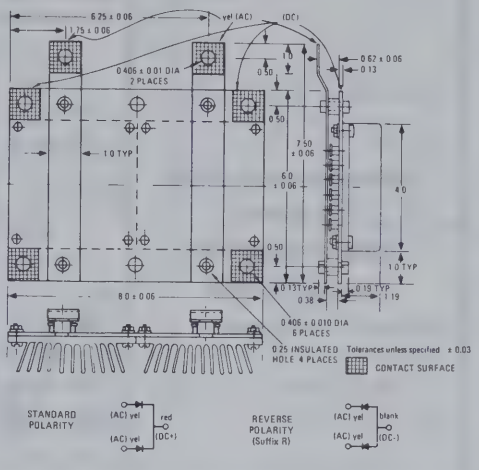
CASE 155A



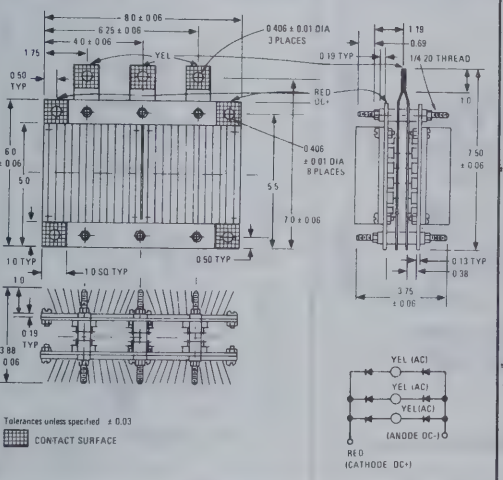
CASE 156



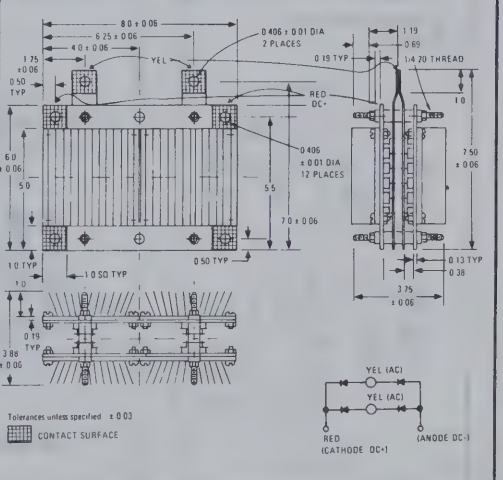
CASE 156A



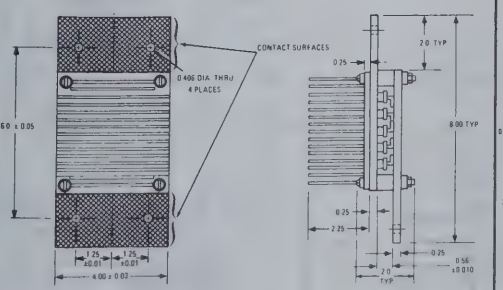
CASE 157



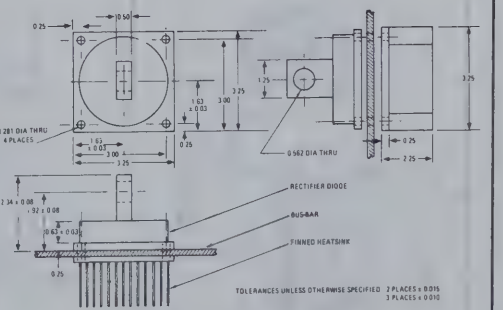
CASE 157A



CASE 158



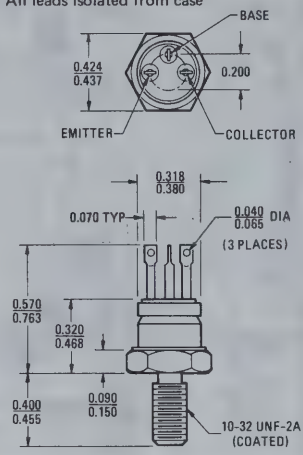
CASE 159



Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

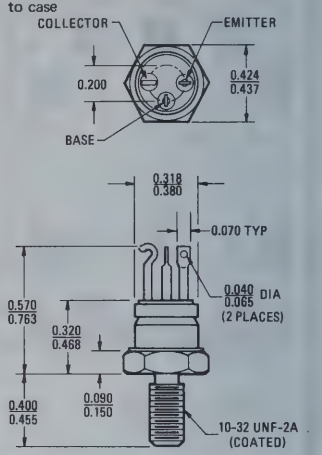
CASE 160 TO-59 Package

All leads isolated from case



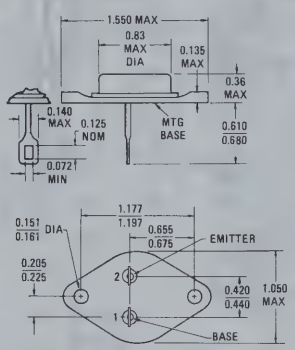
CASE 160A TO-59 Package

Collector connected to case

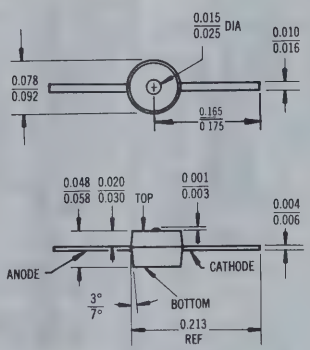


CASE 161 TO-41 Package

Collector connected to case

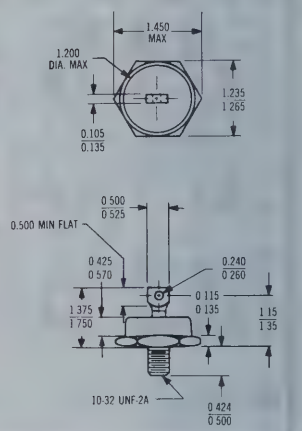


CASE 166

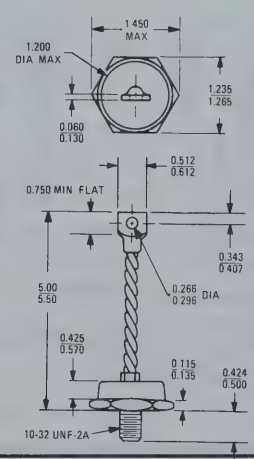


Cathode identified by color dot on top of package.

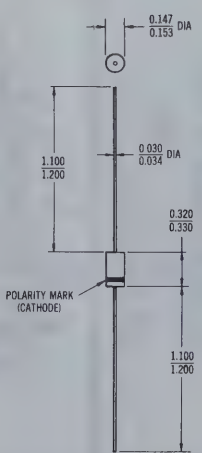
CASE 167



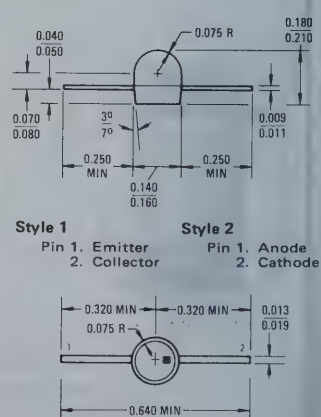
CASE 168



CASE 169



CASE 171



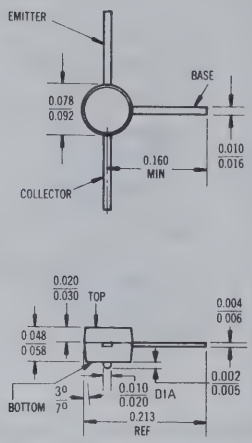
Style 1
Pin 1. Emitter
2. Collector

Style 2
Pin 1. Anode
2. Cathode

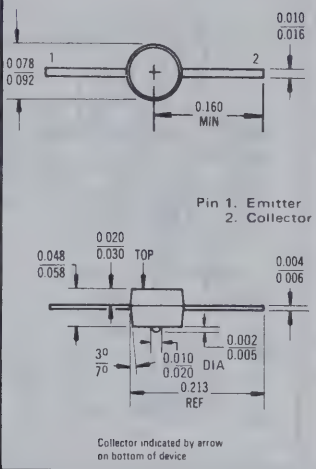
Lead 2 indicated by square bonding pad on bottom of the device.

Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

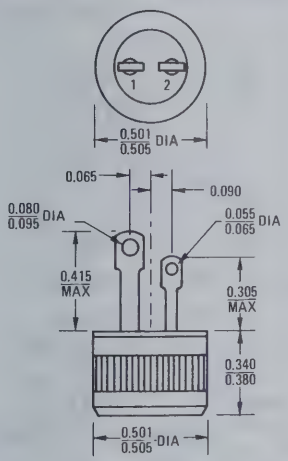
CASE 172



CASE 173



CASE 174



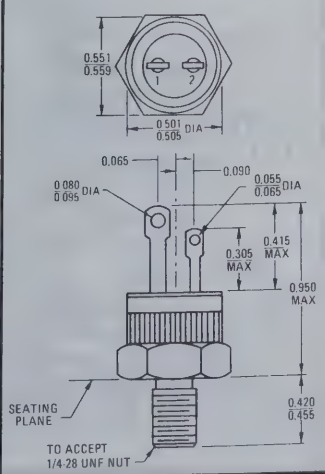
CASE 174 STYLES

Style 1
Pin 1. Cathode
2. Gate
Case. Anode

Style 2
Pin 1. Anode
2. Gate
Case. Cathode

Style 3
Pin 1. Main Terminal 1
2. Gate
Case. Main Terminal 2

CASE 175



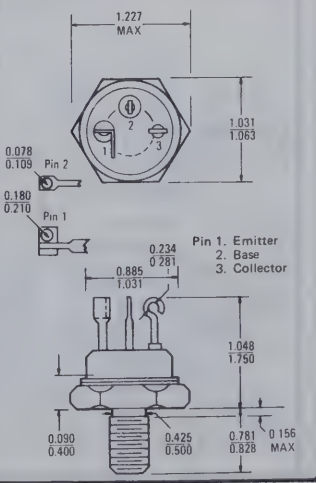
CASE 175 STYLES

Style 1
Pin 1. Cathode
2. Gate
Case. Anode

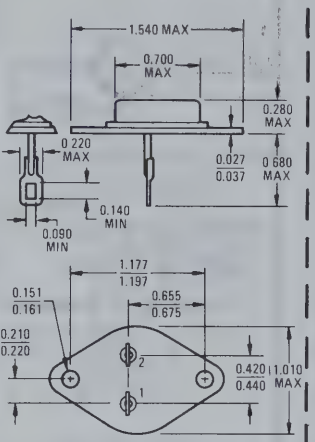
Style 2
Pin 1. Anode
2. Gate
Case. Cathode

Style 3
Pin 1. Main Terminal 1
2. Gate
Case. Main Terminal 2

CASE 177 TO-114 Package



CASE 178

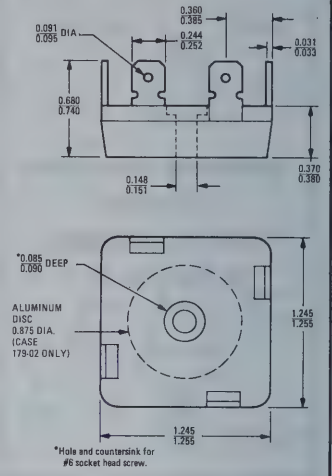


CASE 178 STYLES

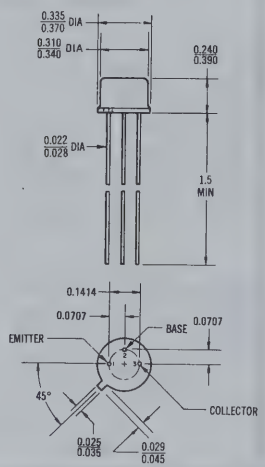
Style 1
Pin 1. Gate
2. Cathode
Case. Anode

Style 2
Pin 1. Gate
2. Main Terminal 1
Case. Main Terminal 2

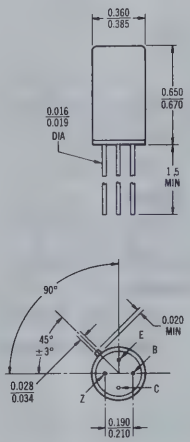
CASE 179-01,-02



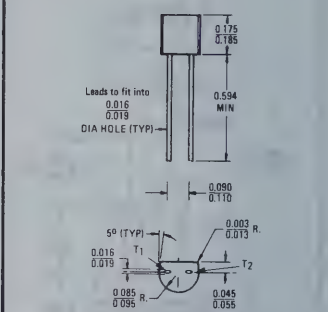
CASE 180



CASE 181



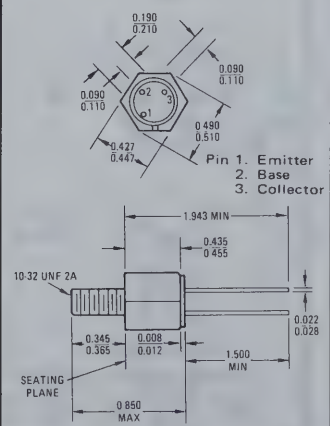
CASE 182-01



Style 1
Pin 1. Anode
2. Cathode

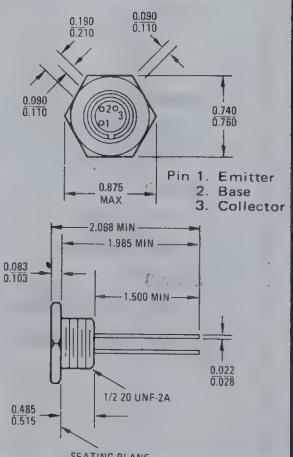
Style 2
Pin 1. Cathode
2. Anode

CASE 183



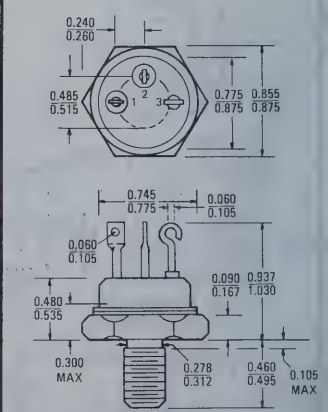
Pin 1. Emitter
2. Base
3. Collector

CASE 184



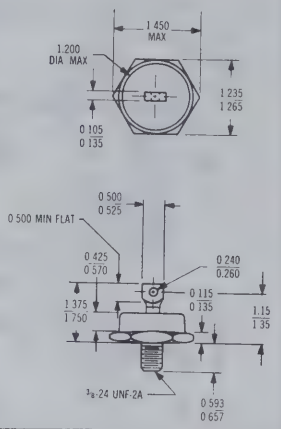
Pin 1. Emitter
2. Base
3. Collector

CASE 188

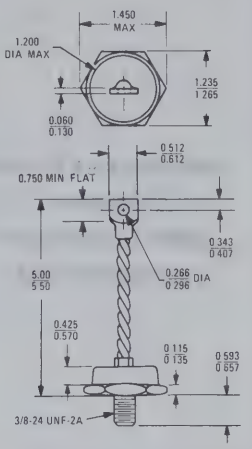


Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

CASE 189

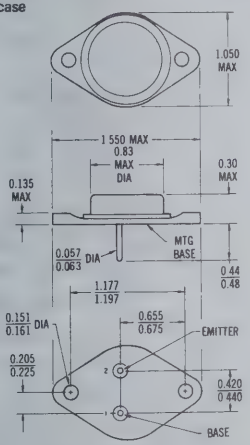


CASE 190



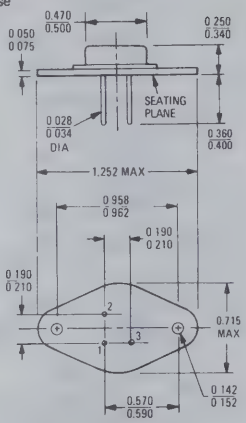
CASE 197

Collector connected
to case



CASE 198

Collector connected
to case

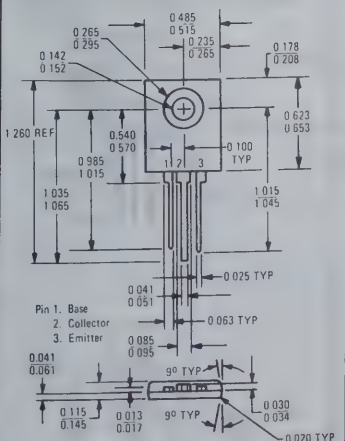


CASE 198 STYLES

Style 1
Pin 1. Emitter
2. Base 1
3. Base 2

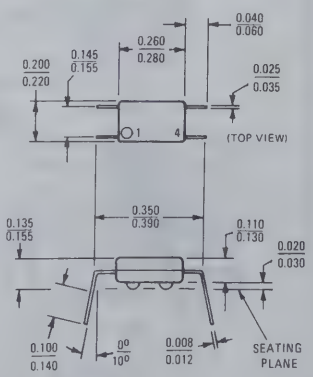
Style 2
Pin 1. Base 1
2. Emitter
3. Base 2

CASE 199-01



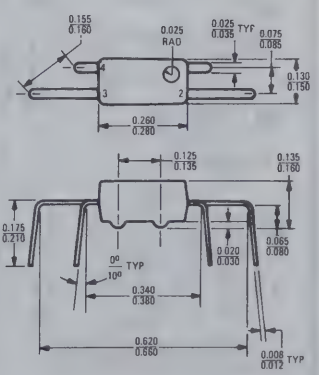
CASE 206

Weight≈0.25 gram (Plastic)



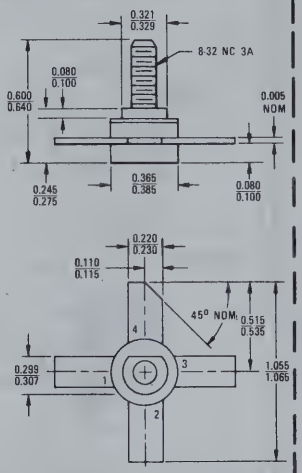
CASE 206A

(Plastic)



Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

CASE 208

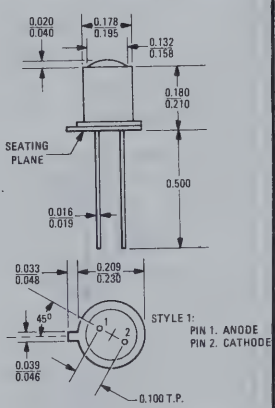


CASE 208 STYLES

Style 1
Pin 1. Emitter
2. Base
3. Emitter
4. Collector

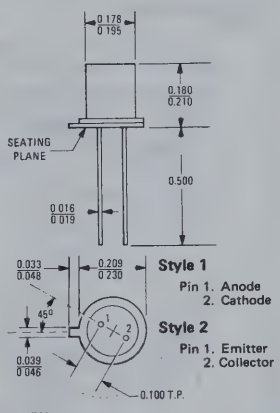
Style 2
Pin 1. Emitter
2. Base
3. Emitter
4. Collector
1 & 3 Grounded to Stud

CASE 209



NOTES:
1 - LEADS ARE GOLD PLATED KOVAR
2 - CATHODE CONNECTED TO CASE
3 - PKG. WT. ≈ 0.45 GRAMS.

CASE 210

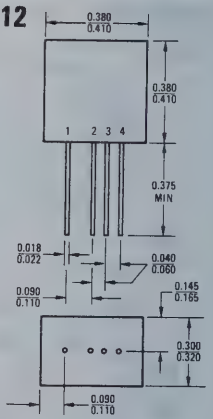


Style 1
Pin 1. Anode
2. Cathode

Style 2
Pin 1. Emitter
2. Collector

NOTES
1 - LEADS ARE GOLD PLATED KOVAR
2 - CATHODE CONNECTED TO CASE
3 - PKG. WT. ≈ 0.45 GRAMS.

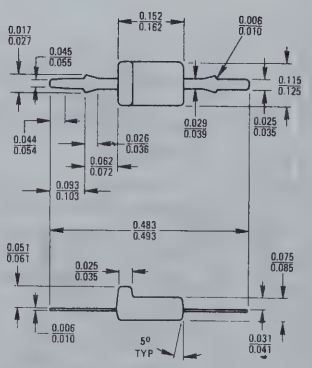
CASE 212



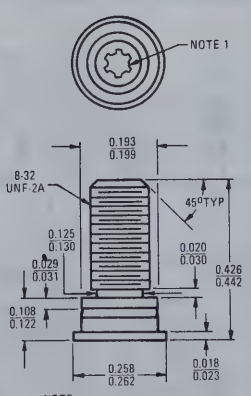
Style 1
Pin 1. Zener
2. Emitter
3. Base
4. Collector

Style 2
Pin 1. Anode
2. Emitter
3. Base
4. Collector

CASE 226



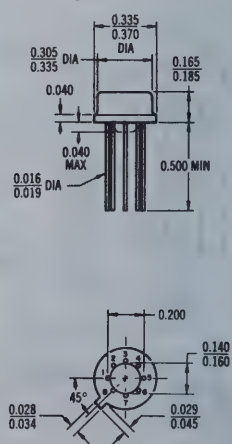
CASE 229-01



NOTE:
1. INTERNAL BRISTOL TYPE SPLINE 0.096 TYP (2.44 MM) 0.070 MIN. (1.78 MM) DEEP.

CASE 601 TO-99 Package

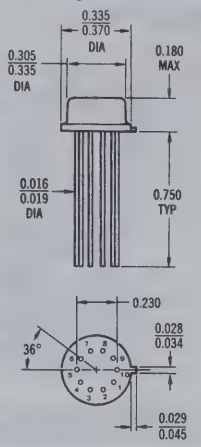
Weight ≈ 0.92 gram



Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

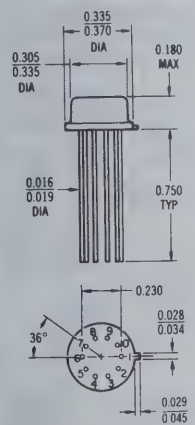
CASE 602A

Weight ≈ 0.918 gram



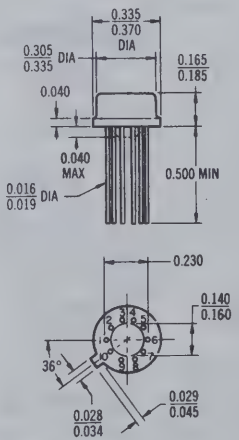
CASE 602B

Weight ≈ 0.918 gram

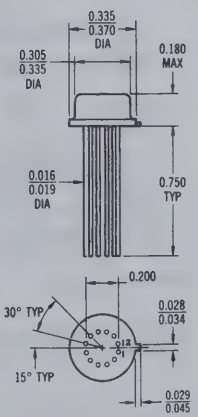


CASE 603 TO-100 Package

Weight ≈ 0.918 gram

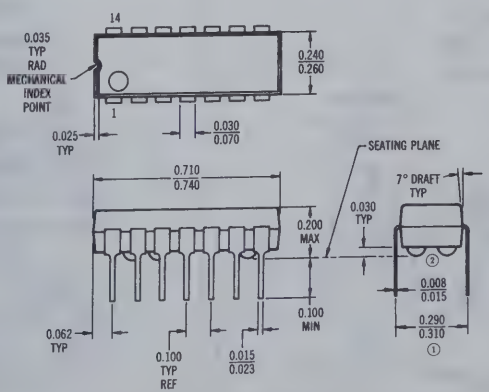


CASE 604



CASE 605 TO-116 Package

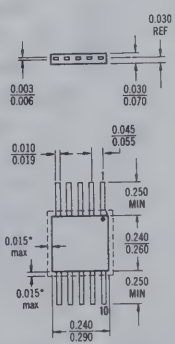
Weight ≈ 0.911 gram
(Plastic)



① This dimension is measured at the seating plane.
② 4 insulating stand-offs are provided.

CASE 606 TO-91 Package

Weight ≈ 0.127 gram
(Ceramic)

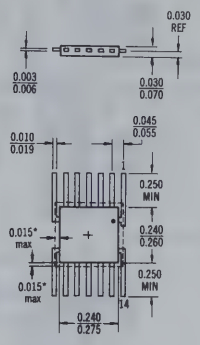


Lead 1 identified by color dot or by shoulder on lead.
All leads electrically isolated from package.
*Tolerance for lid skewing, glass meniscus, and glass overrun.

Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

CASE 607 TO-86 Package

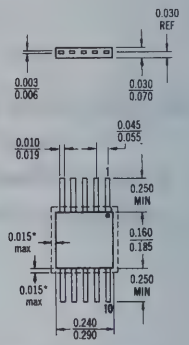
Weight ≈ 0.218 gram
(Ceramic)



Lead 1 identified by color dot or by elbow on lead.
All leads electrically isolated from package.
*Tolerance for lid skewing, glass meniscus, and glass overrun.

CASE 608 TO-90 Package

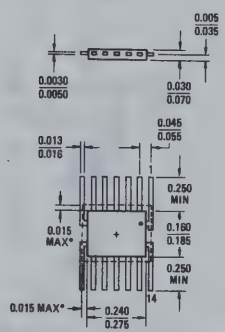
Weight ≈ 0.127 gram
(Ceramic)



Lead 1 identified by color dot or by shoulder on lead.
All leads electrically isolated from package.
*Tolerance for lid skewing, glass meniscus, and glass overrun.

CASE 609 TO-85 Package

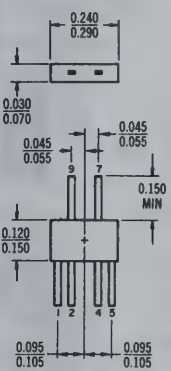
(Ceramic)



Lead 1 identified by color dot or by elbow on lead.
All leads electrically isolated from package.
*Tolerance for lid skewing, glass meniscus, and glass overrun.

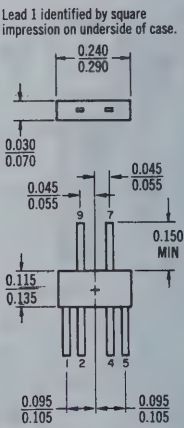
CASE 610-02 TO-89 Package

All leads isolated from case

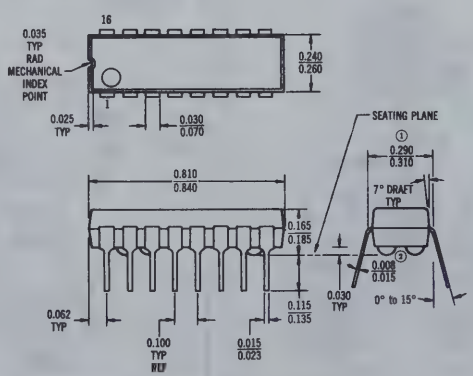


CASE 610A

All leads isolated from case



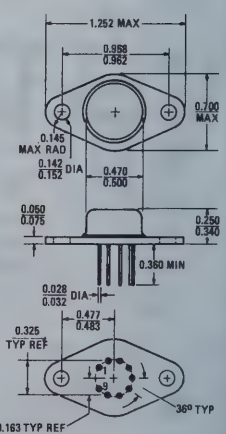
CASE 612 (Plastic)



① This dimension is measured at the seating plane.
③ 4 insulating stand-offs are provided.

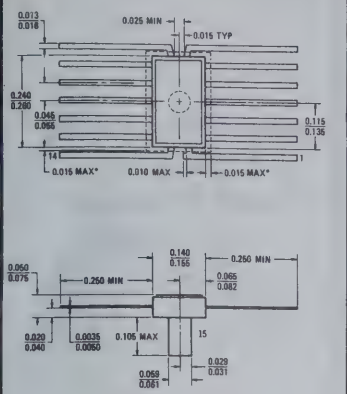
CASE 614

Weight ≈ 6.315 grams



CASE 617

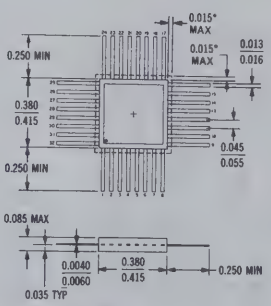
(Ceramic)



Lead 1 identified by a tab on that lead.
*Tolerance for lid skewing, glass meniscus, and glass overrun.

CASE 618

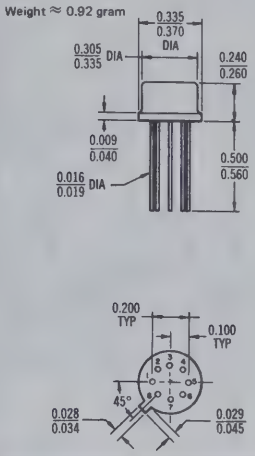
(Ceramic)



Lead 1 identified by color dot.
All leads electrically isolated from package.
*Tolerance for lid skewing, glass meniscus, and glass overrun.

CASE 619

Weight ≈ 0.92 gram

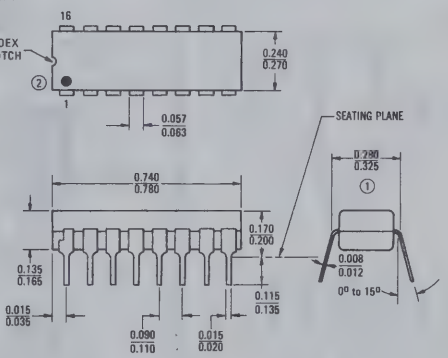


CASE 619-02



CASE 620

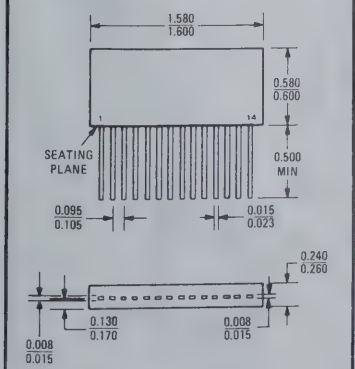
Weight ≈ 1.97 grams
(Ceramic)



① This dimension is measured from the lead centers at the seating plane with leads vertical.
② Lead 1 identified by color dot, notch in lead, or notch in ceramic.

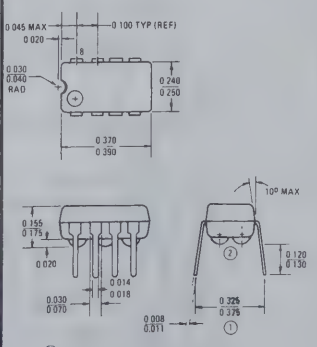
CASE 625

Weight≈ 9.0 gram max.
(Plastic)



CASE 626

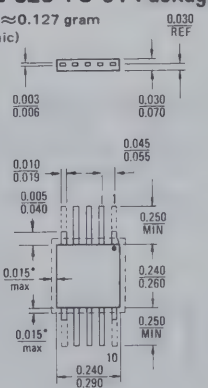
Weight≈0.446 gram
(Plastic)



① This dimension is measured at the seating plane.
② Four insulating stand-offs are provided.

CASE 628 TO-91 Package

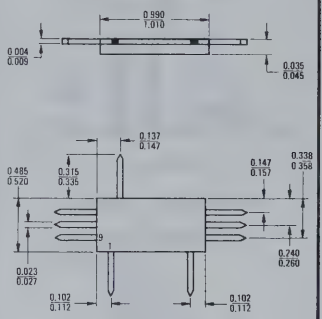
Weight≈0.127 gram
(Ceramic)



Lead 1 identified by color dot or by shoulded on lead.
Leads 1, 5, 6, 10 are clipped.
All leads electrically isolated from package.
*Tolerance for lid skewing, glass meniscus, and glass overrun.

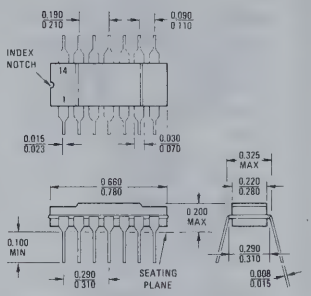
CASE 631

Weight ≈1.0 gram



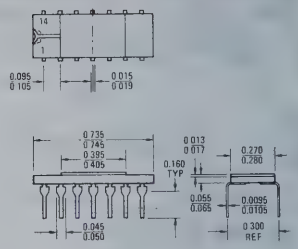
CASE 632 TO-116 Package

Weight ≈ 1.954 grams
(Ceramic)

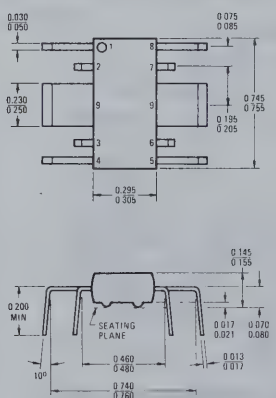


CASE 637

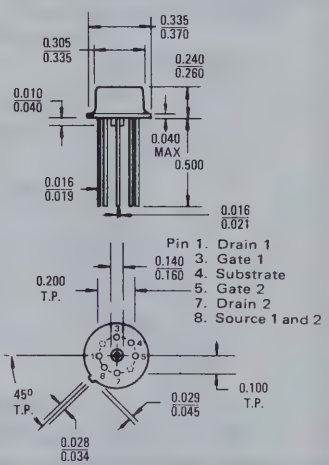
(Ceramic)



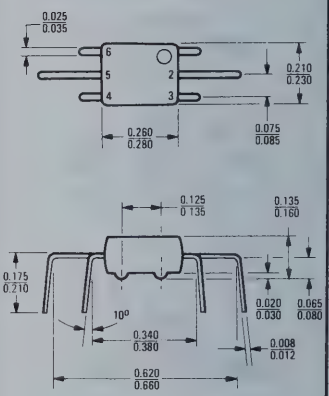
CASE 641



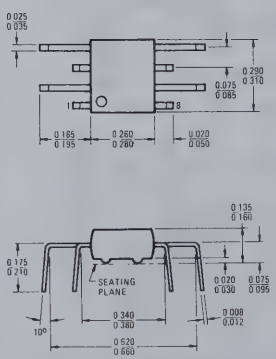
CASE 642 TO-76 Package



CASE 643

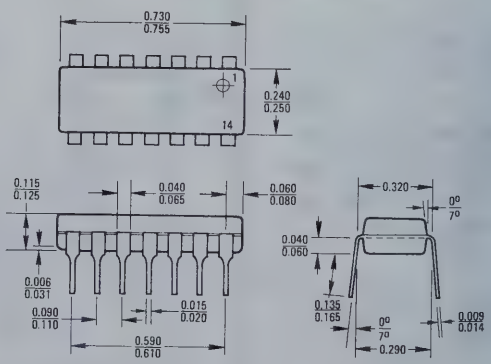


CASE 644



CASE 646 TO-116 Package

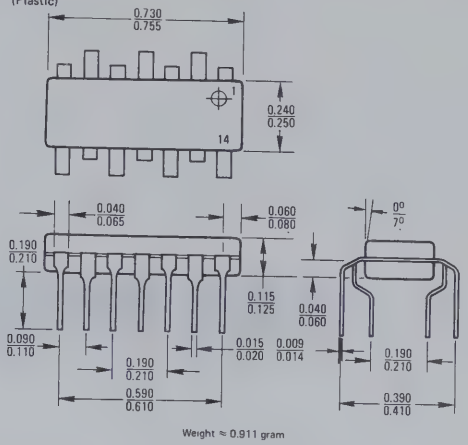
Weight ≈ 0.911 gram
(Plastic)



Dimensions are in inches.
To convert
inches to millimeters
multiply by 25.4.

CASE 647

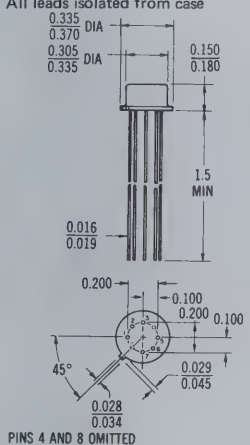
Weight ≈ 0.911 gram
(Plastic)



Weight ≈ 0.911 gram

CASE 654-01

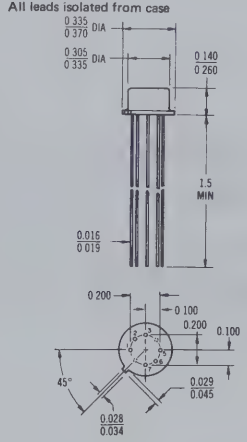
All leads isolated from case



PINS 4 AND 8 OMITTED

CASE 654-03

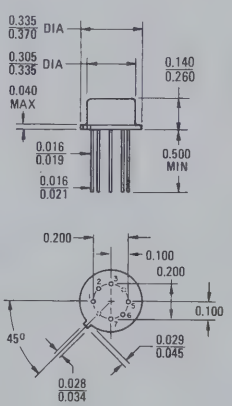
All leads isolated from case



PINS 4 AND 8 OMITTED

CASE 654-04

All leads isolated from case



PINS 4 AND 8 OMITTED

CASE 654-05

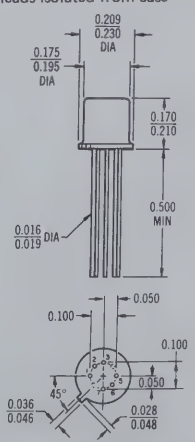
All leads isolated from case



PINS 4 AND 8 OMITTED

CASE 655 TO-71 Package

All leads isolated from case



PINS 4 AND 8 OMITTED



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APPLICATION NOTE SELECTION GUIDE

The Application Notes described in this section have been prepared to acquaint the circuits and systems engineer with the broad line of Motorola Semiconductor Products and their applications. The Cross Reference Table lists the application categories in alphabetical order. The section entitled Application Note Abstracts gives a brief summary of the application note content.

To obtain copies of these notes, simply list the AN-number or numbers and send your request on your company letterhead to: Technical Information Center, Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036.

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Audio	
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3-35 W, Plastic Transistor	AN-484
40-100 W, Metal Package	AN-485
20, 30 W, Darlington	AN-483
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APPLICATION NOTE ABSTRACTS

AN-134 Low-Cost Power Inverter Circuits Using Off-the-Shelf Components

Design of efficient power inverters requires careful matching of transistors, transformers, and starting network. This note provides insights to this matching problem and gives a comprehensive table allowing the designer to select the proper transistor for his specific inverter requirement.

AN-139 Understanding Transistor Response Parameters

This note explains high-frequency transistor response parameters and discusses their interdependence. Useful nomograms are given for determining h_{fe}, f_T, $f_{\alpha e}$, f_{max}, and many other parameters.

AN-140 Characterization of SCR's as Switches for Line Type Modulators

Although Silicon Controlled Rectifiers are highly desirable as switches in DC pulse circuits, they are usually specified and characterized for AC applications only. This article discusses the SCR characteristics desirable for DC pulse applications, and proposes simple test circuits for evaluating such devices as pulse circuit switches. A device already characterized for such applications is described.

AN-147 High-Power Varactor Diodes: Theory and Application

This article treats varactors in non-rigorous terms, discussing what they are, how they work, and how to use them in practical high-power, high-frequency, output circuits.

AN-150 Getting Transistors Into Single-Sideband Amplifiers

Silicon power transistors coupled with unique circuit design approaches make possible a 30 watt peak-power single-sideband transmitter operating at 30 MHz.

AN-151 Charge Storage Varactors for Extra UHF Power

This report describes a varactor multiplier which may be used to achieve power outputs of more than 50 Watts at 150 MHz, and 20 Watts at 450 MHz. With such high-frequency capabilities, transistor-varactor combinations can replace triodes and klystrons in many UHF and microwave applications.

AN-156 An All-Solid-State Marine Band Transmitter

This report gives all the necessary details: circuit drawings, construction techniques, etc., for a low - cost all - solid-state, crystal-controlled, marine-band transmitter. The unit operates between 2.0 and 2.85 MHz, and features low current drain (1.5 Adc), a high efficiency output stage, and direct operation from a 13 volt dc supply.

AN-159 Design Tips for Coaxial-Cavity Varactor Multipliers

Most microwave engineers picture a coaxial cavity as a bulky construction, difficult to design easily. This report demonstrates that varactor multipliers can easily be designed as small as any other. Design principles and operational data for 500 MHz - 1000 MHz doublers are given.

AN-161 High Power RF Switching Diode Can Replace Mechanical Coax Relays

This report gives a complete description of the design and capabilities of the new MV1892 RF switching diode. Characterizing parameters and various circuit recommendations are also given.

AN-163 Silicon Power Transistors Provide New Solutions to Voltage Control Problems

Three useful circuits - a short circuit proof voltage regulator, an inexpensive switching regulator and a 100 kHz dc-to-dc converter are described.

AN-166 Using Linvill Techniques for RF Amplifiers

A design procedure, derived from theory developed by J. G. Linvill, simplifies the design of single stage small-signal RF amplifiers. A 200 MHz amplifier serves as an example of the technique.

AN-169 A Low Voltage High Current Converter

The output of low-voltage sources, i.e. solar cells, etc., often must be converted to a higher voltage to be useful. Utilizing a high-performance power transistor to efficiently perform this task, this converter can switch currents as high as 50 amperes.

AN-173 Reducing (di/dt) – Effect Failures in Silicon Controlled Rectifiers

In SCR circuits with device-limited currents, severe local heating problems often develop in the SCR's. Three useful techniques are presented to eliminate this problem.

AN-174 High-Efficiency, Low-Voltage Inverters

Two low-voltage inverter circuits, employing a new fast-switching power transistor, operate at approximately 80% efficiency, reducing heat dissipation to a minimum.

AN-176 Power Varactor Gives 5 Watts Output at 3 GHz

A discussion of the design and performance of the high power MV1808 varactor, including design details of a 1 GHz frequency doubler and a 1 GHz to 3 GHz tripler.

AN-177 Two Stage Varactor Multiplier Provides High Power at 400 MHz

This "times-eight" frequency multiplier can provide a nominal 40 watts of CW power at an output frequency of 400 MHz with a conversion efficiency of 30 percent.

AN-178 Epicap Tuning Diode Theory and Applications

General electronic-tuning considerations are discussed, including important parameters such as Q, tuning range, and temperature stability.

AN-181 A Regulated Power Supply Using a Reference Amplifier

This useful industrial circuit, specially designed to provide highly stable output, uses a reference amplifier semiconductor device to minimize voltage fluctuations and temperature variations.

AN-182 A Method of Predicting Thermal Stability

Variations in DC bias current with temperature is an important consideration in the design of reliable transistor audio amplifiers. This note gives a useful method of predicting the thermal stability of biasing circuits.

AN-186 A Single Stage Video Amplifier

High-performance germanium transistors allow the design of this simple, low-cost, single-stage video amplifier, suitable for small-screen television receivers.

AN-187 MECL Integrated Circuit Line Driver

Specially designed for high fan-out capabilities, this integrated circuit line driver can supply a signal to 150 logic gates without deterioration.

AN-189 Solid-State Pulse Width Modulation DC Motor Control

Pulse-width modulation, an effective method of dc voltage control, provides motor speed regulation under varying torque conditions - ideal for traction drive vehicles.

AN-191 Varactor Diodes and Circuits for High Power Output and Linear Response

Three new varactors are described, and varactor multiplier circuits - a 50 MHz to 100 MHz push-push doubler, a 500 MHz to 1000 MHz harmonic doubler, and a 200 MHz to 600 MHz harmonic tripler - - are presented in detail.

AN-193 Using Negative Bias to Improve SCR Performance

The circuit designer can take advantage of a fundamental SCR property - turn-off gain at low anode current - - to reduce turn-off time and increase holding current.

AN-194 Designing Integrated Serial Counters

MECL monolithic integrated J-K flip-flops serve as building blocks for ultra-high-speed ripple counters. General design techniques for designing counters of any arbitrary count.

AN-196 Epicap Tuning of Resonant Circuits

Designers may now extend reliability and circuit performance by replacing mechanical tuning parts with new high Q Epicap voltage-variable capacitor tuning diodes. A design procedure leads to the selection of the optimum Epicap for any circuit.

AN-199 A Solid-State 15 kHz Power Inverter

Fast-switching power transistors allows the design of a high-frequency power converter featuring minimum size and weight of reactive components.

AN-202 Noise Margins of MECL Integrated Circuits

A knowledge of ground line and signal line dc and pulse noise margins is essential to the logic designers. Many curves illustrate the variations of input and ground line noise margins with temperature and fan-out.

AN-203 Tuned Amplifier Design with an Emitter-Coupled Integrated RF Amplifier

This note describes the design of a tuned amplifier utilizing the MC1110 integrated circuit as a basic building block. DC considerations, characterization in terms of y-parameters, and amplifier design using Linvill's method are discussed.

AN-204 High Performance Integrated Operational Amplifiers

Two new high performance monolithic operational amplifiers feature exceptionally high input impedance and high open loop gain. This note describes

the function of each stage in the circuit, methods of frequency compensating and dc biasing. Four applications are discussed: a summing circuit, an integrator, a dc comparator, and transfer function simulation.

AN-208 A Unique, Ultra-High-Speed, Switching-Time Test Device

Ultra-high-speed test fixture allows accurate measurement of switching times for a wide variety of transistors.

AN-210 FM Modulation Capabilities of Epicap VVC's

The author shows by empirical methods that the frequency vs. voltage curve for Epicap voltage variable capacitors is linear for small (sufficient for most FM modulator applications) voltage variations.

A rigorous mathematical explanation of this linear interdependence follows the empirical demonstration.

AN-211 Field Effect Transistors in Theory and Practice

The basic theory, construction, and application information for field effect transistors (junction and MOS types) are given. Also included are some typical test circuits for checking FET parameters.

AN-213 Varactor Multipliers Provide High Output Power Above 6 GHz

The author employs a high performance varactor diode in the design of several multiplier circuits which feature exceptionally high output power versus frequency capabilities. Among the circuits discussed are a 2 to 5 GHz doubler, a 2 to 6 GHz tripler, a 2.83 to 8.5 GHz tripler, and a 500 MHz to 4 GHz one-step multiplier.

A physical and electrical characterization of the 1N5154, 1N5155 varactors, sufficient for design purposes, precedes the actual design discussion.

AN-214 A 160 MHz 15 Watt Solid-State Power Amplifier

High performance RF power transistors make possible the design of a three stage 160 MHz amplifier with 15 Watts power output. The amplifier operates on 28 Vdc supply voltage with an overall efficiency of 62%, and features 30.5 dB overall power gain

The author employs large-signal transistor input-output admittance data in the network designs for this amplifier.

AN-215 RF Small Signal Design Using Admittance Parameters

The author shows that the power gain and stability of high frequency transistors may be completely described by two-port parameters.

This paper presents a summary of the overall design solution for the small signal RF amplifier using admittance parameters. Design considerations and relationships for both stable and the potentially unstable transistor are presented together with a discussion of the neutralized, unneutralized, matched, and mis-matched amplifiers.

AN-216 UHF Transmission-Line Oscillator-Design Using the Smith Chart

Two high performance UHF oscillators; a 500 MHz, 1 Watt oscillator; and a 1 GHz, 0.5 Watt oscillator employ transmission lines for linear elements. The author illustrates that the use of transmission lines simplifies the breadboard design of many UHF circuits. An important feature is the use of the Smith Chart to simplify the network synthesis.

AN-217 UHF Transmission Line Power Amplifier Designed with Smith Chart Techniques

A UHF power amplifier capable of 2 Watts power output at 450 MHz employs transmission lines for linear elements. The author illustrates that the use of transmission lines simplifies the design of many UHF circuits. An important feature is the use of the Smith Chart to simplify the network synthesis.

AN-219 The Field Effect Transistor in Digital Applications

Field effect transistors have definite advantages over junction transistors in many digital applications; high fan-out, direct coupled circuitry (lower component count), extremely low power dissipation, and low temperature coefficient circuits are among the most important.

This paper provides the designer with an up-to-date discussion of JFET and IGFET switching characteristics and how they are used in the design of basic digital circuits. The final portion of this paper discusses a family of JFET logic circuits, a family of IGFET, and future prospects.

AN-220 FET's in Chopper and Analog Switching Circuits

The author's discussion begins with elementary chopper and analog switch characteristics -- explores fully the considerations required for conventional and FET chopper and analog switch design -- and finishes with specific FET circuit examples.

AN-221 4-Layer and Current-Limiter Diodes Reduce Circuit Cost and Complexity

The authors present four simple circuits in which 4-layer diodes and current-limiter diodes are

used to provide increased circuit performance: A Saw-tooth generator (two variations), a staircase generator and a ring counter.

A brief discussion of the electrical characteristics of 4-layer and field effect diodes precedes the circuit examples.

AN-222 The ABCs of Solid-State DC to AC Inverters

The author provides a comprehensive examination of the entire field of dc to ac inverters. Among the topics discussed are: the proper inverter for a specific application; operation principles of different types of inverters; the problem of proper device selection in the design of inverters; an inverter design example.

AN-223 Cascade Noise Figure for Integrated Circuit Transistors

In vacuum tube circuitry, the combination of the grounded-cathode and the grounded-grid cascade has superior noise properties to all other two-stage amplifiers. In transistor circuitry the noise performance of a single-stage amplifier is well known, but little information has been published about the best performance obtainable from two-stage transistor amplifiers. This paper evaluates the noise performance of all possible two-stage transistor amplifiers. Also, since the noise contribution of stages beyond the second is normally small, this analysis will be valid for amplifiers with any number of stages.

AN-225 High Performance All Solid-State Servo Amplifiers

The design of 7.5 Watt transformer-coupled solid-state servo amplifier and a 10 Watt complementary transistor servo amplifier are fully discussed. The transformer coupled amplifier, requiring only three transistors, provides a stable voltage gain of 100. The complementary amplifier, though more complex, is direct coupled throughout thus eliminating the transformer and its accompanying phase shift problems.

AN-226 Thermal Measurements on Semiconductors

This note describes the techniques used by Motorola to obtain the thermal resistance of transistors, rectifiers, and thyristors.

AN-227 Thyristor Trigger Circuits for Power-Control Applications

Variations of the basic triggering circuit using the MPT20 to control thyristors are shown. AC control circuits are detailed for both triacs and SCRs as well as an SCR DC control.

AN-228 20 Watts at 1 GHz with Step Recovery Varactors

Varactor harmonic multiplier circuit power handling capabilities have now been extended to 20 Watts at 1 GHz and 10 Watts at 2 GHz by two new varactors, the 1N5149 and 1N5150. This note provides a complete discussion of the design and performance of these two varactors. Several high performance multiplier circuits: a 0.5 GHz to 1 GHz doubler; a 0.4 GHz to 1.2 GHz tripler; and a 0.46 GHz to 1.84 GHz quadrupler are also discussed.

AN-229 High Speed Complementary Flip-Flop Features Extremely Low Power Dissipation

New complementary micro-power transistors permit the design of an ultra-high speed flip-flop featuring extremely low power dissipation. The complementary character of the 2N3493 and 2N2409 "0-pF" transistors allow the engineer to design flip-flops with high operating frequency, high circuit efficiency, and high gain.

AN-231 FET Differential Amplifier

The field effect transistor is often a better choice than the bipolar transistor in many differential amplifier applications, particularly when high input impedance is required. This report discusses drift compensation of field effect transistors for differential amplifier applications.

AN-232 1.5 GHz 10 Watt Two-Stage Cascade Multiplier

Two high-performance varactors - - the 1N5149 and 1N5150 - - are employed in a cascade multiplier which features over 10 watts power output at 1.5 GHz.

AN-233 Design of Monostable Multivibrators Using MECL Integrated Circuits

This application note describes an integrated monostable multivibrator composed of a MECL R-S or J-K flip-flop plus a few discrete components. A main feature of the multivibrators is their complete compatibility with the MECL family of current mode integrated circuits. These multivibrators can provide a timed output ranging from 60 ns to the millisecond range. The note discusses special circuits which have even faster recovery times. Pulsed recovery (recovery during any point during the delay time) is possible with both types of multivibrators.

AN-234 MRTL Family of Integrated Circuits

The purpose of this note is to familiarize the logic designer with the Motorola Resistor Transistor

Logic (MRTL) family. Logic diagrams, pin layouts, and loading data are given for each device. Three illustrative applications of MRTL; an asynchronous 4-bit comparator, an asynchronous 5-bit adder, and a shift register, serve as design examples. This family is noted for its economy and variety of logical elements.

AN-235 Using the Motorola MDTL Line of Integrated Circuits

The MDTL line of integrated circuits is briefly characterized with important capabilities of the MDTL series, such as noise immunity, discussed. MDTL applications are presented, including shift registers, ripple counters, clocked counters, and decade shift counters.

AN-238 Transistor Mixer Design Using Admittance Parameters

Mixer circuit design may be simplified by the use of small-signal admittance parameters. This note describes in detail the effective application of this design technique and the corresponding results. Several design examples are discussed.

AN-239 MECL Integrated Circuit Schmitt Triggers

The Schmitt Trigger, a regenerative circuit which changes state abruptly when the input signal crosses specified dc trigger levels, can be fabricated from MECL integrated logic gates. This note describes the modifications necessary to convert standard MECL logic gates to Schmitt Triggers, and also the performance to be expected from such units. Examples of the MECL Schmitt Trigger used for wave shaping and pulse generator applications are also included.

AN-240 SCR Power Control Fundamentals

Relationships of control angle to peak voltage, average voltage, RMS voltage and power are presented in chart form. Time constant for relaxation oscillators are discussed for both DC and AC supplies. These basics form the heart of SCR control.

AN-241 Low-Cost High-Voltage Servo Amplifier

The availability of low-cost high-voltage power transistors make possible the design of a practical high voltage servo amplifier without transformers and with greatly reduced phase shift problems.

AN-242 A Modulated SCR Zero-Point Switching Circuit

By employing SCR devices in a zero-point switching mode, the circuit designer can greatly reduce RFI generation. This note describes the zero-point switching concept, and provides a circuit design example (AC controller - - DC half-wave controller).

AN-243 Transistor-Varactor-Multiplier Versus Transistor-Multiplier

Several watts of power in the upper portion of the L band may be obtained with either the transistor amplifier driving a varactor multiplier (TAVM), or the transistor amplifier-multiplier (TAM). This report presents a careful evaluation of both types of circuits.

AN-244 The MECL Line of Digital Integrated Circuits

This note familiarizes the digital integrated circuit user with Motorola MECL integrated circuits; pin layouts, and logical diagrams. Pertinent characteristics for each device in the MECL integrated circuit line are given. The note includes applications of various circuits illustrating the versatility of the MECL family. High speed operation, high input impedance, high fan-out, and very low internally generated noise characterize the line of integrated circuits.

AN-245 An Integrated Core Memory Sense Amplifier

This application note discusses core memories and related design considerations for a sense amplifier. Performance and environmental specifications for the amplifier design are carefully established so that the circuit will work with any computer using core memories. The final circuit design is then analyzed and measured performance is discussed. The amplifier features a small uncertainty region (6 mV max), adjustable voltage gain, and fast cycle time (0.5 μs).

AN-246 A 50 Watt 50 MHz Solid-State Transmitter

This three-stage, three-transistor transmitter can provide 50 watts continuous power output at 50 MHz with 62% overall efficiency. The author employs a straightforward design approach based on large-signal transistor input/output admittances.

AN-247 An Integrated Circuit RF-IF Amplifier

A new, versatile integrated circuit for RF-IF applications is introduced which offers high gain, extremely low internal feedback and wide AGC range. The circuit is a common-emitter, common-base pair (the cascade connection) with an AGC transistor and associated biasing circuitry. The amplifier is built on a very small die and is economically comparable to a single transistor, yet it offers performance advantages unobtainable with a single device. This application note describes the AC and DC operation of the circuit, a discussion of Y-parameters for calculating optimum power and voltage gain, and a variety of applica-

tions as an IF single-tuned amplifier, IF stagger-tuned amplifier, oscillator, video-audio amplifier and modulator. A discussion of noise figure is also included.

AN-248 A High Voltage Monolithic Operational Amplifier

This note introduces a high voltage monolithic operational amplifier featuring high open loop gain, large common mode input signal, and low drift. The function of each stage in the circuit is analyzed, and methods for frequency compensating the amplifier are discussed. DC biasing parameters are also examined. Four applications using the amplifier are discussed: a source follower, a twin tee filter and oscillator, a voltage regulator, and a high input impedance voltmeter.

AN-249 Designing Around the Tuning Diode Inductance

The effect of varactor inductance is described, and equations and graphs are presented in order to predict the inductance value and to determine when its effects on performance is significant.

In addition a design example of a varactor-tuned capacity-loaded half-wave cavity from 470 MHz to 890 MHz, and derivations of design equations for varactor tuned quarter wave and half-wave cavities as well as for lumped series tuned circuits are shown.

AN-251 Decade Counters Using MRTL Integrated Circuits

This application note discusses the design and implementation of decade counters using the MRTL family of integrated logic. Ripple counters, shift counters, and parallel clocked counters are developed using BCD, 2'421, and excess 3 digital codes. Up and down counting techniques are discussed. Output decoding, problem areas and circuit limitations are covered for all counter types.

AN-252 Choosing MRTL Integrated Logic Circuits

This article discusses resistor-transistor logic, MRTL, integrated circuits, and the considerations a user should make prior to using this integrated circuit family. Full consideration is given to the advantages as well as the limitations one encounters with this logic form. The discussion is general in nature and applies to all popular versions of resistor-transistor logic.

AN-253 An Analysis of MRTL Integrated Logic Circuits

Special emphasis is given to noise margin specifications, large circuit fan-out, operating speeds, and interfacing with saturated logic in this analysis of Motorola MRTL integrated logic circuits. The J-K flip-flop circuit is reviewed and basic counting and shifting circuits are presented to illustrate typical J-K applications.

AN-254 Using MRTL Integrated Circuit Flip-Flops

Circuit operation of MRTL J-K flip-flops is explained fully. The R-S flip-flop is also briefly discussed. Pulse input requirements and loading considerations are discussed and some applications of the J-K flip-flop shown in the form of minimum-logic small-count counters.

AN-257 Decade Counters Using MECL J-K Flip-Flops

This note discusses the use of MECL integrated circuits in four types of decade counters. The logic and circuit design of an excess three up-down counter, a 2'421 up-down counter, a Gray code counter, and a switch-tail ring counter with ten line output are illustrated.

AN-258 Monostable Multivibrator Design Using An Integrated Circuit Operational Amplifier

This application note discusses the use of integrated operational amplifiers connected as monostable multivibrators. The classical monostable circuit including some limitations with respect to the conventional component and integrated device designs are briefly reviewed. The basic circuit theory and qualifications of the operational amplifier connected as a monostable device are then discussed and the timing equation derived. Alternate monostable configurations and their ultimate design limitations are briefly reviewed with respect to utilization of the MC1430/1530 and MC1431/1531 family of devices. Finally a design example is used to illustrate the principles and limitations outlined.

AN-259 Using Integrated Circuits in a Stagger Tuned IF Strip

Integrated Circuits are quickly becoming "the way to go" in the electronic industry, and justifiably so. Their small size and high reliability, coupled with low cost make them an ideal component for radio, television, communication gear, computers, and an infinite number of other uses. This application note describes the use of an Integrated Circuit High Frequency Amplifier, the MC1550, in a stagger tuned I-F strip. The design frequency is 45 MHz; however, the procedure is similar for designs covering its full range of operation (DC to 300 MHz).

AN-260 Selecting Varactor Diodes

High output power in the UHF region can be achieved with varactors. A device selection procedure

based on experience, theory and common sense is offered.

AN-261 Transistor Logarithmic Conversion Using an Operational Amplifier

The design of a log amplifier using a common base transistor configuration as the feedback element of an integrated circuit operational amplifier circuit is discussed in this application note. Six decades of logarithmic conversion are obtained with less than 1% error of output voltage. The possible causes of error are discussed followed by two applications: direct multiplication of two numbers, and solution of the equation $Z = X^n$.

AN-262A Decade Counters Using MDTL Integrated Circuits

Decade counting is a basic digital operation and may be performed by a wide variety of counting circuits. This note illustrates how some of the commonly used $\div 10$ counting techniques can be accomplished with Motorola Diode-Transistor Logic (MDTL) integrated circuits. Ripple, clocked, and shift decade counters using a variety of coding methods are discussed.

AN-263 Choosing DTL Integrated Logic Circuits

This article discusses diode-transistor logic, DTL, integrated circuits, and the considerations a user should make in choosing this integrated circuit family. Consideration is given to the advantages and limitations one encounters with this logic form. Three versions of DTL are considered in this report; conventional DTL, modified DTL, and high noise immunity DTL.

AN-264 MRTL Integrated Circuit Shift Registers

This note discusses the design considerations for the implementation of a 16-bit shift register using J-K flip-flops. The shift register described has the capability, upon command, to shift left or shift right and to enter information serially or in parallel. All problems encountered in the implementation and operation of the register are discussed.

AN-266 MECL Integrated Circuit Flip-Flops

Current Mode bi-stable elements are discussed along with pertinent characteristics and specifications. The R-S, J-K, and Master-Slave types of flip-flops are evaluated according to performance. Methods of reducing overshoot when driving a large number of flip-flops and flip-flop fan-in, fan-out capabilities are also given.

AN-267 Matching Network Designs with Computer Solutions

Computer solutions for four networks commonly used in solid-state high frequency amplifiers have been tabulated.

AN-268 Pulse Triggering of Radar Modulator SCR's

Factors involved in dynamic gate triggering are examined and relations of gate triggering characteristics to variations of total current amplifications with gate current are shown.

AN-270 Nanosecond Pulse Handling Techniques

The rapid advancement in the field of high speed digital integrated circuits has brought into focus many problem areas in the methods of pulse measurement techniques and new concepts dealing with these problems. This paper is intended to discuss the more common, yet perhaps not well known, pitfalls of measurement systems, a method of detecting them and possible solutions.

AN-271 Breadboard Techniques For Low Frequency Integrated Circuit Feedback Amplifiers

Certain considerations, unnecessary for discrete devices, are of critical importance in the breadboarding of integrated circuit systems. This paper provides the engineer or technician with some wiring tips and important precautions for integrated circuit breadboarding.

AN-273 More Value out of Integrated Operational Amplifier Data Sheets

The operational amplifier is rapidly becoming a basic building block in present day solid state electronic systems. The purpose of this application note is to provide a better understanding of the open loop characteristics of the amplifier and their significance to overall circuit operation. Also, each parameter is defined and reviewed with respect to closed loop considerations. The importance of loop gain stability and bandwidth is discussed at length. Input offset circuits are also reviewed with respect to closed loop operation.

AN-274 MECL Integrated Circuit Shift Registers

A generic shift-right, shift-left register with parallel entry, end-around-shift, and complementation capabilities is discussed. Maximum practical operating speed, delay times and timing considerations of the logic gating signals are determined. The basic register as developed may be used for data handling,

for number scaling, or in the arithmetic portion of a digital computer.

AN-276 Useful Frequency Range Extension for MC1530 Operational Amplifiers

This application note explains various frequency compensating techniques designed to extend operating frequency of the MC1530. In addition circuit configurations and frequency response curves are shown for various compensation techniques. Examination shows this amplifier can be used at frequencies up to 14 MHz.

AN-277 Overshoot and Ringing in High-Speed Digital Systems

The amount of overshoot and ringing that may be expected in a system is determined as a function of driving source impedance, rise-time, wiring length, and loading. Determination of allowed overshoot and methods of reducing overshoot are discussed for conventional point to point wiring methods. Capacitive loading effects of MECL devices and circuit hardware are also discussed.

AN-278 Using Shift Registers as Pulse Delay Networks

This note discusses high speed clocked shift registers using J-K flip-flops and employed as a digital incremental delay. The register may be clocked with a frequency division counter to accomplish any desired delay with increments as small as 20 ns. The circuit as developed may be used for timing basic computer decisions or as an adjustable delay line for pulse.

AN-279 Setup and Release Times in the MRTL J-K Flip-Flop

This application note discusses the setup and release times for J-K flip-flops. The method used to measure setup and release time is discussed. A few simple decade counters are analyzed for worst case release times.

AN-280 MECL 85 MHz J-K Flip-Flop

A new high-speed J-K flip-flop is discussed. Capabilities, performance, and applications are explained along with typical and worst case operating data. This flip-flop with four J inputs and four K inputs more than doubles the operating speed of registers and counters as employed in a system.

AN-282 Systemizing RF Power Amplifier Design

The design of high-power, Class C, RF transistor amplifiers can be greatly simplified through the use of large-signal device characterization. This note explains design procedures and furnishes large-signal impedance data for thirteen Motorola RF power transistors.

AN-283 Using MDTL IC Flip-Flops

To properly implement a logic system with integrated circuits, it is important that the logic designer be familiar with the devices he uses. One of the more complex of integrated circuits is the clocked flip-flop. The purpose of this report is to acquaint the reader with the operation of the MDTL flip-flop, to discuss the different modes of operation, and to show some typical uses for this flip-flop.

AN-284 MDTL IC Shift Registers

This report shows some frequently encountered shift register designs implemented with MDTL logic devices. Various operating characteristics are discussed as well as some of the important design considerations.

AN-286 Binary Addition Using MRTL IC's

This note discusses the principles of binary addition with positive numbers and considers the implementation of binary adders with MRTL. The full adder function is illustrated using MRTL half adders, NOR gates arranged to simulate half adders, and with NOR gates in a two level logic scheme.

The full adder and associated logic is developed for a four-bit parallel (asynchronous) adder and for serial (synchronous) adder.

AN-287 Color IF Amplifier and AGC Circuit

A non-neutralized, three-stage IF video amplifier is described. Included is the associated keyed AGC circuitry. The circuits were used in a transistorized color set built in the Applications Laboratory at Motorola.

AN-288 Color TV Solid State Horizontal Deflection

This report describes a horizontal deflection system for a large screen (23 inch) color television receiver capable of delivering an ultor power in excess of 40 Watts at 24 kV. The system includes a horizontal phase detector, AFC amplifier, horizontal oscillator, pre-driver, driver, and two horizontal output devices operating in a parallel mode.

AN-290A Mounting Procedure, and Thermal Aspects of, Thermopad Plastic Power Devices

Several Motorola power devices are now encapsulated into the plastic Thermopad package.Two package sizes are presently available: One about 0.3 by 0.4 inch (Case 77), and the larger 0.5 by 0.625 inch (Case 90). The mounting methods are similar for both packages. This note describes several methods and considers some thermal aspects.

AN-292 Thermal Response of Semiconductors

This note explains a workable method – using the concept of transient thermal resistance – of predicting junction temperature at any point in time regardless of the power waveform.

AN-293 Theory and Characteristics of the Unijunction Transistor

The unijunction transistor is examined as to theory of operation, design structures, static and transient characteristics.

AN-294 Unijunction Transistor Timers and Oscillators

Twelve different unijunction transistor circuits, complete with parts lists are given. Temperature stabilization of the peak-point voltage is examined and dynamic operation paths are discussed.

AN-295 Suppressing RFI in Thyristor Circuits

Measures taken to suppress RFI are shown. Design considerations and examples are explored as well as some solutions to the RFI problem.

AN-296 Construction of A Master-Slave Flip-Flop from MRTL Gates

Information is provided on the construction of a master-slave flip-flop circuit from standard MRTL gates. Characteristics of the resulting circuit are given and an application of the configuration illustrates the advantage of this type of flip-flop.

AN-297 Integrated Circuits for High Frequency to Voltage Conversion

This application note concerns the technique of using integrated circuits in a linear frequency to voltage converter from 1 MHz to 30 MHz. A theoretical analysis is given as well as a working design.

AN-298 Noise Immunity With High Threshold Logic

A comparison of noise immunity characteristics is made between MHTL devices and standard saturated logic devices.

AN-299 An IC Wideband Video Amplifier With AGC

This application describes the use of the MC1550 as a wideband video amplifier with AGC. The analysis of a single stage amplifier with 28 dB of gain and 22 MHz bandwidth is given with the results extended to a 78 dB video amplifier with 10 MHz bandwidth.

AN-400 An Operational Amplifier Tester

A simple and inexpensive tester for Motorola's line of operational amplifiers is described which will measure the open loop voltage gain, the equivalent input offset voltage, the maximum positive and negative output voltage swing, and a view of the transfer function which shows the linearity of the device.

Included is an elementary discussion of the parameters measured and their relationship to closed loop performance.

AN-401 The MC1554 One-Watt Monolithic Integrated Circuit Power Amplifier

This application note discusses four different applications for the MC1554, along with a circuit description including dc characteristics, frequency response, and distortion. A section of the note is also devoted to package power dissipation calculations including the use of the curves on the power amplifier data sheet.

AN-402 Insulated Gate FET's Used in IC's

The note acquaints the circuit designer with the integrated FET. A brief description of the operation of the Insulated-Gate Field Effect transistor is presented. This discussion is followed by a description of the FET in integrated form and finally, the basic advantages of FET IC's are explored.

AN-403 Single Power Supply Operation of IC Op Amps

A split zener biasing technique that permits use of the MC1530/1531, MC1533, and MC1709 operational amplifiers and their restricted temperature counterparts MC1430/1431, MC1433 and MC1709C from a single power supply voltage is discussed in detail. General circuit considerations as well as specific ac and dc device considerations are outlined to minimize operating and design problems.

AN-404 A Wideband Monolithic Video Amplifier

This note describes the basic principles of ac and dc operation of the MC1552G and MC1553G,

characteristics obtained as a function of the device operating modes, and typical circuit applications.

AN-405 DC Comparator Operations Utilizing Monolithic IC Amplifiers

The use of the MC1533 operational amplifier and the MC1710 differential comparator are discussed. The capabilities and performance are given along with typical operating curves for both devices.

AN-406 UHF Broadband Amplifier Design

A design technique is given for a wideband amplifier operating at UHF frequencies. A shunt-shunt feed-back network and Y-parameters at sampled frequencies are used.

AN-407 A General Purpose IC Differential Output Operational Amplifier

This application note discusses four different applications for the MC1520 and a complete description of the device itself. The final sections of the note discuss such topics as operation from single and split power supplies, frequency compensation, and various feedback schemes.

AN-408 Problems and Solutions With MDTL and MRTL

Problems which may be encountered in using MRTL or MDTL integrated circuits in low or medium speed systems are examined in this report. Methods of shaping clock waveforms, restrictions on input and output terminals when interfacing with discrete components, and techniques for extending temperature range are discussed.

AN-409 MDTL Multivibrator Circuits

This note describes methods of using MDTL gates to form astable and monostable multivibrators. The operation of the MC951/MC851 monostable multivibrator is also covered as well as a simple pulse-shaping circuit.

AN-410 A Unified Approach to Optimum FET Mixer Design

The optimization of conversion gain, noise figure, and cross modulation are treated in relation to the basic mixer analysis and meaningful device parameters.

AN-411 The MC1535 Monolithic Dual Op Amp

This note discusses two dual operational amplifier applications and an input compensation scheme for fast slew rate for the MC1535. A complete ac and dc circuit analysis is presented in addition to many of the pertinent electrical characteristics and how they might affect the system performance.

AN-412 Duplexing With Step Recovery Varactors

The switching function in a duplexer circuit can be performed automatically by a step recovery varactor, eliminating the need for an external bias circuit. In this note, two CW duplexers are described: a 133 MHz lumped constant component duplexer and a 450 MHz microstrip transmission line duplexer.

AN-413 Unijunction Trigger Circuits for Gated Thyristors

This note describes the methods of supplying controlled pulse widths in synchronization with the ac power line to gated thyristors. The unijunction transistor provides a simple and convenient means of obtaining such pulses as well as including feedback with very little additional circuitry.

AN-414 Operation and Application of MHTL I/C Flip-Flops

A master-slave R-S and a dual J-K are the initial flip-flop elements available in the Motorola High Threshold Logic (MHTL) family. This note describes operation and characteristics of each unit and illustrates several applications of these devices.

AN-415 Avoiding Second Breakdown

The use of safe-area data, the physical mechanism of second breakdown and applications to various circuits are presented. Also included is a short discussion of test procedures and a typical test circuit used to establish safe area curves.

AN-416 One-Step High Order Frequency Multipliers

The circuits described in this report include the use of lumped constants, coaxial cavities, and waveguides. The design of lumped constant, low order multipliers is discussed in Application Notes AN-147 and AN-151 and coaxial cavity multiplier design is treated in Note AN-159. Therefore, only a brief outline of the X2 and X3 multiplier circuits will be given.

AN-417 IC Crystal Controlled Oscillators

Crystal controlled square wave oscillators can be used as clock drivers, harmonic sources for frequency markers, in frequency synthesizers, frequency comparators, etc. It is difficult to obtain high frequency square waves due to the long propagation delays of the most integrated circuits. The MECL II clock driver with 2 ns propagation delay eliminates this problem. This note describes square wave oscillator circuits with crystal control that are capable of output frequencies, inverted and non-inverted, up to 150 MHz.

AN-418 High Speed Monostable Multivibrator Design with MECL Integrated Circuits

This note describes two configurations of monostable multivibrators using the MC1023 clock driver and a delay element. Operating frequencies in excess of 70 MHz and pulse widths of 4 nanoseconds are possible. Methods of obtaining the predetermined delay are also discussed.

AN-419 UHF Amplifier Design Using Data Sheet Design Curves

This note describes the design of UHF narrowband amplifiers using the device loading admittances taken directly from the device data sheet. A design example is given in the form of a 1 GHz microstrip amplifier. Predicted results are compared to actual measured values. Also included is a short discussion on practical microstrip construction techniques.

AN-420 An Integrated Circuit Stereo Preamplifier

This note describes the use of the MC1303P dual preamplifier integrated circuit in a high quality stereo preamplifier circuit. It shows the designer how to adapt or modify the circuit to meet particular needs. The resultant preamplifier is suitable for use in systems having the most critical requirements.

AN-421 Semiconductor Noise Figure Considerations

A summary of many of the important noise figure considerations related with the design of low noise amplifiers is presented. The basic fundamentals involving noise, noise figure, and noise figure-frequency characteristics are then discussed with the emphasis on characteristics common to all semiconductors. A brief introduction is made to various methods of data sheet presentation of noise figure and a summary is given for the various methods of measurement. A discussion of low noise circuit design, utilizing many of the previously discussed considerations, is included.

AN-422 Testers for Thyristors and Trigger Diodes

This paper describes inexpensive go-no-go testers for thyristors and trigger diodes. Each is very simple to use and is well adapted to incoming inspection and other applications requiring fast testing of major parameters.

AN-423 Field-Effect Transistor RF Amplifier Design Techniques

Amplifier design theory utilizing the two port network model for an active device has been well developed and used extensively in bipolar transistor high frequency amplifier design.

This paper discusses some of the theoretical and practical considerations for using this popular method to design field effect transistor amplifiers.

AN-424 Designing a Digital Organ Tone Generator

A digital organ tone generator is described here to familiarize the reader with the capabilities of Motorola in-stock integrated circuits in novel electronic organ designs. An organ using this kind of tone generator has several advantages over the conventional 12-master oscillator divider organ.

AN-425 Transistor Inverter–40 Watts, 400 Hz, Square Wave Output

A two-transistor, two-transformer circuit is described that uses a novel UJT starting circuit and a zener diode for maintaining frequency control.

AN-426A Low-Power Audio Amplifiers Using Complementary Plastic Transistors

The use of complementary-symmetry output transistors in low-power audio amplifiers enables the circuit designer to achieve maximum circuit performance at minimum component cost. This note describes several audio amplifier circuits suitable for power outputs of up to 2 watts with 8-, 16- and 40-ohm loads. Also described is a line-operated single-ended audio amplifier suitable for table-radio or television applications.

AN-430 An Integrated-Circuit Chroma Demodulator for Solid State Color Television Receivers.

This note describes an integrated-circuit chroma demodulator for solid-state television receivers, using the Motorola XC-1325P. The demodulator requires only the chroma signal and two reference phases from the 3.58 MHz color oscillator for providing low-impedance color difference signals to drive the chroma output stages directly.

AN-432A A Monolithic Integrated FM Stereo Decoder System

This application note discusses the circuit approach that has been taken in the realization of the first monolithic integrated stereo multiplex decoder built for consumer usage, as well as some of the details concerning its incorporation in an FM stereo receiver.

AN-435 The Electronic "Strobotuner", An Accurate Digital Musical Instrument Tuning Aid

This report presents the electrical design of an accurate digital tool for tuning musical instruments.

The concepts basic to the design and the principles of operation are discussed with a step-by-step procedure for using the tuner. A method of checking the accuracy after a tuning procedure is also included.

AN-436 Conventional and Soft-Start Dimming of Incandescent Lights

This note describes two dimmers that provide wide-range control of incandescent light intensity by adjusting the angle of conduction in a series triac. One dimmer features simplicity for small size and low cost, while the other offers soft-start operation to limit inrush current and lengthen lamp life.

AN-437 Design Considerations and Performance of Motorola Temperature-Compensated Zener Reference Diodes

This application note defines Motorola temperature-compensated zener (reference) diodes, explains the device characteristics, describes electrical testing, discusses the advanced concepts of device reliability and quality assurance, and outlines device construction.

AN-438 Analysis and Design of Active Filters Using Op Amps

Excellent filters for frequencies below 100 kHz can be economically realized with operational amplifiers. Increased Q, design flexibility, reduced weight and cost also add to the attractiveness of operational amplifier active filters. Rigorous design theory and practical circuit examples are given in this note.

AN-439 MC1539 Op Amp and its Applications

This application note discusses the MC1539, a second generation operational amplifier. The general use and operation of the amplifier is discussed with special mention made of improved operation over that of its first generation predecessor—the 709 type amplifier.

In addition to the detailed discussion on the dc and ac operation of the device, considerable emphasis is placed on operational performance. Many applications are offered to demonstrate the device capability, including a high frequency feed-forward scheme, and a source follower application.

AN-440 Theory and Characteristics of Photo Transistors

A brief history of the photo-electric effect is discussed, followed by a comprehensive analysis of the effect in bulk semiconductors, pn junctions and phototransistors. A model is presented for the phototransistor. Static and transient data for the MRD300 provide typical phototransistor characteristics. Appendices provide a discussion of the relationship of irradiation and illumination and define terms specifically related to phototransistors.

AN-441 SCR Slaving Circuits

This circuit makes use of a low-cost transistor to overcome the limitations of a conventional R-C discharge circuit in slave firing of an SCR. It is especially useful where zero-point switching techniques are employed to control large electrical loads.

AN-442 Designing DC-DC Converters for Capacitor Charging with Batteries

This paper outlines design considerations for converters used for charging energy-storage capacitors with low-voltage batteries. The ratio of capacitor voltage to battery voltage is chosen to be greater than 100.

A discussion of converter characteristics is presented here from the standpoint of efficiency, frequency of oscillation, rate of energy transfer from battery to capacitor, and peak battery current drain.

A complete circuit is included that is tolerant of semiconductor parameter variations and is thus suitable for economical mass production.

AN-443 Directional and Speed Control for Series, Universal and Shunt Motors

A simple circuit containing few components allows control of both speed and direction of rotation of dc motors. The use of thyristors provides continuous driver control through the speed range without compromising the torque characteristics of the motors.

AN-444 Triac Prevents High Current Relay Arcing

A triac in shunt with the contacts of a relay that switches large currents drastically reduces the size of contacts required. Since the triac is subjected to current surges for only a short time and at a low duty cycle, it can conduct currents many times its steady-state rated value.

AN-445 Pulse-Width Modulation for DC-Motor Speed Control

Feedback derived from a motor's armature and dependent on its speed can be used to counteract the reduction in speed that accompanies loading. This note describes two speed-control circuits which use different methods to obtain the feedback signal. One method uses voltage sensing, and the other an optical pickup.

AN-446 128-Bit Read Only Memory

Read Only Memories can now be fabricated as integrated circuit arrays and hence will have a great

impact upon digital system design. Applications of the Motorola 16-word, 8-bit Read Only Memory (ROM) are discussed. The applications are grouped into two classifications according to the type of memory addressing utilized – (1) Random Accessing (2) Sequential Addressing.

AN-447 Fast Charging Systems for Ni-Cd Batteries

This note discusses the requirements and problems encountered in designing fast charging systems for nickel-cadmium (Ni-Cd) cells, including some cell characteristics affected by high-rate charging.

AN-449 AC and DC Relay Drivers

Though semiconductor devices are replacing electro-mechanical relays in many uses, some applications require the switching of a signal which is isolated from power and other sources. This can be done only with a relay. This application note describes three different circuits that can be used for electronic control of these relays.

AN-450 Induction Motor Speed Control

A method of providing speed control above and below design speed for an induction motor is shown in this note. Such speed control increases the versatility of an induction motor and permits it to be used in fulfilling requirements formerly satisfied only by dc motors.

AN-451 A Frequency Counter Using Motorola RTL Integrated Circuits

A frequency-period counter with a total hardware cost under $200.00, based on unit quantity prices, is described. The instrument measures the periods and frequencies of periodic waveforms, ranging in frequency from 10 Hz to 20 MHz, and counts random occurances for selected gate times of one millisecond to 10 seconds. A four digit decimal readout is provided. The low cost is achieved by utilizing plastic MRTL devices in unique versions of a crystal controlled oscillator, a period selector, a one shot multivibrator, a pulse shaper, and a switch contact bounce eliminator circuit.

AN-452 An Op Amp RC Bandpass Filter

The design of audio range active filters using operational amplifiers and RC frequency elements is discussed. A computer program in BASIC is given for general design. The design example, a filter with a center frequency of about 1600 Hz and adjustable Q from 10–200, is provided.

AN-453 Zero Point Switching Techniques

This note discusses two unique pulse-type thyristor triggering circuits which meet the exact timing requirements of zero-point switching. They dissipate very little power and can be used with either sensitive or "shorted" gate devices.

AN-454 AC Overcurrent Protective Circuit with Automatic Reset

A unique circuit that will protect ac resistive loads from both overvoltage and overcurrent is shown. One feature of this circuit is that the sensing element is not in series with the load when the load is turned on.

AN-455 Using the FET Designers Data Sheet for Worst Case Amplifier Circuit Design

Basic information for the use of field effect transistors is provided, and is an aid to complete understanding of the Designers* Data Sheet. This report discusses the advantages, disadvantages, types and modes of operation of FETs and presents a definitive discussion of key parameters with their relationship to circuit design, when applicable.

AN-456 A 50 MHz Programmable Counter Designed with MECL II Integrated Circuits

A high speed programmable counter using the MECL II family of logic is discussed. The counter is designed to accept an input frequency up to 50 MHz and divide it by any number from 2 to 999. This number is programmed into three decades of synchronous down counters. These decades with additional decoding and control logic comprise a complete high speed divide-by-N counter system.

AN-457 Switching Voltage Regulator Uses Discrete and Integrated-Circuit Approaches

A switching voltage regulator can be considerably more efficient than the conventional series-pass continuously conducting regulator. This note discusses the operation of switching regulators including design information. It also describes practical regulators using discrete and integrated-circuit driver circuits.

AN-459 A Simple Technique for Extending Op Amp Power Bandwidth

The design of fast response amplifiers is presented without the use of "tricky" compensation procedures or calculations using data sheet information. Circuit analysis for compensation procedure is given.

AN-460 Using Transient Response to Determine Operational Amplifier Stability

This application note describes a technique for evaluating the stability of any particular feedback amplifier configuration by analyzing its response to a step-function input. A theoretical analysis is given along with an example.

AN-461 Transient Suppression with a Power Zener Diode

Voltage transients are a major cause of component failure in semiconductor circuits. A design engineer must consider this problem carefully if he is to insure maximum circuit reliability. This note discusses the sources of transients and their detection, and describes transient suppression using power zener diodes designed for this purpose.

AN-462 FET Current Regulators—Circuits and Diodes

Included are numerous FET current sourcing circuits, along with an extensive treatment of the current regulating diode and its uses as a valuable component in circuit design.

AN-463 An Integrated Circuit Phase-Locked Loop Digital Frequency Synthesizer

A digital frequency synthesizer design is detailed which incorporates digital channel selection and exhibits excellent frequency stability through the use of a phase-locked loop. The system design takes advantage of state of the art in both linear and digital monolithic integrated circuits, plus some ideas new to the synthesizer field.

AN-464 MTTL Designer's Note – The MC4004/MC4005, A 16-Bit Random Access Memory

High speed, non-destructive readout (NDRO) memory systems can be constructed with the MTTL 16-bit memory chip. Information concerning the chip that is pertinent to the design of a complete memory system is herein presented. The topics discussed are: (1) operation of the 16-bit memory including typical read and write sequences, (2) typical dc and switching characteristics as a function of temperature, power supply, and output load, and (3) examples of memory system organization utilizing the 16-bit memory as the basic cell.

AN-465 MTTL Designer's Note – The MC4006/MC4007 Decoders

Two MTTL complex functions, the MC4006 Binary to One-of-Eight Decoder and the MC4007 Dual Binary to One-of-Four Decoder are discussed. Their basic modes of operation and expansion capabilities are described. Examples of the use of the decoders in various systems are presented.

AN-466 Circuit Applications for the Triac

This note discusses the basic theory of operation of the triac with control methods and circuit applications. Among the applications included are basic switches, lamp dimmers, motor controls, a heater control, a flasher, a regulator, protective circuits and zero-point switching.

AN-467 Using Motorola High Threshold Logic

This application note explains operation of the Motorola High Threshold Logic (MHTL) family of integrated circuits. It briefly describes the members of the family and provides many of the characteristics of the units. Several examples are provided to aid the reader in the application of this unique logic family.

AN-469 Line Operated 15-kHz Inverter

The circuit shown in this note is a line-operated inverter. It makes use of high-voltage, high-frequency silicon power transistors to provide 120 volts and 200 watts at 15 kilohertz. Because of the high frequency of operation, the components used can be small in size, resulting in a very compact inverter.

AN-470 Bipolar Chopper Transistors and Circuits

Bipolar transistor chopper circuits are used in many applications for low-drift amplification of dc and low-frequency ac signals. This note discusses the characteristics of transistors used as choppers and the circuits in which they can be used.

AN-471 Analog-To-Digital Conversion Techniques

The subject of analog-to-digital conversion and many of the techniques that can be used to accomplish it are discussed. The paper is written in general terms from a system point of view and is intended to assist the reader in determining which conversion technique is best suited for a given application.

AN-472 Mounting and Heat Sinking Uniwatt Plastic Transistors

The Uniwatt plastic package is now being used for several medium-power transistor types. This note describes several methods for mounting such devices, with emphasis on proper heat sinking for best thermal characteristics.

AN-473 A Monolithic High-Power Series Voltage Regulator

This note discusses MC1560/MC1561 voltage regulator in terms of internal operation, development of these circuits, and how they are advantageously used in supply fabrication.

AN-474 The MC1541 – A Gated Dual-Channel Sense Amplifier for Core Memories

The MC1541 sense amplifier can provide many magnetic core memory systems with lower system cycle times and a lower package count than with previous sense amplifiers. Circuit operation, design considerations, interface problems and typical applications are discussed.

AN-475 Using the MC1545 – A Monolithic, Gated-Video Amplifier

Because of the unique design of the MC1545, this amplifier can be used as a gated video amplifier, sense amplifier, amplitude modulator, frequency shift keyer, balanced modulator, pulse amplifier, and many other applications. This note describes the ac and dc operation of the circuit and presents applications of the device as a video switch, amplitude modulator, balanced modulator, pulse amplifier, and others.

AN-476 MTTL Designer's Note – The MC4000 Data Selector and the MC4002 Data Distributor

Two MTTL complex functions, the MC4002 four and two-channel data distributor, and the MC4000 dual four-channel data selector are discussed. Their basic modes of operation and expansion capabilities are described. Examples of the use of the data distributor and the data selector in various systems are presented.

AN-477 A 30-Watt 175 MHz Power Amplifier Using PNP Transistors

This note describes a three-stage power amplifier that delivers 30 watts output at 175 MHz. It utilizes the first commercially available VHF PNP high-power transistors to provide 29 dB gain, 50% overall efficiency, and low spurious output.

AN-478 Small Signal RF Design with Dual-Gate MOSFETS

The dual-gate MOSFET offers low noise, high gain, and excellent AGC, cross-modulation and overload characteristics in RF applications. Recent devices also feature silicon nitride passivation for ease of handling and reliability. This note discusses the characteristics of dual-gate MOSFETs, with emphasis on designing circuits, noise figure, AGC, bandwidth and detuning, cross-modulation and mixer operation.

AN-480 Regulators Using Operational Amplifiers

The theory of op amp voltage regulator design is discussed. The problem areas associated with such designs are also detailed. The MC1560 is used as a OTC voltage reference in the op amp regulator designs that are shown. It is shown that regulation from 0.01% to 0.001% is possible.

AN-481 A Broadband 4-Watt Aircraft Transmitter

This report describes a 4-W wideband AM aircraft transmitter intended for light aircraft. The frequency range is 118 to 136 MHz and no tuning is required when changing frequency. The RF circuitry can be operated from 12.5 V, or can be used with a series modulator described in the note from 26 V.

AN-482 Electronic Speed Control of Appliance Motors

This application note discusses the possibilities of controlling several types of induction motors, universal motors, and permanent-magnet motors, and includes circuit designs for each. By matching the motor to its electronic control, the designer can obtain a simple and efficient system.

AN-483 20 and 30 Watt Power Amplifiers Using Darlington Output Transistors

Use of monolithic power Darlington output transistors can greatly simplify the design of high-fidelity amplifiers. Described herein is a 20-W amplifier which uses only three transistors, and a 30-W amplifier which uses four.

AN-484 Medium-Power Audio Amplifiers Using Complementary Plastic Transistors

This note describes complementary-symmetry power amplifiers of 3- to 35- watt capability designed for 8-ohm loads. The circuits use inexpensive plastic-encapsulated silicon transistors in both low-level and output stages. Information is provided for specifying the transistors, power supplies and heat sinking.

AN-485 High-Power Audio Amplifiers with Short-Circuit Protection

This application note describes a recommended circuit approach for high-performance audio amplifiers in the 35-W to 100-W RMS power range. Circuitry is included which enables the amplifier to operate safely continuously under any load condition including a short.

AN-486 A Monolithic Circuit for Television Sound Systems

This application note describes the MC1351P monolithic integrated circuit designed for television sound systems. The circuit consists of a limiting 4.5 MHz IF amplifier and a full wave quadrature detector; in addition, it has an audio preamplifier and an audio driver on the same chip, capable of delivering 3 Vrms to the audio output stage.

AN-487 A High-Speed Ripple-Through Arithmetic Processor

A simple, systematic building block approach for designing a high-speed, ripple-through arithmetic

processor is described. Using only gates and full adders, ultra-high speed multiplication, division, square root extraction, addition, and subtraction may be performed. Several variations of an arithmetic processor design are detailed and comparisons of speed and package count using the MECL and MDTL logic in 14-pin, 16-pin, 24-pin, 32-pin, and 64-pin packages are given.

AN-488 High-Speed Addition Using Lookahead Carry Techniques

The use of the lookahead carry principle to increase the operating speed of adder systems is described. Several adders of different sizes using variations of lookahead carry are developed and the logical implementation of these using the MTTL III and MECL II and III logic families is given.

AN-489 Analysis and Basic Operation of the MC1595

The MC1595 monolithic linear four-quadrant multiplier is discussed. The equations for the analysis are given along with performance that is characteristic of the device. A few basic applications are given to assist the designer in system design.

AN-490 Using the MC1595 Multiplier in Arithmetic Operations

This application note discusses the use of the MC1595 linear four quadrant multiplier in arithmetic operations. Included is a discussion of the MC1595 used in the multiply, divide, square and square root modes of operation. Actual circuits for these functions are shown with measured data and a discussion of the errors occurring in each mode.

• Denotes Application Notes appearing for the first time in this index.

• AN-491 Gated Video Amplifier Applications The MC1545

This application note reviews the basic operation of the MC1545 and discusses some of the more popular applications for the MC1545. Included are several modulator types, temperature compensation of the active gate, AGC, gated oscillators, FSK systems, and single supply operation.

• AN-492 Operating Characteristics of Motorola MC3000/MC3100 Series Transistor-Transistor Logic Gates

This application note explains the advantages of using the MC3000/MC3100 Series of conventional TTL. Design data is included which should allow determination of the operating characteristics under almost any set of conditions.

• AN-493 The MC3000/MC3100 Series Transistor-Transistor Logic Flip-Flops

This application note explains the basic operation of the various flip-flops available in the MC3000/MC3100 series of transistor-transistor logic from Motorola. Typical operating characteristics are included so that operation under different conditions can be determined.

• AN-494 The Motorola Transistor-Transistor Logic Lines

This application note contains a general description and comparison of Motorola's MTTL I, MTTL II, MTTL III, MTTL 5400/7400, and the MC4000 lines. The basic gate and the MTTL III bypass circuit are discussed and tables of electrical characteristics are included. Two appendices provide definitions of common MTTL terms, a discussion of the effect of input diodes, and loading rules for the MC4000 series complex functions.

• AN-495 A 25-Watt, 175 MHz Transmitter for 12.5-Volt Operation

This note describes the power amplifier stages of a 175-MHz 25-watt transmitter. The transmitter requires a 12.5 volt dc power source and is therefore suitable for operation directly from the electrical system of a 12-volt vehicle.

• AN-496 Error Detection and Correction Using Exclusive-OR Gates and Parity Trees

The availability of Exclusive OR gates and parity trees allows digital system designers to use error detection and correction codes to improve their system reliability and maintainability without the major cost penalty that has existed in the past. Use of Exclusive-OR gates and parity trees available in the MRTL, MTTL, MDTL, and MECL families to design simple parity and single error Hamming parity detection and correction circuits is discussed.

• AN-497 A Floating Voltage and Current Regulator-The MC1566

This note discusses the MC1566 theory, operation, and application in the context of high-voltage regulation. Several circuits are given to demonstrate the versatility of this regulator.

• AN-498 Voltage and Current Boost Techniques Using The MC1560-61

The stability requirements for the current boosted MC1560-61 are discussed. Both internal and external compensation techniques are shown, along with heat-sink design information and typical circuits, including a self-oscillating switching regulator, and a voltage boost circuit.

- **AN-499 Shutdown Techniques for the MC1560-61/69 Monolithic Voltage Regulators**

This note discusses the many ways one can use the shutdown control for the MC1560 Monolithic Voltage Regulator. These include logic control, short circuit detection, over voltage detection, junction temperature control, and thermal feedback. Also discussed, are current foldback and methods of restarting automatically from the shutdown state. The techniques discussed apply equally to the MC1560, MC1561, and MC1569 positive voltage regulators.

- **AN-500 Development, Analysis, and Basic Operation of the MC1560-61 Monolithic Voltage Regulators**

In this note, the analysis and basic operation of the MC1560 and the MC1561 voltage regulators are discussed. The tests and parameters used on the data sheet are considered, and the problems of specifying a monolithic voltage regulator are identified. The basic circuit configurations are shown with some insight for the typical performance one can expect.

- **AN-503 A 25-W Broadband Aircraft Transmitter**

This report describes a wideband aircraft transmitter with a typical carrier output of 25 watts. The frequency range is 118-136 MHz and no tuning is required. The supply voltage is 13.6 V.

- **AN-504 The MC1600 Series MECL III Gates**

This application note explains the basic operation of the various gates available in the MECL III logic family. Typical operating characteristics are included as an aid to the designer of high-speed logic along with recommended layout, breadboarding, and testing procedures. This note will also provide the designer with some insight into the overall capabilities of this logic line as they apply to this application.

- **AN-505 The MC4012, AN MTTL 4-Bit Shift Register**

The MC4012 is a 4-bit shift register consisting of four D-type flip-flops operated in the synchronous mode and may be used for temporary storage of information. The MC4012 may be operated in either the parallel or serial mode input depending upon the logic state of the mode control. Circuit operation and various applications of the device are the subject of this application note.

- **AN-506 Code Conversion with Semiconductor Read Only Memories**

In digital systems, data is manipulated and transmitted in coded form and frequently must be translated from one code into another. The use of read only memories to perform the various code conversions is discussed in this note. In particular, methods for converting data from the binary code to the binary coded decimal representation, and vice versa, are detailed. Conversion from the Hollerith code to the common 8-bit codes, such as the RS-358, ASC II, and EBCDIC codes, as well as conversions between the 8-bit codes are also treated.

- **AN508 Apprications of Phototransistors in Electro-Optic Systems**

This note reviews phototransistor theory, characteristics and terminology, then discusses the design of electro-optic systems using device information and geometric considerations. It also includes several circuit designs that are suited to dc, low-frequency and high-frequency applications.

- **AN-509 True RMS Voltage Regulators**

This note describes ac voltage regulators that are ideal for use with electronic and electrical equipment such as lamps and heaters that are highly sensitive to supply voltage. These regulators maintain constant rms voltage levels for input or load changes.

- **AN-510 A Function Generator**

This report describes an inexpensive function generator with sine-, square-, and triangular-wave outputs. A combination of discrete and integrated circuits provide lowest cost without sacrificing good performance. Maximum output amplitude of all waveforms is 20 volts peak to peak from a 50-ohm output impedance. Frequency range is 1 Hz to 1 MHz.

- **AN-511 Low Frequency Applications of Field-Effect Transistors**

Field-effect transistors enjoy usage in a wide range of applications at both high and low frequencies. This report discusses the low-frequency applications. with an emphasis on the lesser-known uses. General topics covered are switches and choppers, amplifiers, voltage-variable resistors, current limiters, and microwatt logic.

- **AN-513 A High Gain Integrated Circuit RF-IF Amplifier With Wide Range AGC**

This note describes the operation and application of the MC1590G, a monolithic RF-IF amplifier. Included are several applications for IF amplifiers, a mixer, video amplifiers, single and two-stage RF amplifiers.

- **AN-516 Direct Digital Display Using MTTL Complex Functions**

This application note examines some of the different design methods for digital readouts with the added circuitry advantage of integrated circuit complex functions; in particular the MC5400/7400 series.

- **AN-517 Improving the Efficiency of Low Voltage, High-Current Rectification**

  The efficiency of low-voltage, high-current rectification can be improved by using either barrier rectifier diodes or synchronous rectification. This note discusses both approaches and compares them to the use of conventional silicon rectifiers.

- **AN-518 Constant-Speed Motor Control Using Tachometer Feedback**

  A simple tachometer can provide feedback control for shaded-pole motors and better brush life for universal motors. This note describes pickups and circuits suitable for use in such equipment as home appliances and power tools.

- **AN-519 Using MDTL Logic Blocks**

  This Application Note discusses typical applications of basic MDTL components such as gates and flip-flops, with emphasis placed on the positive logic AND, OR, NOR, NAND, and Exclusive-OR functions. Methods of interfacing MDTL with other popular logic families are also discussed.

THEORY AND CHARACTERISTICS OF PHOTOTRANSISTORS

INTRODUCTION

Phototransistor operation is based on the sensitivity of a pn junction to radiant energy. If radiant energy of proper wave-length is made to impinge on a junction, the current through that junction will increase. This optoelectronic phenomenon has provided the circuit designer with a device for use in a wide variety of applications. However, to make optimum use of the phototransistor, the designer should have a sound grasp of its operating principles and characteristics.

HISTORY

The first significant relationships between radiation and electricity were noted by Gustav Hertz in 1887. Hertz observed that under the influence of light, certain surfaces were found to liberate electrons. This photo-emissive effect was put into theory by Max Planck in 1900. He proposed that light of a frequency f contained energy bundles or packets, which he called photons. Furthermore, the energy content of each photon was directly proportional to the light frequency:

$$E = hf, \qquad (1)$$

where E is the photon energy,
h is Planck's constant, and
f is the light frequency.

Planck theorized that a metal had associated with it a work function, or binding energy for free electrons. If a photon could transfer its energy to a free electron, and that energy exceeded the work function, the electron could be liberated from the surface. The presence of an electric field could enhance this by effectively reducing the work function. Einstein extended Planck's findings by showing that the velocity, and hence the momentum of an emitted electron, depended on the work function and the light frequency.

PHOTO EFFECT IN SEMICONDUCTORS

Bulk Crystal

If light of proper wavelength impinges on a semiconductor crystal, the concentration of charge carriers is found to increase. Thus, the crystal conductivity will increase:

$$\sigma = q(\mu_e n + \mu_h p), \qquad (2)$$

where σ is the conductivity,
q is the electron charge,
μ_e is the electron mobility,
μ_h is the hole mobility,
n is the electron concentration, and
p is the hole concentration.

The process by which charge-carrier concentration is increased is shown in Figure 1. The band structure of the semiconductor is shown, with an energy gap, or forbidden region, of Eg electron volts. Radiation from two light sources is shown striking the crystal. Light frequency f_1 is sufficiently high that its photon energy, hf_1, is slightly greater than the energy gap. This energy is transferred to a bound electron at site one in the valence band, and the electron is excited to a higher energy level, site one in the conduction band, where it is free to serve as a current carrier. The hole left behind at site one in the valence band is also free to serve as a current carrier.

The photon energy of the lower-frequency light, hf_2, is less than the band gap, and an electron freed from site two in the valence band will rise to a level in the forbidden region, only to release this energy and fall back into the valence band and recombine with a hole at site three.

The above discussion implies that the energy gap, Eg, represents a threshold of response to light. This is true, however, it is not an abrupt threshold. Throughout the photo-excitation process, the law of conservation of mo-

Circuit diagrams external to Motorola products are included as a means of illustrating typical semiconductor applications; consequently, complete information sufficient for construction purposes is not necessarily given. The information in this Application Note has been carefully checked and is believed to be entirely reliable. However, no responsibility is assumed for inaccuracies. Furthermore, such information does not convey to the purchaser of the semiconductor devices described any license under the patent rights of Motorola Inc. or others.

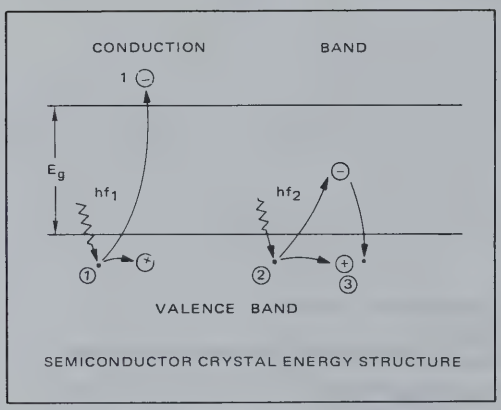


FIGURE 1 – Photoeffect in a Semiconductor

mentum applies. The momentum and density of hole-electron sites are highest at the center of both the valence and conduction bands, and fall to zero at the upper and lower ends of the bands. Therefore, the probability of an excited valence-band electron finding a site of like momentum in the conduction band is greatest at the center of the bands and lowest at the ends of the bands. Consequently, the response of the crystal to the impinging light is found to rise from zero at a photon energy of Eg electron volts, to a peak at some greater energy level, and then to fall to zero again at an energy corresponding to the difference between the bottom of the valence band and the top of the conduction band.

The response is a function of energy, and therefore of frequency, and is often given as a function of reciprocal frequency, or, more precisely, of wave length. An example is shown in Figure 2 for a crystal of cadmium-selenide. On the basis of the information given so far, it would seem reasonable to expect symmetry in such a curve; however, trapping centers and other absorption phenomena affect the shape of the curve[1].

The optical response of a bulk semiconductor can be modified by the addition of impurities. Addition of an acceptor impurity, which will cause the bulk material to become p-type in nature, results in impurity levels which lie somewhat above the top of the valence band. Photo-excitation can occur from these impurity levels to the conduction band, generally resulting in a shifting and reshaping of the spectral response curve. A similar modification of response can be attributed to the donor impurity levels in n-type material.

PN Junctions

If a pn junction is exposed to light of proper frequency, the current flow across the junction will tend to increase. If the junction is forward-biased, the net increase will be relatively insignificant. However, if the junction is reverse-biased, the change will be quite appreciable. Figure 3 shows the photo effect in the junction for a frequency well within the response curve for the device.

1. See references for a detailed discussion of these.

Photons create hole-electron pairs in the crystal on both sides of the junction. The transferred energy promotes the electrons into the conduction band, leaving the holes in the valence band. The applied external bias provides an electric field, $\mathcal{E}$, as shown in the figure. Thus the photo-induced electrons in the p-side conduction band will flow down the potential hill at the junction into the n-side and from there to the external circuit. Likewise, holes in the valence band of the n-side will flow across the junction into the p-side where they will add to the external current.

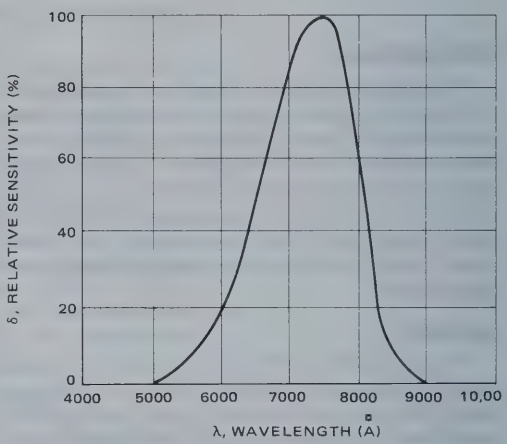


FIGURE 2 – Spectral Response of Cadmium Selenide

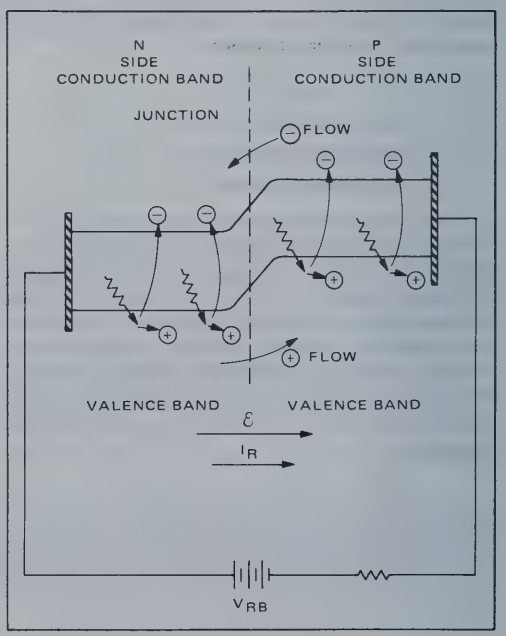


FIGURE 3 – Photo Effect in a Reverse-Biased PN Junction

Under dark conditions, the current flow through the reverse-biased diode is the reverse saturation current, I_O. This current is relatively independent of the applied voltage (below breakdown) and is basically a result of the thermal generation of hole-electron pairs.

When the junction is illuminated, the energy transferred from photons creates additional hole-electron pairs. The number of hole-electron pairs created is a function of the light intensity.

For example, incident monochromatic radiation of H (watts/cm^2) will provide P photons to the diode:

$$P = \frac{\lambda H}{hc}, \qquad (3)$$

where λ is the wavelength of incident light,

h is Planck's constant, and

c is the velocity of light.

The increase in minority carrier density in the diode will depend on P, the conservation of momentum restriction, and the reflectance and transmittance properties of the crystal. Therefore, the photo current, I_λ, is given by

$$I_\lambda = \eta F q A, \qquad (4)$$

where η is the quantum efficiency or ratio of current carriers to incident photons,

F is the fraction of incident photons transmitted by the crystal,

q is the charge of an electron, and

A is the diode active area.

Thus, under illuminated conditions, the total current flow is

$$I = I_O + I_\lambda. \qquad (5)$$

If I_λ is sufficiently large, I_O can be neglected, and by using the spectral response characteristics and peak spectral sensitivity of the diode, the total current is given approximately by

$$I \approx \delta S_R H, \qquad (6)$$

where δ is the relative response and a function of radiant wavelength,

S_R is the peak spectral sensitivity, and

H is the incident radiation.

The spectral response for a silicon photo-diode is given in Figure 4.

Using the above relations, an approximate model of the diode is given in Figure 5. Here, the photo and thermally generated currents are shown as parallel current sources. C represents the capacitance of the reverse-biased junction while G represents the equivalent shunt conductance of the diode and is generally quite small. This model applies only for reverse bias, which, as mentioned above, is the normal mode of operation.

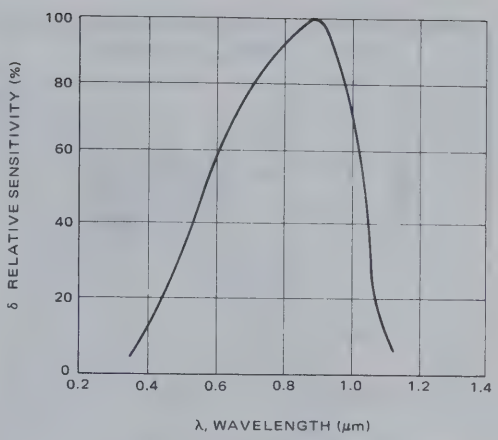


FIGURE 4 – Spectral Response of Silicon Photodiode

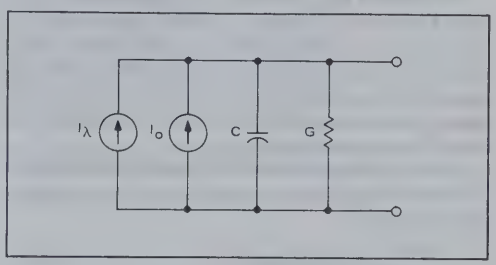


FIGURE 5 – Approximate Model of Photodiode

Photo Transistor

If the pn junction discussed above is made the collector-base diode of a bipolar transistor, the photo-induced current is the transistor base current. The current gain of the transistor will thus result in a collector-emitter current of

$$I_C = (h_{fe} + 1) I_\lambda, \qquad (7)$$

where I_C is the collector current,

h_{fe} is the forward current gain, and

I_λ is the photo induced base current.

The base terminal can be left floating, or can be biased up to a desired quiescent level. In either case, the collector-base junction is reverse biased and the diode current is the reverse leakage current. Thus, photo-stimulation will result in a significant increase in diode, or base current, and with current gain will result in a significant increase in collector current.

The energy-band diagram for the photo transistor is shown in Figure 6. The photo-induced base current is returned to the collector through the emitter and the external circuitry. In so doing, electrons are supplied to the base region by the emitter where they are pulled into the collector by the electric field $\mathcal{E}$.

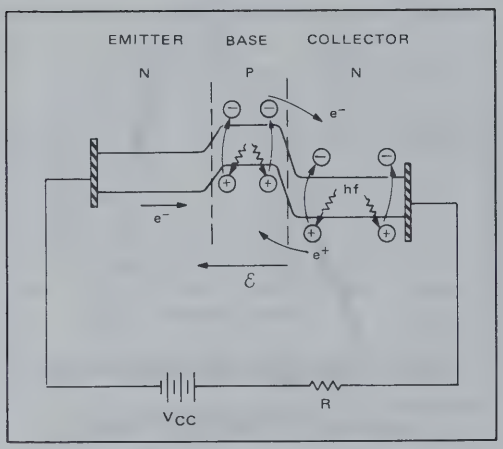


FIGURE 6 – Photoeffect in a Transistor

The model of the photo diode in Figure 5 might also be applied to the phototransistor, however, this would be severely limited in conveying the true characteristics of the transistor. A more useful and accurate model can be obtained by using the hybrid-pi model of the transistor and adding the photo-current generator between collector and base. This model appears in Figure 7.

Assuming a temperature of 25°C, and a radiation source at the wave length of peak response (i.e., $\delta = 1$), the following relations apply:

$$I_\lambda \approx S_{RCBO} \cdot H, \qquad (8a)$$

$$gm = 40\, i_c, \text{ and} \qquad (8b)$$

$$r_{be} = h_{fe}/g_m, \qquad (8c)$$

where S_{RCBO} is the collector-base diode radiation sensitivity with open emitter,

g_m is the forward transconductance,

i_c is the collector current, and

r_{be} is the effective base-emitter resistance.

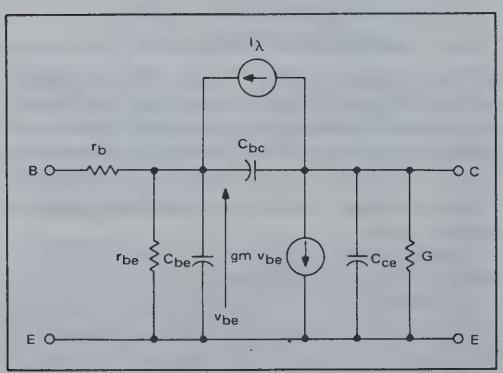


FIGURE 7 – Hybrid-pi Model of Phototransistor

In most cases $r'_b \ll r_{be}$, and can be neglected. The open-base operation is represented in Figure 8. Using this model, a feel for the high-frequency response of the device may be obtained by using the relationship

$$f_t \approx \frac{g_m}{2\pi C_{BE}}, \qquad (9)$$

where f_t is the device current-gain-bandwidth product.

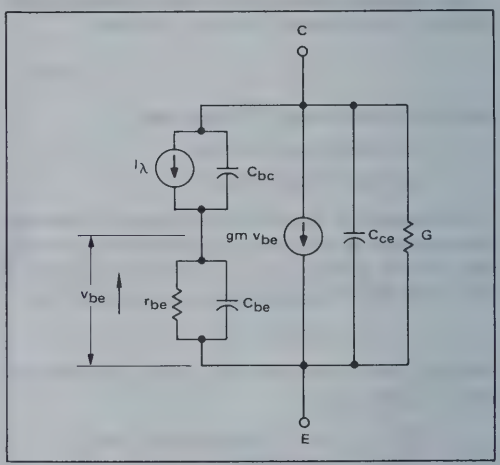


FIGURE 8 – Floating Base Approximate Model of Phototransistor

STATIC ELECTRICAL CHARACTERISTICS OF PHOTOTRANSISTORS

Spectral Response

As mentioned previously, the spectral response curve provides an indication of a device's ability to respond to radiation of different wave lengths. Figure 9 shows the spectral response for constant energy radiation for the Motorola MRD300 phototransistor series. As the figure indicates, peak response is obtained at about 8000 Å (Angstroms), or 0.8 μm.

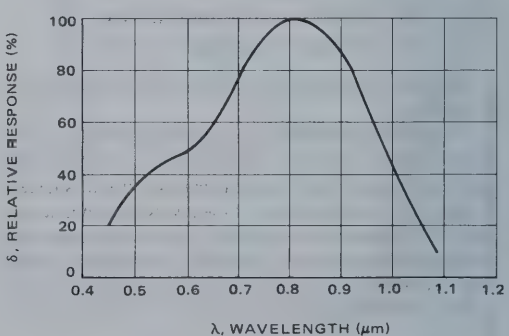


FIGURE 9 – Constant Energy Spectral Response for MRD300

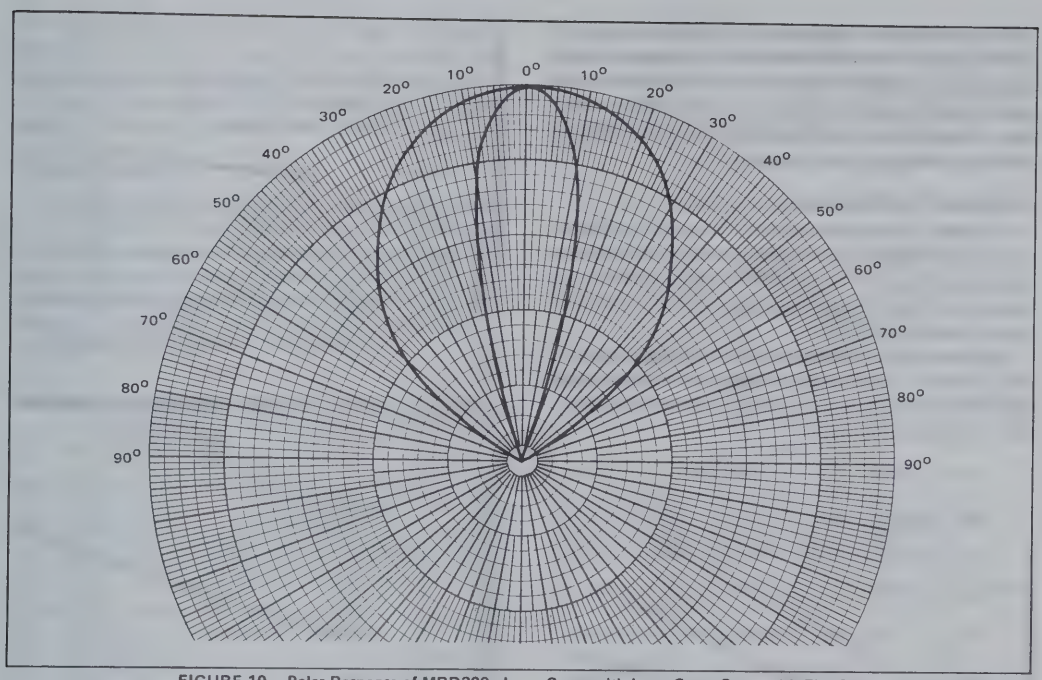


FIGURE 10 – Polar Response of MRD300. Inner Curve with Lens, Outer Curve with Flat Glass.

Angular Alignment

Lambert's law of illumination states that the illumination of a surface is proportional to the cosine of the angle between the normal to the surface and the direction of the radiation. Thus, the angular alignment of a phototransistor and radiation source is quite significant. The cosine proportionately represents an ideal angular response. The presence of an optical lens and the limit of window size further affect the response. This information is best conveyed by a polar plot of the device response. Such a plot in Figure 10 gives the polar response for the MRD300 series.

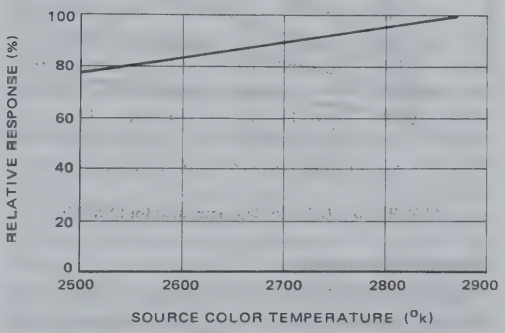


FIGURE 12 – Relative Response of MRD300 versus Color Temperature

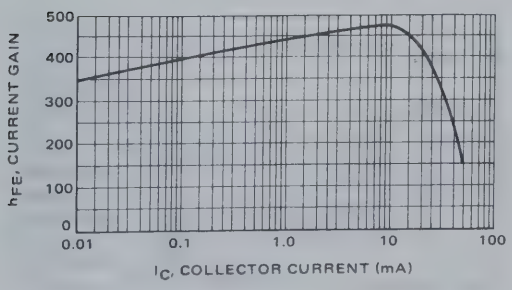


FIGURE 11 – DC Current Gain versus Collector Current

DC Current Gain

The sensitivity of a photo transistor is a function of the collector-base diode quantum efficiency and also of the dc current gain of the transistor. Therefore, the overall sensitivity is a function of collector current. Figure 11 shows the collector current dependence of dc current gain.

Color Temperature Response

In many instances, a photo transistor is used with a broad band source of radiation, such as an incandescent lamp. The response of the photo transistor is therefore dependent on the source color temperature. Incandescent

sources are normally operated at a color temperature of 2870°K, but, lower-color-temperature operation is not uncommon. It therefore becomes desirable to know the result of a color temperature difference on the photo sensitivity. Figure 12 shows the relative response of the MRD300 series as a function of color temperature.

Temperature Coefficient of I_P

A number of applications call for the use of phototransistors in temperature environments other than normal room temperature. The variation in photo current with temperature changes is approximately linear with a positive slope of about 0.667%/°C.

The magnitude of this temperature coefficient is primarily a result of the increase in h_{FE} versus temperature, since the collector-base photo current temperature coefficient is only about 0.1%/°C.

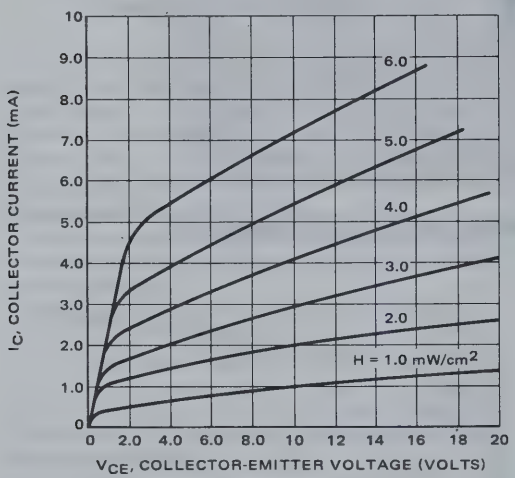


FIGURE 13 — Collector Characteristics for MRD300

Collector Characteristics

Since the collector current is primarily a function of impinging radiation, the effect of collector-emitter voltage, below breakdown, is small. Therefore, a plot of the I_C–V_{CE} characteristics with impinging radiation as a parameter, are very similar to the same characteristics with I_B as a parameter. The collector family for the MRD300 series appears in Figure 13.

Radiation Sensitivity

The capability of a given phototransistor to serve in a given application is quite often dependent on the radiation sensitivity of the device. The open-base radiation sensitivity for the MRD300 series is given in Figure 14. This indicates that the sensitivity is approximately linear with respect to impinging radiation. The additional capability of the MRD300 to be pre-biased gives rise to interest in the sensitivity as a function of equivalent base resistance. Figure 15 gives this relationship.

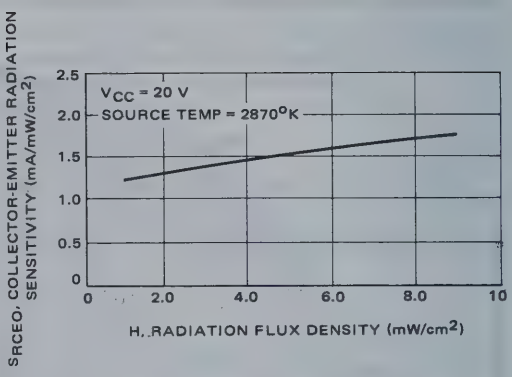


FIGURE 14 — Open Base Sensitivity versus Radiation for MRD300

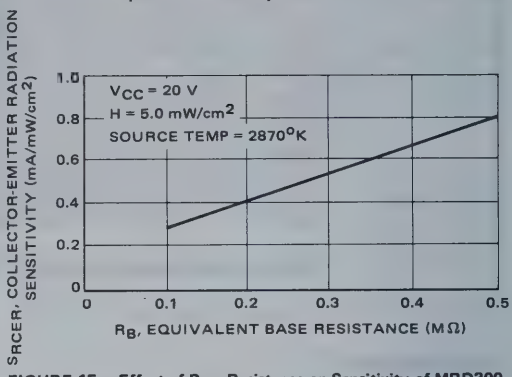


FIGURE 15 — Effect of Base Resistance on Sensitivity of MRD300

Capacitance

Junction capacitance is the significant parameter in determining the high frequency capability and switching speed of a transistor. The junction capacitances of the MRD300 as a function of junction voltages are given in Figure 16.

DYNAMIC CHARACTERISTICS OF PHOTOTRANSISTORS

Linearity

The variation of h_{FE} with respect to collector current results in a non-linear response of the photo transistor over

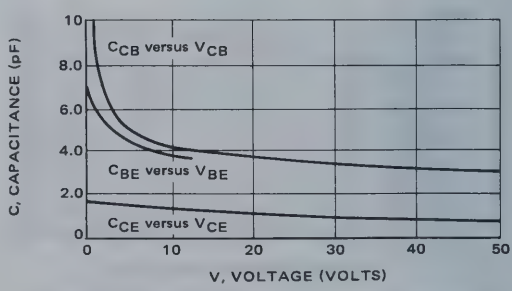


FIGURE 16 — Junction Capacitances versus Voltage for MRD300

large signal swings. However, the small-signal response is approximately linear. The use of a load line on the collector characteristic of Figure 13 will indicate the degree of linearity to be expected for a specific range of optical drive.

Frequency Response

The phototransistor frequency response, as referred to in the discussion of Figures 7 and 8, is presented in Figure 17. The device response is flat down to dc with the rolloff frequency dependent on the load impedance as well as on the device. The response is given in Figure 17 as the 3-dB frequency as a function of load impedance for two values of collector current.

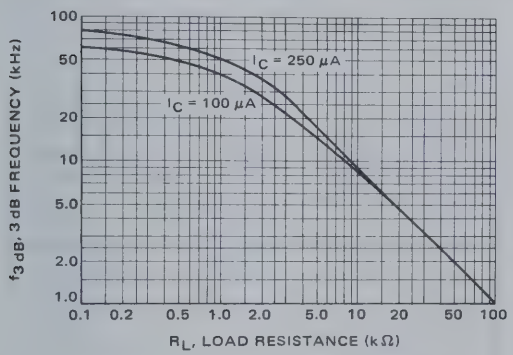


FIGURE 17 – 3 dB Frequency versus Load Resistance for MRD300

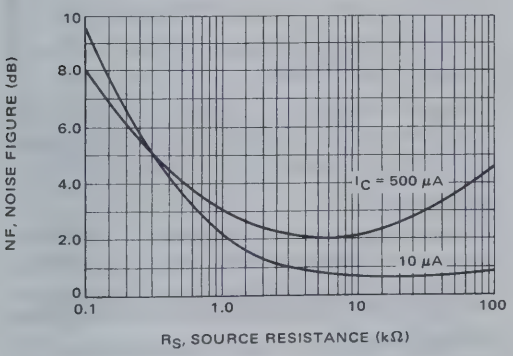


FIGURE 18 – MRD300 Noise Figure versus Source Resistance

Noise Figure

Although the usual operation of the phototransistor is in the floating base mode, a good qualitative feel for the device's noise characteristic can be obtained by measuring noise figure under standard conditions. The 1 kHz noise figure for the MRD300 is shown in Figure 18.

Small Signal h Parameters

As with noise figure, the small-signal h-parameters, measured under standard conditions, give a qualitative feel for the device behavior. These are given as functions of collector current in Figure 19. With this information, the device can be analyzed in the standard hybrid model of Figure 20(a); by use of the conversions of Table I, the equivalent r-parameter model of Figure 20(b) can be used.

TABLE I – Parameter Conversions

$$h_{fb} = \frac{h_{fe}}{1 + h_{fe}}$$

$$r_c = \frac{h_{fe} + 1}{h_{oe}}$$

$$r_e = \frac{h_{re}}{h_{oe}}$$

$$r_b = h_{ie} - \frac{h_{re}\,(1 + h_{fe})}{h_{oe}}$$

SWITCHING CHARACTERISTICS OF PHOTOTRANSISTORS

In switching applications, two important requirements of a transistor are:

(1) speed

(2) ON voltage

Since some optical drives for phototransistors can provide fast light pulses, the same two considerations apply.

Switching Speed

If reference is made to the model of Figure 8, it can be seen that a fast rise in the current I_λ will not result in an equivalent instantaneous increase in collector-emitter current. The initial flow of I_λ must supply charging current to C_{CB} and C_{BE}. Once these capacitances have been charged, I_λ will flow through r_{be}. Then the current generator, $g_m \cdot v_{be}$, will begin to supply current. During turn-off, a similar situation occurs. Although I_λ may instantaneously drop to zero, the discharge of C_{CB} and C_{BE} through r_{be} will maintain a current flow through the collector. When the capacitances have been discharged, V_{be} will fall to zero and the current, $g_m \cdot V_{be}$, will likewise drop to zero. (This discussion assumes negligible leakage currents). These capacitances therefore result in turn-on and turn-off delays, and in rise and fall times for switching applications just as found in conventional bipolar switching transistors. And, just as with conventional switching, the times are a function of drive. Figure 21 shows the collector current (or drive) dependence of the turn-on delay and rise times. As indicated the delay time is dependent on the device only; whereas the rise-time is dependent on both the device and the load.

If a high-intensity source, such as a xenon flash lamp, is used for the optical drive, the device becomes optically saturated unless large optical attenuation is placed between source and detector. This can result in a significant storage time during the turn off, especially in the floating-base mode since stored charge has no direct path out of the

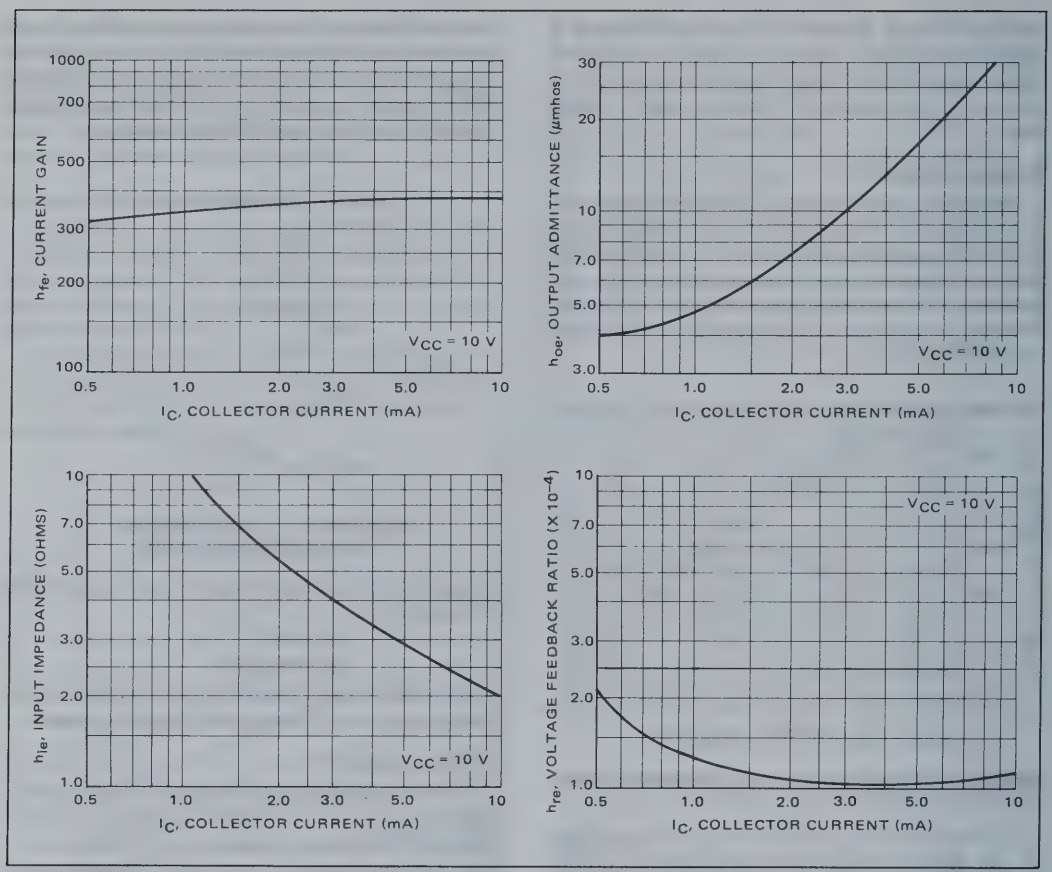


FIGURE 19 – 1 kHz h-Parameters versus Collector Current for MRD300

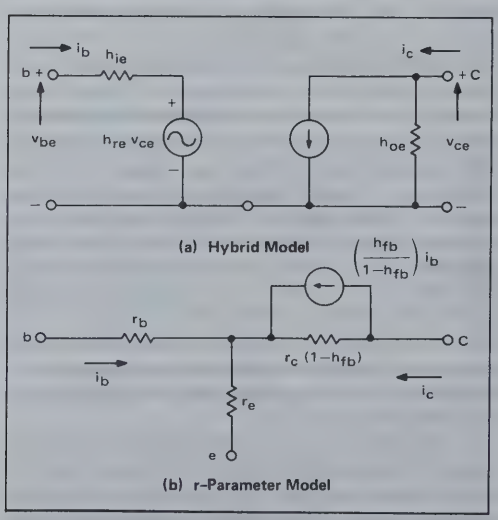


FIGURE 20 – Low Frequency Analytical Models of Phototransistor Without Photo Current Generator

base region. However, if a non-saturating source, such as a GaAs diode, is used for switching drive, the storage, or turn-off delay time is quite low as shown in Figure 22.

Saturation Voltage

An ideal switch has zero ON impedance, or an ON voltage drop of zero. The ON saturation voltage of the MRD300 is relatively low, approximately 0.2 volts. For a given collector current, the ON voltage is a function of drive, and is shown in Figure 23.

APPLICATIONS OF PHOTOTRANSISTORS

As mentioned previously, the phototransistor can be used in a wide variety of applications. Figure 24 shows two phototransistors in a series-shunt chopper circuit. As Q_1 is switched ON, Q_2 is OFF, and when Q_1 is switched OFF, Q_2 is driven ON.

Logic circuitry featuring the high input/output electrical isolation of photo transistors is shown in Figure 25.

Figure 26 shows a linear application of the phototransistor. As mentioned previously, the linearity is obtained for small-signal swings.

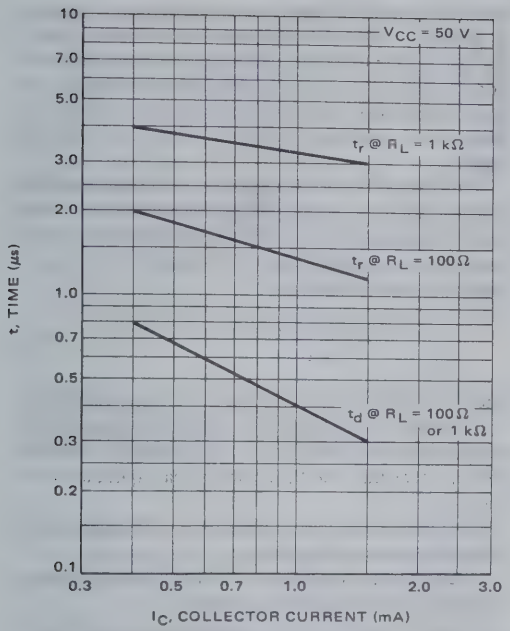


FIGURE 21 – Switching Delay and Rise Times for MRD300

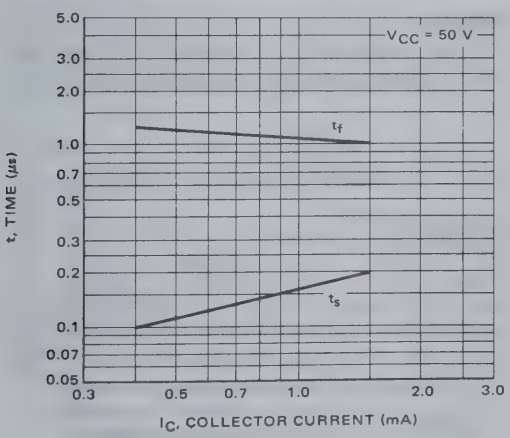


FIGURE 22 – Switching Storage and Fall Times for MRD300

A double-pole, single-throw relay is shown in Figure 27.

In general, the phototransistor can be used in counting circuitry, level indications, alarm circuits, tachometers, and various process controls.

Conclusion

The phototransistor is a light-sensitive active device of moderately high sensitivity and relatively high speed. Its response is both a function of light intensity and wavelength, and behaves basically like a standard bipolar transistor with an externally controlled collector-base leakage current.

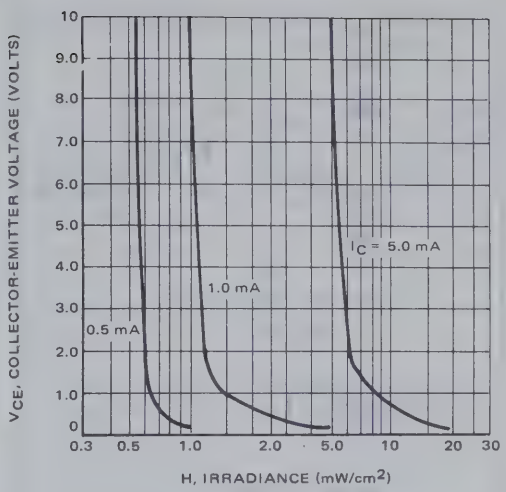


FIGURE 23 – Collector Emitter Saturation Voltage as a Function of Irradiance for MRD300

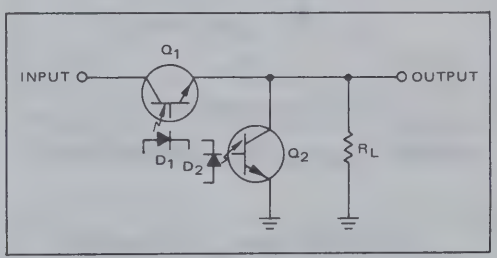


FIGURE 24 – Series-Shunt Chopper Circuit Using MRD300 Phototransistors and GaAs Light Emitting Diodes (LEDs)

APPENDIX I

Radiant energy covers a broad band of the electromagnetic spectrum. A relatively small segment of the band is the spectrum of visible light. A portion of the electromagnetic spectrum including the range of visible light is shown in Figure I-1.

The portion of radiant flux, or radiant energy emitted per unit time, which is visible is referred to as luminous flux. This distinction is due to the inability of the eye to respond equally to like power levels of different visible wavelengths. For example, if two light sources, one green and one blue are both emitting like wattage, the eye will perceive the green light as being much brighter than the blue. Consequently, when speaking of visible light of varying color, the watt becomes a poor measure of brightness. A more meaningful unit is the lumen. In order to obtain a clear understanding of the lumen, two other definitions are required.

The first of these is the standard source (Fig. I-2). The standard source, adopted by international agreement, con-

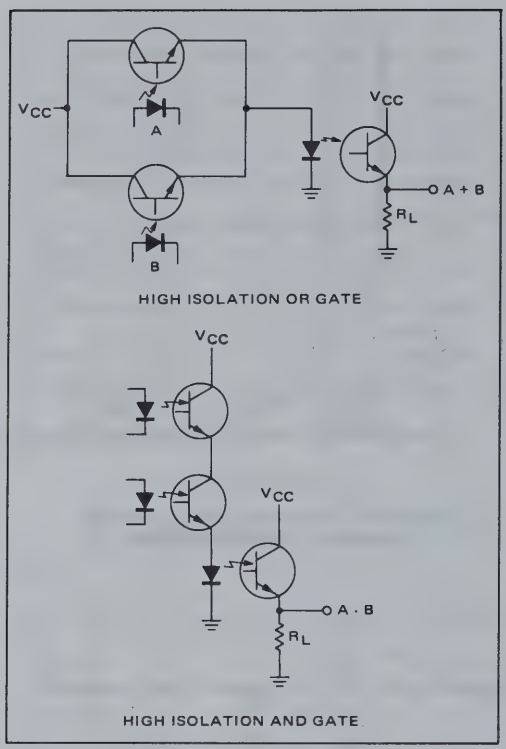


FIGURE 25 – Logic Circuits Using the MRD300 and LEDs

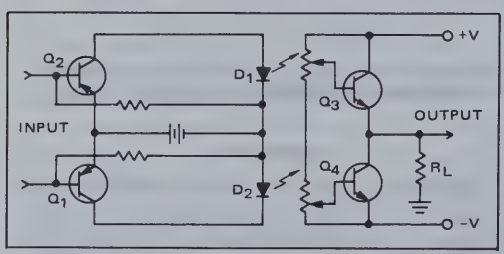


FIGURE 26 – Small Signal Linear Amplifier Using MRD300 and LEDs

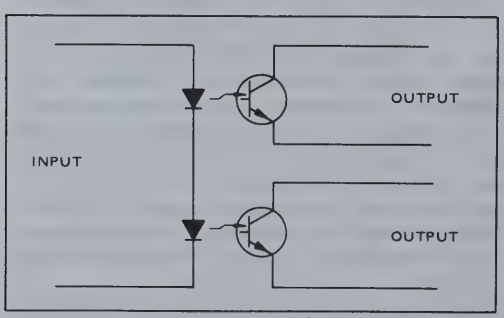


FIGURE 27 – DPST Relay Using MRD300s and LEDs

sists of a segment of fused thoria immersed in a chamber of platinum. When the platinum is at its melting point, the light emitted from the chamber approximates the radiation of a black body. The luminous flux emitted by the source is dependent on the aperture and cone of radiation. The cone of radiation is measured in terms of the solid angle.

The concept of a solid angle comes from spherical geometry. If a point is enclosed by a spherical surface and a set of radial lines define an area on the surface, the radial lines also subtend a solid angle. This angle, ω, is shown in Figure I-3, and is defined as

$$\omega = \frac{A}{r^2}, \qquad \text{(I-1)}$$

where A is the described area and r is the spherical radius.

If the area A is equal to r^2, then the solid angle subtended is one unit solid angle or one steradian, which is nothing more than the three-dimensional equivalent of a radian.

With the standard source and unit solid angle established, the lumen can be defined.

A lumen is the luminous flux emitted from a standard source and included within one steradian.

Using the concept of the lumen, it is now possible to define other terms of illumination.

Illuminance

If a differential amount of luminous flux, dF, is impinging on a differential area, dA, the illuminance, E, is given by

$$E = \frac{dF}{dA}. \qquad \text{(I-2)}$$

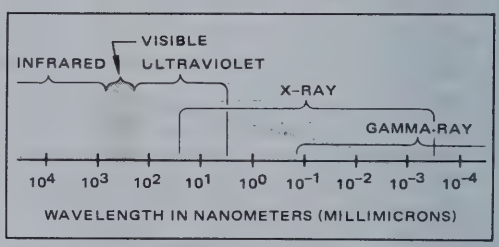


FIGURE I–1 – Portion of Electromagnetic Spectrum

Illuminance is most often expressed in lumens per square foot, or foot-candles. If the illuminance is constant over the area, (I-2) becomes

$$E = F/A. \qquad \text{(I-3)}$$

Luminous Intensity

When the differential flux, dF, is emitted through a differential solid angle, $d\omega$, the luminous intensity, I, is given by

$$I = \frac{dF}{d\omega}. \qquad \text{(I-4)}$$

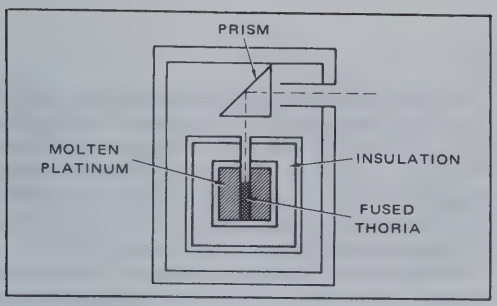


FIGURE I–2 – International Standard Source

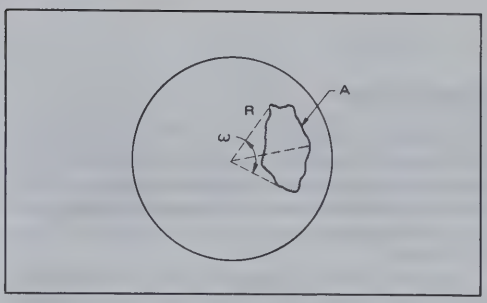


FIGURE I–3 – Solid Angle, ω

Luminous intensity is most often expressed in lumens per steradian or candela. If the luminous intensity is constant with respect to the angle of emission, (I-4) becomes:

$$I = \frac{F}{\omega} \qquad \text{(I-5)}$$

If the wavelength of visible radiation is varied, but the illumination is held constant, the radiative power in watts will be found to vary. This again illustrates the poor quality of the watt as a measure of illumination. A relation between illumination and radiative power must then be specified at a particular frequency. The point of specification has been taken to be at a wavelength of 0.555 μm, which is the peak of spectral response of the human eye. At this wavelength, 1 watt of radiative power is equivalent to 680 lumens.

APPENDIX II
OPTOELECTRONIC DEFINITIONS

F, Luminous Flux: Radiant flux of wavelength within the band of visible light.

Lumen: The luminous flux emitted from a standard source and included within one steradian (solid angle equivalent of a radian).

H, Radiation Flux Density (Irradiance): The total incident radiation energy measured in power per unit area (e.g., mW/cm^2).

E, Luminous Flux Density (Illuminance): Radiation flux density of wavelength within the band of visible light. Measured in lumens/ft^2 or foot candles. At the wavelength of peak response of the human eye. 0.555 μm (0.555×10^{-6}m), 1 watt of radiative power is equivalent to 680 lumens.

S_R, Radiation Sensitivity: The ratio of photo-induced current to incident radiant energy, the latter measured at the plane of the lens of the photo device.

S_I, Illumination Sensitivity: The ratio of photo-induced current to incident luminous energy, the latter measured at the plane of the lens of the photo device.

Spectral Response: Sensitivity as a function of wavelength of incident energy. Usually normalized to peak sensitivity.

Constants

Planck's constant: $h = 4.13 \times 10^{-15}$ eV-s.
electron charge: $q = 1.60 \times 10^{-19}$ coulomb.
velocity of light: $c = 3 \times 10^{8}$ m/s.

Illumination Conversion Factors

Multiply	By	To Obtain
lumens/ft^2	1	ft. candles
lumens/ft^2*	1.58×10^{-3}	mW/cm^2
candlepower	4π	lumens

*At 0.555 μm.

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USING THE FET DESIGNERS DATA SHEET FOR WORST CASE AMPLIFIER CIRCUIT DESIGN

INTRODUCTION

This report discusses in detail the Motorola Designers Data Sheet (D.D.S.) which permits the design of most circuits entirely from the information presented. Limit curves, representing minimum and/or maximum boundaries for device characteristics, are given to facilitate "worst case" design.

A discussion of the temperature effects of drain current (I_D) and gate to source voltage (V_{GS}) with design equations is covered, and a detailed "worst case" design example is given with a discussion of trade-offs required for different I_{DSS} ratio devices. The report concludes with a section on small signal analysis.

ADVANTAGES AND DISADVANTAGES OF FET's

The field effect transistor (FET) has several advantages over the conventional transistor: it is relatively free of noise, is more resistant to the degrading effects of nuclear radiation because carrier lifetime effects are comparatively unimportant to its operation, and is inherently more resistant to burnout than a conventional bipolar transistor.

There are additional attributes of the FET which are advantageous for certain design considerations. The inherently high input impedance—typically many megohms, is a characteristic that is very useful in impedance transformations, chopper and switching applications. Since it is a voltage controlled device, it can readily be "self-biased" which frequently makes for a more simple circuit than would be possible with a bipolar transistor. It also has a nonlinearity (at a drain-source voltage less than pinch-off) that can be exploited for automatic gain control applications. In addition, JFET's have a very high output resistance making it useful as a constant current source when it is operated at a drain-source voltage greater than pinch-off. Table I illustrates a comparison of some JFET key parameters and their relative magnitudes as compared to vacuum tubes, bipolar transistors and MOSFETs.

When compared with bipolar transistors, the chief shortcoming of the FET is its relatively small gain-bandwidth product. Although the JFET is free from carrier-transit-time limitations, its parasitic capacitances place it at a relative disadvantage.

TYPES OF FET's AND MODES OF OPERATION

There are two categories of field effect transistors, Junction Field-Effect Transistors (JFET) and Metal-Oxide-Silicon Field-Effect Transistors (MOSFET). As the names imply, a JFET uses the characteristics of a reverse-biased junction to control the drain-source current, while in the MOSFET the gate is a metal deposited on an oxide layer and is insulated from the source and drain. Both devices operate on the principle of a "channel" current controlled by an electric field. The control mechanisms for the two are different, resulting in considerably different characteristics. The main difference between the two is in the gate characteristics. The input of the JFET behaves like a reversed biased diode while the input of a MOSFET is similar to a small capacitor.

Figure 1-A shows a simplified diagram of an N-channel JFET, and Figures 1-B and 1-C show how depletion regions

TABLE 1

CHARACTERISTICS	VACUUM TUBE	JFET	MOS FET	BIPOLAR
Input Impedance	High	High	Very High	Low
Noise	Low	Low	Unpredictable	Low
Warm-Up Time	Long	Short	Short	Short
Size	Large	Small	Small	Small
Power Consumption	Large	Small	Small	Small
Aging	Noticeable	Not Noticeable	Noticeable	Not Noticeable
Bias Voltage Temp Coefficient	Low, Not Predictable	Low Predictable	High, Not Predictable	Low Predictable
Typical Gate/Grid Current	1 nA	0.1 nA	10 pA	—
Gate/Grid Current Change With Temp	High Unpredictable	Medium Predictable	Low Unpredictable	—
Reliability	Low	High	High	High
Sensitivity To Overload	Very Good	Good	Poor	Good

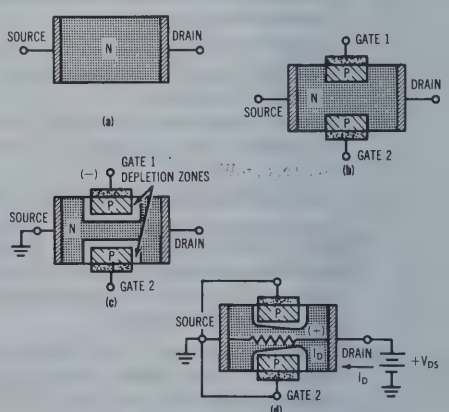


FIGURE 1 – Development of Depletion Regions

Circuit diagrams external to Motorola products are included as a means of illustrating typical semiconductor applications; consequently, complete information sufficient for construction purposes is not necessarily given. The information in this Application Note has been carefully checked and is believed to be entirely reliable. However, no responsibility is assumed for inaccuracies. Furthermore, such information does not convey to the purchaser of the semiconductor devices described any license under the patent rights of Motorola Inc. or others.

are formed by biasing either the drain-source channel or gate-source junction. The depletion region is formed around the gate and controls the effective width of the channel between the drain and source which in turn controls the amount of current that can flow from source to drain. Due to the difficulty of diffusing a gate into each side of a semiconductor wafer, a single-ended geometry is used as shown in Figure 2. The geometry shown in Figure 1 is still a useful aid for understanding some of the basic characteristics (such as breakdown voltage and leakage current) of a JFET.

There are two fundamental modes of operation--depletion and enhancement. In depletion mode maximum drain current (I_{DSS}) flows when the gate-source voltage, (V_{GS}), is zero and decreases for increasing V_{GS}. Enhancement mode is just the opposite in that minimum drain current flows at $V_{GS} = 0$ but increases for increasing V_{GS}.

The transfer characteristics for depletion and enhancement modes and the industrial designation of types according to mode(s) of operation are given in Figure 3. Devices designated as "Type A" are defined in the depletion mode only, "Type B" devices are defined in the both the depletion and enhancement modes, and "Type C", in the enhancement mode only.

The test circuits in Figure 3 show the biasing for N channel devices. Note that V_{DS} is always positive for the three types. In the useful range of operation, V_{GS} is negative for a "Type A" device, positive for "Type C", and either polarity for "Type B". For a P channel FET, all polarities must be reversed.

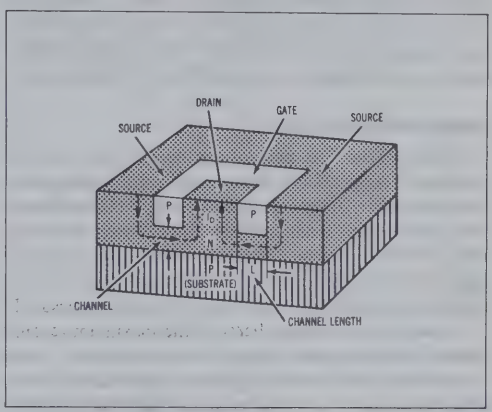


FIGURE 2 – Single Ended Geometry JFET

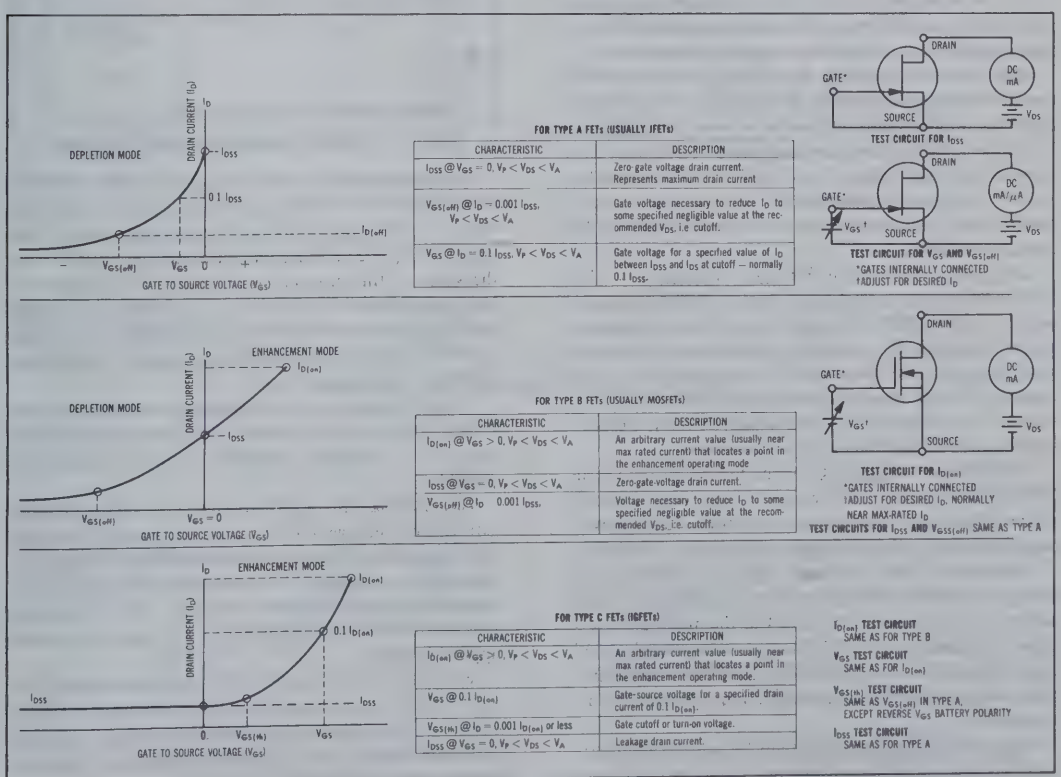


FIGURE 3 – Static characteristics (Drain Current versus Gate to Source Voltage) for the three FET types are defined by the above curves, tables, and test circuits

THE DESIGNERS DATA SHEET

The remainder of the paper discusses only JFET's and uses the Designers Data Sheet for the 2N5265 thru 2N5270 as a basis for the discussion.

The Designers Data Sheet permits the design of most circuits entirely from the information presented. For instance, key parameters such as I_{DSS} and Y_{fs} have both minimum and maximum specified values. Also, limit curves, representing boundaries for device characteristics, are presented, and, for the forward transfer characteristics, min/max curves are given at three different temperatures.

Ratings and Characteristics

Figure 4 (the first page of the data sheet) gives the maximum ratings of the device, mechanical dimensions, and pin layout. It will suffice to say that if the maximum ratings are exceeded, abnormal circuit operation will occur and the device may be destroyed. Figure 5 (the second page of the data sheet) presents the electrical characteristics and operating conditions under which they were measured.

Forward Gate Current, $I_{G(f)}$, is the maximum recommended forward current through the gate terminal. This is a limiting factor in some applications and is caused by a large forward bias current on the gate. When this condition occurs, the gate current must be limited or degeneration of the device will occur. A resistor in series with the gate will limit the current, but its value will determine the variance of gate bias as affected by the gate leakage current.

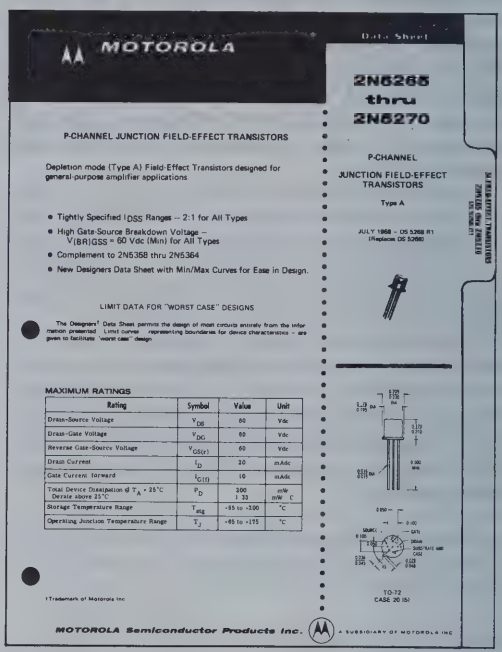
Total Device Dissipation, P_D, is the maximum power that can be dissipated within the device at 25°C without exceeding the maximum allowable internal temperature, in this case, 200°C. The power is derated according to the thermal resistance value of 1.33 mW/C°. For example, at 125°C the power dissipated in the device must not exceed 77 mW. Operation above the maximum value could damage the device.

Gate-Source Breakdown Voltage, $V_{(BR)GSS}$, is the breakdown voltage from gate to source with the drain and source shorted. With drain and source shorted, the gate-channel junction also meets the breakdown specification since the drain and source are the connections to the channel. For the designer this means the drain and source may be interchanged, for symmetrical devices, without worrying about individual junction breakdown.

The minimum $V_{(BR)GSS}$ voltage for the 2N5265 thru 2N5270 is 60 volts. This relatively high value is useful where large signal swings are required, high voltage power supplies are used, or high voltage transients are encountered.

Gate-Source Cutoff Voltage, $V_{GS(off)}$, is defined as the gate to source voltage required to reduce the drain current to 0.01 or preferably 0.001 of the minimum I_{DSS} value as defined by JEDEC formats. A standard I_D of 1 μAdc is used for the 2N6265 thru 2N5270 which facilitates testing and meets the JEDEC requirements for all the devices.

Pinch-off voltage, V_P, is essentially the same as $V_{GS(off)}$, only measured in a different manner. V_P is shown in Figure 6 and is the drain to source voltage at which the drain current increases very little for an increase in drain to source voltage at $V_{GS} = 0$. Most of the equations used to describe the operation of a FET use V_P but the value of $V_{GS(off)}$ can be used instead.



MOTOROLA

Data Sheet

2N6265 thru 2N5270

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion mode (Type A) Field Effect Transistors designed for general-purpose amplifier applications

- Tightly Specified I_{DSS} Ranges — 2:1 for All Types
- High Gate-Source Breakdown Voltage — $V_{(BR)GSS}$ = 60 Vdc (Min) for All Types
- Complement to 2N5358 thru 2N5364
- New Designers Data Sheet with Min/Max Curves for Ease in Design.

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Type A

JULY 1968 — DS 5268 R1 (Replaces DS 5268)

LIMIT DATA FOR "WORST CASE" DESIGNS

The Designers' Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing boundaries for device characteristics — are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	60	Vdc
Drain-Gate Voltage	V_{DG}	60	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	60	Vdc
Drain Current	I_D	20	mAdc
Gate Current Forward	$I_{G(f)}$	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.33	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C

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FIGURE 4 — 2N5265 thru 2N5270 Designers Data Sheet

An approximate value for $V_{GS(off)}$ can also be determined from the transfer-characteristic curve shown in Figure 7. $V_{GS(off)}$ is found by taking the slope of the curve at $V_{GS} = 0$ and extending it to the V_{GS} axis. Twice the value of this intercept is $V_{GS(off)}$. From Figure 7, $V_{GS(off)}$ minimum is about 2 X 1.25 volts or 2.5 volts and $V_{GS(off)}$ maximum is about 2 X 1.8 volts or 3.6 volts at 25°C. This technique can be used on any of the I_D-V_{GS} curves for other temperatures.

$V_{GS(off)}$ must be used to determine the minimum operational drain-to-source voltage. As a rule of thumb, when $V_{DS} > 1.5\ V_{GS(off)}$, operation in the active region is assured.

Gate Leakage (Reverse) Current, I_{GSS}, is defined as the gate-channel leakage with the drain shorted to the source and is a measure of the static short-circuit input impedance. Since gate to channel is a reverse biased diode junction, I_{GSS} approximately doubles for every 15°C increase in temperature and is proportional to the square root of the applied voltage.

For the 2N5265 thru 2N5270, I_{GSS} is measured at 30 volts which is much higher than the normal gate to source voltage. On the other hand, a gate-drain voltage of 30 volts is perhaps typical so that I_{GSS} exceeds the worst case gate leakage current for most applications.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	60	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 μAdc)	2N5265, 2N5266	$V_{GS(off)}$	-	3.0	Vdc
	2N5267, 2N5268		-	6.0	
	2N5269, 2N5270		-	8.0	
Gate Reverse Current (V_{GS} = 30 Vdc, V_{DS} = 0)		I_{GSS}	-	2.0	nAdc
(V_{GS} = 30 Vdc, V_{DS} = 0, T_A = 150°C)			-	2.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5265	I_{DSS}	0.5	1.0	mAdc
	2N5266		0.8	1.6	
	2N5267		1.5	3.0	
	2N5268		2.5	5.0	
	2N5269		4.0	8.0	
	2N5270		7.0	14	
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 0.05 mAdc)	2N5265	V_{GS}	0.3	1.5	Vdc
(V_{DS} = 15 Vdc, I_D = 0.08 mAdc)	2N5266		0.4	2.0	
(V_{DS} = 15 Vdc, I_D = 0.15 mAdc)	2N5267		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 0.25 mAdc)	2N5268		1.0	4.0	
(V_{DS} = 15 Vdc, I_D = 0.4 mAdc)	2N5269		2.0	6.0	
(V_{DS} = 15 Vdc, I_D = 0.7 mAdc)	2N5270		2.0	6.0	
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5265	$\|y_{fs}\|$	900	2700	μmhos
	2N5266		1000	3000	
	2N5267		1500	3500	
	2N5268		2000	4000	
	2N5269		2200	4500	
	2N5270		2500	5000	
Forward Transconductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N5265	$Re(y_{fs})$	800	-	μmhos
	2N5266		900	-	
	2N5267		1400	-	
	2N5268		1700	-	
	2N5269		1900	-	
	2N5270		2100	-	
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	-	75	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	2.0	pF
Common-Source Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_G = 1.0 M ohm, f = 100 Hz, BW = 1.0 Hz)		NF	-	2.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 Hz, BW = 1.0 Hz)		e_n	-	115	$nV/\sqrt{Hz}$

FIGURE 5 – 2N5265 thru 2N5270 Designers Data Sheet

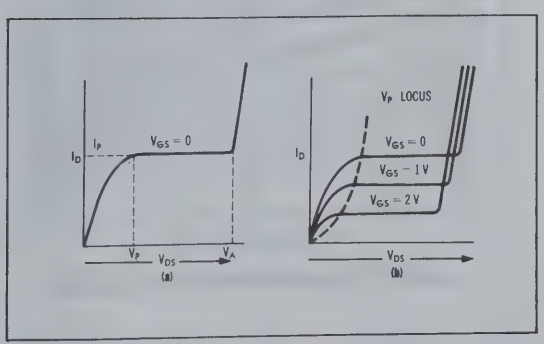


FIGURE 6 – FET Output Capacitance

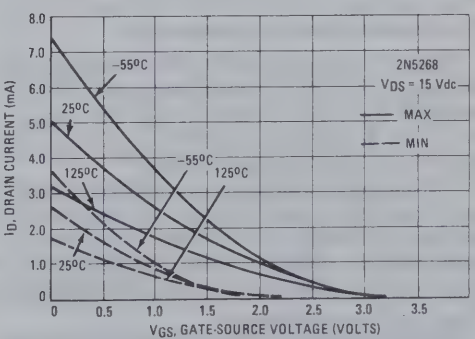


FIGURE 7 – Forward Transfer Characteristic Curves for Min/Max I_{DSS} Limits

Zero Gate Voltage Drain Current, I_{DSS}, is defined as the drain-to-source current with the gate shorted to the source at a specified drain-source voltage. I_{DSS} is a basic parameter for JFETs and is considered to be a figure of merit. For the 2N5265 thru 2N5270, each device has a min/max I_{DSS} ratio of 2:1. This tight ratio has numerous advantages, especially for worst case design, where higher stage gain can be obtained, there is less distortion and less source degeneration. A smaller source resistor achieves these results and, is obtained by having a tight I_{DSS} ratio. With a larger I_{DSS} ratio, the $-55^{o}C$ curve, as shown in Figure 17, would shift to the right which would decrease the slope of the load line, for the same I_D, hence increasing R_S. This is discussed further in the "worst case" design example.

Minimum/maximum transfer characteristics curves for the 2N5268 at three different temperatures are shown in Figure 7. Using these curves, worst-case design is reduced to a simple graphical technique and requires no further testing of the devices.

Gate-Source Voltage, V_{GS}, is a range of gate to source voltages with 0.1 I_{DSS} drain current flowing as required for JEDEC registration. The specified drain to source voltage is the same as for I_{DSS}. This characteristic gives the designer the min/max variation in V_{GS} for different devices for a given I_D and V_{DS}.

Forward Transadmittance, $|Y_{fs}|$, is defined as the magnitude of the common-source forward transfer admittance. It shows the relationship between input signal voltage and output signal current, and is a key dynamic characteristic for all FETs. $|Y_{fs}|$ is specified at 1 kHz, with dc operating conditions the same as for I_{DSS}.

At 1 kHz Y_{fs} is almost entirely real; therefore, $|Y_{fs}|$ at 1 kHz = Y_{fs} is a good assumption. At higher frequencies $|Y_{fs}|$ includes the effects of gate-to-drain capacitance and may be misleadingly high; for high frequency operation the real part of transadmittance, $Re(Y_{fs})$, as discussed later, should be used.

Figure 8 shows $|Y_{fs}|$ versus I_D with typical and minimum values shown. The curves end abruptly where $I_D = I_{DSS}$ and at this value $|Y_{fs}|$ is at its maximum.

Figure 9 shows the typical temperature coefficient of $|Y_{fs}|$ versus drain current. For this curve V_{DS} = 15 V and V_{GS} is varied to obtain the variations of I_D.

Forward Transconductance, $Re(Y_{fs})$, is defined as the common source forward transfer conductance. For high frequency applications $Re(Y_{fs})$ is considered a figure of merit. The dc operating conditions are the same as for $|Y_{fs}|$, but the test frequency is 100 MHz.

In comparing $Re(Y_{fs})$ with $|Y_{fs}|$ it is seen that the minimum values of the two are quite close, considering the difference in frequency at which the measurements are made. At high frequencies, about 30 MHz and above, $|Y_{fs}|$ would increase due to the effect of C_{gd} so that $|Y_{fs}|$ would be misleadingly high.

Output Admittance, $|Y_{os}|$, is defined as the magnitude of the common source output admittance and is measured

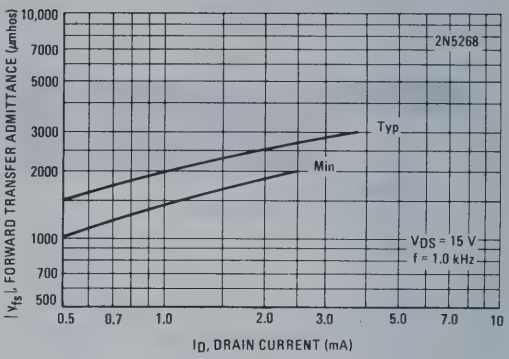


FIGURE 8 – Typical and Minimum Forward Admittance

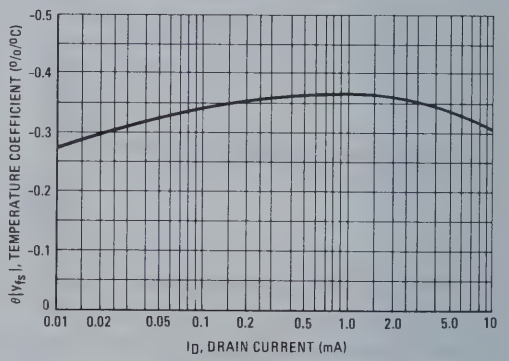


FIGURE 9 – Forward Transadmittance Coefficient versus Drain Current

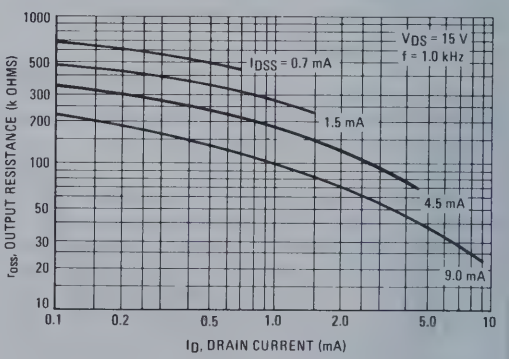


FIGURE 10 – Output Resistance versus Drain Current

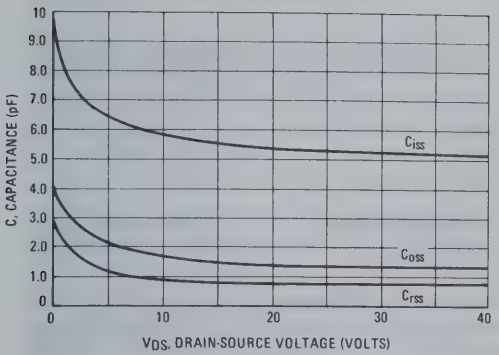


FIGURE 11 – Capacitances versus Drain-Source Voltage

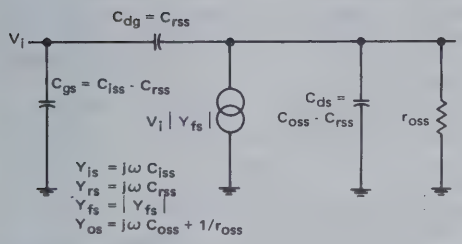


FIGURE 12 – Equivalent Low Frequency Circuit

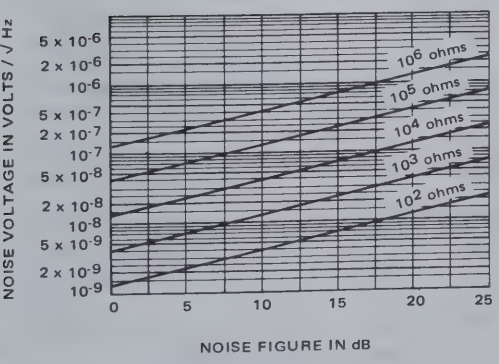


FIGURE 13 – Noise Figure Conversion Chart

at the same operating conditions and frequency as $|Y_{fs}|$. Y_{os} is a complex number so at low frequencies only the magnitude is specified. For higher frequencies, Y_{os} can be calculated using r_{oss} as shown in Figure 12.

The common-source output resistance, r_{oss}, is the real part of Y_{os}. Figure 10 shows the variation of r_{oss} versus I_d for several I_{DSS} units. These are also measured at 1 kHz, V_{DS} = 15 V, and V_{GS} varied to obtain the different values of I_D. Notice from these curves that the lower I_{DSS} units have a higher output resistance for the same drain current.

Input Capacitance, C_{iss} is the common-source input capacitance with the output shorted, and is used in place of Y_{iss}, the short circuit input admittance. Y_{iss} is entirely capacitive at low frequencies as the input is a back biased silicon diode. The real part of Y_{iss} could be calculated from I_{GSS}, but is negligible even at low frequencies.

Reverse Transfer Capacitance, C_{rss}, is defined at the common source reverse transfer capacitance with the input shorted. C_{rss} is used in place of Y_{rs}, the short circuit reverse transfer admittance, since Y_{rs} is almost entirely capacitive over the useful frequency range of the FET. Figure 11 shows C_{iss}, C_{rss} and C_{oss} as functions of V_{DS}.

A notable feature of the Designers Data Sheet is the equivalent circuit of the FET as shown in Figure 12. For the 2N5265 thru 2N5270 the circuit is valid up to about 30 MHz and shows how to obtain all of the short circuit Y parameters from the data given in the data sheet.

Common-Source Noise Figure, NF, represents a ratio between input signal to noise and output signal to noise and is measured in dB. Short-circuit input noise voltage, e_n, is the equivalent short circuit input noise, expressed in volts per root cycle.

NF, as specified, includes the effects of e_n and i_n, where i_n is the equivalent open circuit input noise current. For a FET, the contribution of i_n is small compared to e_n. From Figure 15, NF attains its highest value for a small generator resistance and decreases for increasing generator resistance, indicating a large noise contribution from the noise-voltage generator. For this reason NF and e_n are specified and i_n is neglected. NF is independent of operating current and proportional to voltage but the voltage effects are slight over the normal operating range.

Figure 13 is a nomograph for converting noise figure to equivalent input noise voltage for different generator source impedances, R_s. This nomograph can be used with any FET. Since NF and e_n are frequency dependent, Figure 13 must be used in conjunction with Figure 14 (noise figure versus frequency at a specified source impedance) to determine e_n. For example, to find the input noise at 100 Hz and R_s = 1 megohm, NF, from Figure 14, is found to be about 1.5 dB. Next, from Figure 13, e_n is found to be 1.5 X 10^{-7} volts or 150 nV. If the stage had a voltage gain of 10, the output noise would be 10 X 150 nV or 1.5 μV of 100 Hz noise.

Figure 15 shows NF versus generator resistance at a fixed frequency. The only point common to Figures 14

and 15 is at R_S = 1 Megohm and f = 1 kHz, but for other values of R_S and f, NF can be estimated by using both figures, then e_n is found, as before, from Figure 13.

Temperature Coefficient of I_D or V_{GS}

While there is no single specification dealing with the zero TC effect of FET's, its importance warrants discussion. Figure 16 shows the typical I_D temperature coefficient, θI_D versus I_D, for the 2N5265 thru 2N5270. All of the devices have a temperature coefficient of zero at approximately I_D = 0.5 mA.

The positive temperature coefficient occuring at small values of drain current is caused by a change in the width of the thermally generated depletion layer at the gate-channel junction and changes at a rate equivalent to −2.2 mV/°C across the gate source junction. This is the same value and phenomenon as the forward biased base-emitter junction of a bipolar transistor. The negative TC occurs at high values of I_D due to a decrease in carrier mobility (increasing resistivity) in the channel. At some value of I_D these two effects cancel each other and zero TC of I_D or V_{GS} occurs.

The design equations for zero TC operation are:

$$V_{GSZ} \approx V_P - 0.63 \qquad (1)$$

$$I_{DZ} \approx I_{DSS}\left(\frac{0.63}{V_P}\right)^2 \qquad (2)$$

$$\text{Drift in mV/°C} \approx 2.2\left(1 - \frac{\sqrt{I_D}}{I_{DZ}}\right) \qquad (3)$$

where subscript Z indicates the zero temperature coefficient point for the parameter.

Equation 3 is valid near, but not at, I_{DZ}. Equations 1 and 2 must both be satisfied for zero TC operation. Since V_P and I_{DSS} vary from device to device, an adjustment for V_{GS} or I_D is necessary. It is noted in passing that resistor temperature coefficients and the effects of I_{GSS} with temperature must also be considered.

"Worst Case" Design Example

The following example is presented to show how the transfer characteristic curves from the Designers Data Sheet are used in the "worst case" design of a typical bias network (Figure 18).

Given: V_{DD} = 30 Vdc, I_D = 1.0 ± 0.25 mAdc
from −55°C to +125°C

Procedure: The 2N5268 "worst case" bias conditions for the given temperature range are shown in Figure 17. The first step in designing the bias network is to determine the value of the source resistance (R_S in Figure 18) necessary to maintain the ±0.25 mAdc I_D bias tolerance over the required temperature range. From Figure 17:

$$R_S = \frac{V_{GS(max)} - V_{GS(min)}}{I_{D(max)} - I_{D(min)}} = \frac{1.9 - 0.8}{1.25 - 0.75} = 2.2\ k\Omega$$

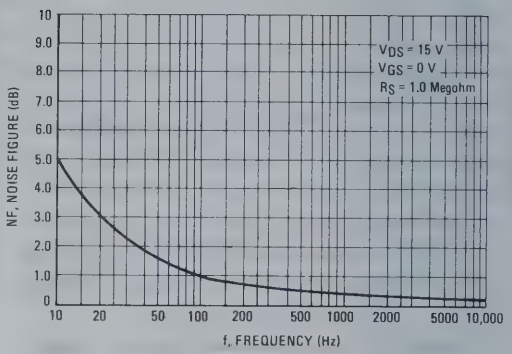


FIGURE 14 – Noise Figure versus Frequency

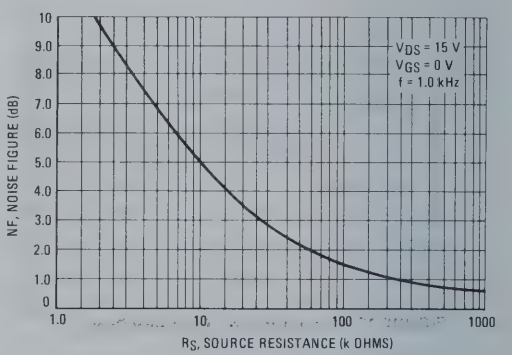


FIGURE 15 – Noise Figure versus Source Resistance

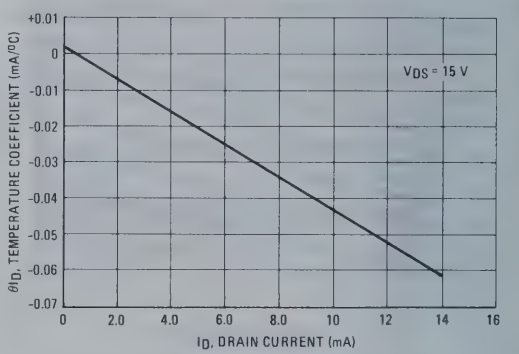


FIGURE 16 – Drain Current Temperature Coefficient versus Drain Current

V_G is determined from the intercept of the load line with the V_{GS} axis and is computed from:

$$V_G = \frac{I_{D(max)}\, V_{GS(min)} - I_{D(min)}\, V_{GS(max)}}{I_{D(max)} - I_{D(min)}}$$

$$= \frac{1.25 \text{ X } 0.80 - 0.75 \text{ X } 1.9}{0.5} = 0.85 \text{ Vdc.}$$

The maximum value of R_1 is determined by the maximum gate reverse current. Gate reverse current variations with temperature follow the pattern of all silicon devices, and, as a rule, it can be assumed that it will double with each 15°C temperature rise; therefore, a maximum reverse current of approximately 0.5 μAdc at 125°C based on the specified maximum of 2 μAdc at 150°C can also be assumed. The variation in V_G versus temperature will not be too great if a value for R_1 is chosen such that I_1, in Figure 17, is 5 times greater than the maximum reverse current. Assuming a value of 9.1 megohm for R_1, I_1 is 3.3 μA which satisfies the above requirement. R_2 is now found from a simple voltage divider relationship, ignoring the effect of I_G.

$$R_2 = \frac{V_G\, R_1}{V_{DD} - V_G} = \frac{0.85 \text{ X } 9.1 \text{ X } 10^6}{30 - 0.85} \approx 300 \text{ k}$$

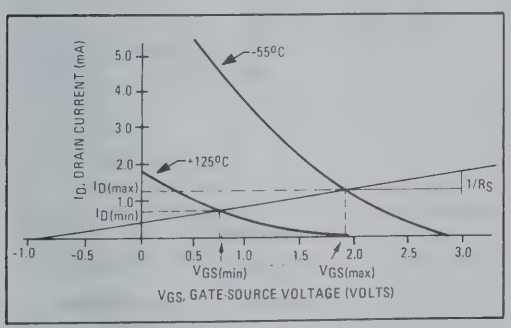


FIGURE 17 – I/R_S Load Line

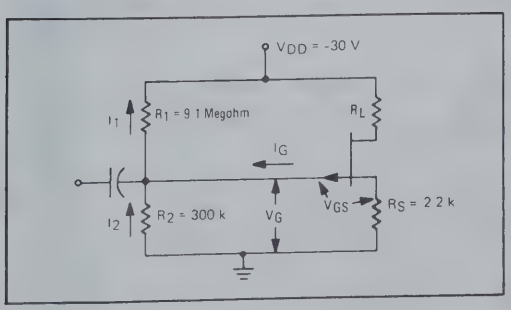


FIGURE 18

Using the above values of R_1 and R_2, the variation in V_G is from 0.81 Vdc, at I_G = 0.5 μA, to 0.96 Vdc, at I_G = 0. The effect on I_D by the variation of V_G is found from the slope of the load line and the change in V_G. For a ΔV_G of 0.15 Vdc, ΔI_D = 0.068 mA and is small compared to the maximum variation in I_D. For a worst case design the tolerance and temperature coefficient of R_1 and R_2 are very important.

Once the bias resistor values are determined the maximum load resistor can be determined and then the voltage gain. The maximum value of R_L is determined by the voltage drop across R_L and I_D max. The voltage drop across R_L is:

$$V_{RL} = 30 - 1.5 \text{ X } V_{GS(off)} - I_{DC(max)} \text{ X } R_S.$$

For the 2N5268 the maximum value of $V_{GS(off)}$ is 3.6 volts as calculated earlier. With an R_S of 2.2 kΩ the voltage drop across R_L is:

$$V_{RL} = 30 - 1.5 \text{ X } 3.6 \text{ V} - 1.25 \text{ X } 2.2 = 21.85 \text{ volts}$$

therefore,

$$R_{L(max)} = \frac{V_{RL}}{I_{DC(max)}} = \frac{21.85}{1.25} = 17.5 \text{ k}\Omega.$$

Assuming a standard 1% resistor, a value of 16.9 kΩ would be used.

In the following section it is shown that the voltage gain is approximately:

$$A_V \approx \frac{-R_L}{\frac{1}{Y_{fs}} + R_S}.$$

where Y_{fs} is found from Figure 8. For the worst case voltage gain the minimum Y_{fs} is used and occurs at an I_D of 0.75 mA where Y_{fs} is 1300 μmhos.

$$A_{V(min)} \approx \frac{-16.9 \text{ X } 10^3}{\frac{1}{1.3 \text{ X } 10^3} + 2.2 \text{ X } 10^3} = \frac{-16.9 \text{ X } 10^3}{2.98 \text{ X } 10^3} = -5.7$$

With R_S sufficiently bypassed, the minimum voltage gain is:

$$A_{V(min)} = -Y_{fs}\, R_L = -1.3 \text{ X } 10^{-3} \text{ X } 16.9 \text{ X } 10^3 = -22.$$

Noise figure and noise voltage are easily found. Ignoring the effects of the coupling capacitor, which at high frequencies might lower the input impedance, and noting that the parallel combination of R_1 and $R_2 \approx 300$ k ohms, NF, from Figure 15 is 0.9 dB at 1 kHz. From Figure 13 e_n is 70 nV/$\sqrt{\text{Hz}}$.

The most important thing the 2:1 ratio has done for this design is minimizing R_S. If units with a larger ratio of I_{DSS} are used, the slope of the load line (Figure 17) will decrease (the -55°C will move to the right or the +125°C load line will move to the left). In either case, with a lesser slope, R_S will increase. With R_S larger and the drain current tolerance as specified, then more voltage is dropped across R_S, consequently, less voltage apprears across R_L, therefore, R_L is smaller. The net effect on voltage gain may not be too great as the increase in R_S would only be about 1 to 2 k ohms.

A second effect of higher I_{DSS} ratio devices is in the change of V_P, which, depending upon the magnitude of I_{DSS} may or may not cause a problem:

$$\frac{I_{DSS}}{I_{DSS(ref)}} = \left[\frac{V_P}{V_{P(ref)}}\right]^{1.5} \quad \ldots (4)$$

Equation 4 is an empirically derived relationship that will be used to examine the effect of the I_{DSS} ratio on the V_P ratio. If we assume the maximum I_{DSS} is the same for the unit with high I_{DSS} ratio as for units with a 2:1 I_{DSS} ratio, then $V_{P(max)}$ will be about the same for the two different types and the calculation for $R_{L(max)}$ will be unchanged. However, if the minimum I_{DSS} is the same for the two different types, then $V_{P(max)}$ for the higher I_{DSS} ratio types will be higher than the 2:1 I_{DSS} ratio types. For example, assume a 4:1 I_{DSS} ratio and a $V_{P(min)}$ of 2.4 volts.

From Equation 4:

$$\frac{I_{DSS}}{I_{DSS(ref)}} = \left[\frac{V_P}{2.4}\right]^{1.5} = \frac{4}{1}$$

$$V_P = [4(2.4)^{1.5}]\ \frac{1}{1.5} = 6 \text{ volts.}$$

If R_L is calculated as before, but using this higher value of V_P, $R_{L(max)}$ is found to be 14.6 k where the assumed R_S remained at 2.2 k. At 14.3 kΩ, 1% resistor would be used so the voltage gain with R_S unbypassed is 4.8 while the voltage gain with R_S bypassed is 18.6, assuming Y_{fs} remains at 1300 μmhos. Y_{fs} decreases for units with higher I_{DSS} operating at the same drain current. If I_D is small compared to I_{DSS}, the difference in Y_{fs} will be small. In the above example the voltage gain would be less because of the decrease in Y_{fs}, but the decrease would not be too drastic.

The main point of the previous discussion is that the gain will decrease when units with a high I_{DSS} ratio are used. In some cases this is not an important factor and the actual change is not too great. However, it is a tradeoff that must be made when designing with FET's that have a high I_{DSS} ratio.

Small Signal Analysis

Small signal analysis of a FET amplifier stage is easily accomplished with reasonable accuracy by using a few simple equations. The FET model used for the analysis

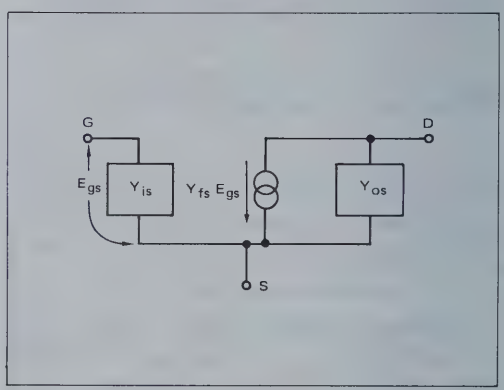


FIGURE 19

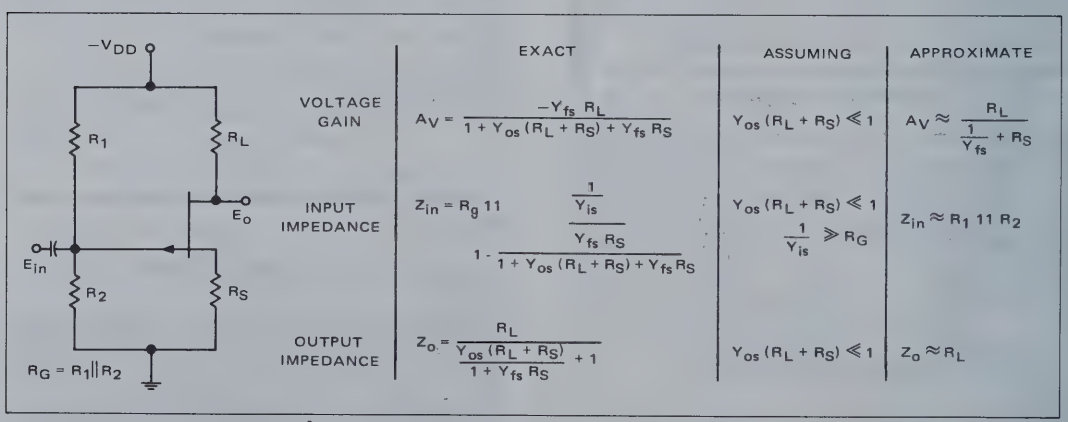


FIGURE 20

is shown in Figure 19. It differs from the previous model (Figure 13) in that C_{rss} is omitted. By omitting all capacitors and using only the real parts of Y_{is}, Y_{fs}, and Y_{os}, the model and the accompanying equations are useful up to about 100 kHz. If capacitance effects are included, the equations are useful into the megahertz region.

Figures 20, 21, and 22 show schematics for common-source, common-drain (source follower), and common-gate circuits. In addition the exact and approximate equations for voltage gain, input impedance, and output impedance are included.

For the common-source circuit the omission of C_{rss} will effect the equations for input impedance and voltage gain but, for low frequencies the error is minimal. If only dc degeneration is required, then the source resistor, R_S, is bypassed. The effects on the design equations are to set $R_S = 0$ so that voltage gain is the product of R_L and Y_{fs}. An important aspect of this circuit is that the voltage gain is virtually independent of the device parameters. Instead, the gain is dependent on R_L and R_S which can be made very stable over a wide temperature range, yielding a stable gain.

The common-drain (source-follower) configuration, Figure 21, is a very useful basic circuit. Some of its properties are, a voltage gain always less than unity with no phase inversion, low output impedance, high input impedance, large signal swing, and active impedance transformation.

The common-gate stage, Figure 22, offers impedance transformation opposite to that of the source follower; namely, low input impedance and high output impedance. The voltage gain is the same as for the common source stage except that there is no phase inversion.

CONCLUSION

The Designers Data Sheet is a valuable aid in the design and/or analysis of worst case conditions. The data presented on the D.D.S. in graphical form eliminates the necessity of laboriously calculating circuit outputs under the many variations of device and environmental conditions. Consequently, less design time is required, and in addition, the min/max values on all pertinent parameters eliminates any further testing on the part of the user.

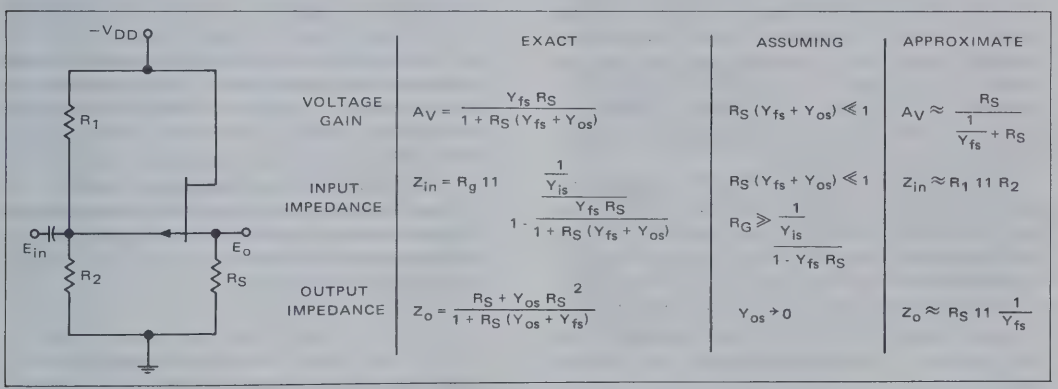


FIGURE 21

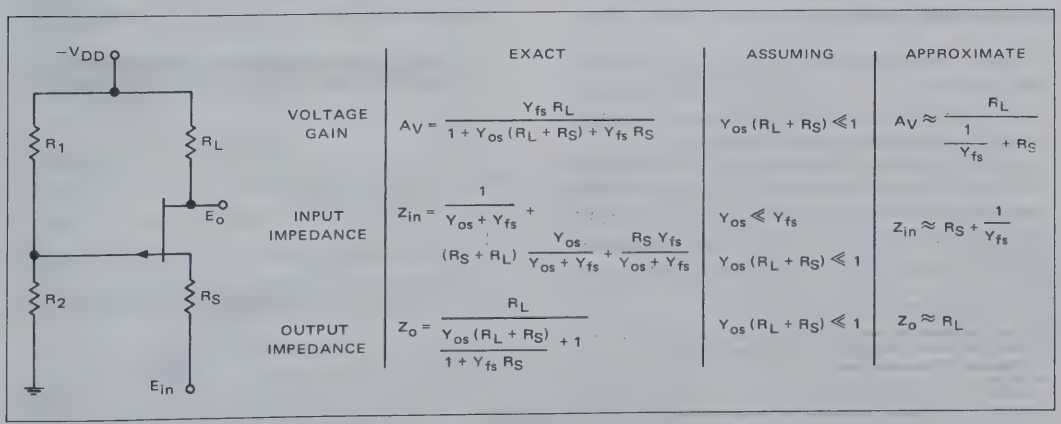


FIGURE 22

SMALL-SIGNAL RF DESIGN WITH DUAL-GATE MOSFETS

INTRODUCTION

Although the dual-gate metal-oxide-semiconductor field-effect transistor (MOSFET) is a relatively new development in transistor technology, it has already gained widespread acceptance and is currently being designed into RF amplifiers, mixers, demodulators, and other RF applications. A few reasons for its success are its high gain, low noise, and excellent AGC, cross-modulation, and overload characteristics. However, until recently, MOSFET technology was hampered by dc bias-point instability. This bias point drift was due to the gradual migration of sodium contaminants in the gate oxide layer. Motorola has solved this problem with silicon-nitride passivation. In addition to being impervious to sodium ion contamination, the silicon nitride has also yielded higher gate breakdown voltages and greater ruggedness. Maximum ratings for V_{G1S} and V_{G2S}, which were typically ±15 V for older devices, are now ±35 V for the MFE3007. Transient ratings are many times higher. The greater ruggedness of the new silicon-nitride passivated devices will be appreciated by those who are familiar with the delicate handling often required with older devices. The author took no special precautions in his laboratory work with the devices used and no static-charge failures were encountered.

The intent of this application note is to acquaint the designer with the RF capabilities and design data for the dual-gate MOSFET. Although the specific device and performance data presented in this application note are for the MFE3007, the theory and discussions will pertain to the dual-gate MOSFET in general. The MFE3007 is an N-channel, type-B MOSFET. The type-B designation implies operation in both the enhancement and depletion modes.[1]

DEVICE OPERATION

Figure 1 shows a cross-section of the dual-gate MOSFET. The construction of the dual-gate transistor is similar to that of the single-gate MOSFET, the major difference being the addition of a second gate.

A brief explanation of the device operation will be given for those unfamiliar with the MOSFET. A more detailed analysis is given in Reference 1. Two polarities of MOSFETs are presently being manufactured, N-channel and P-channel. The channel type refers to the type of impurity used to dope the drain-to-source conduction path. For the MFE3007, the free-charge carriers are electrons, hence the N-type designation. For a P-type device, conduction is by "hole" carriers. The "N+" areas under the source and drain of Figure 1 are highly doped N-type regions. That is, they exhibit a high concentration of free electrons. The areas beneath gates 1 and 2, outlined by the dashed lines, are the conduction channels which are much more lightly doped. The conductivity of these channels is controlled by the gate voltages in the following manner: When a positive voltage is applied between a gate and the source, a negative charge is induced in the channel opposite the gate. The induced negative charge increases the free-electron concentration, and therefore the conductivity in that portion of the channel. This is the mechanism by which the output current is modulated by the input gate voltage. The extent to which the output current changes for a small change in the input voltage is given by the transconductance (g_m, y_{fs}, y_{21}) and is a measure of the device's ability to amplify. Since the dual-gate MOSFET is a voltage-controlled device, once the pinch-off voltage is overcome, the output current (I_D) is dependent only on gate voltages. The pinch-off voltage is the drain-to-source voltage (V_{DS}) at which the drain current reaches a limiting value where further increases in V_{DS} do not produce any appreciable increase in the drain current.

Figure 2 shows typical output characteristics for the common-source configuration. The curves are for V_{G2S} = 4 Vdc, which will be shown to be optimum gate-2 bias for most amplifier applications.

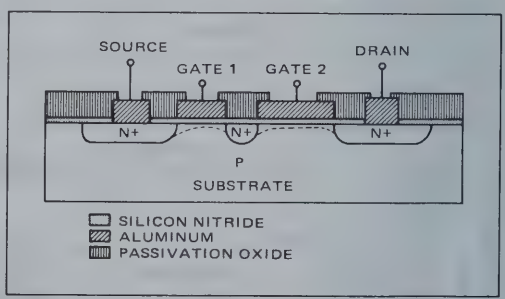


FIGURE 1 – Dual-Gate MOSFET Cross Section

1. For the reader unfamiliar with such terms as "enhancement" and "depletion", a detailed discussion of field-effect transistors is given in Reference 1.

Circuit diagrams external to Motorola products are included as a means of illustrating typical semiconductor applications; consequently, complete information sufficient for construction purposes is not necessarily given. The information in this Application Note has been carefully checked and is believed to be entirely reliable. However, no responsibility is assumed for inaccuracies. Furthermore, such information does not convey to the purchaser of the semiconductor devices described any license under the patent rights of Motorola Inc. or others.

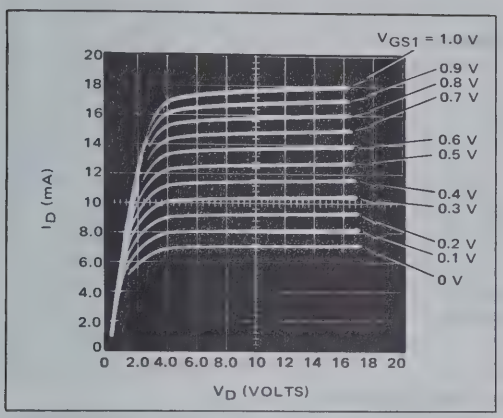


FIGURE 2 – Output Characteristics of MFE3007 at V_{G2S} = 4.0 V

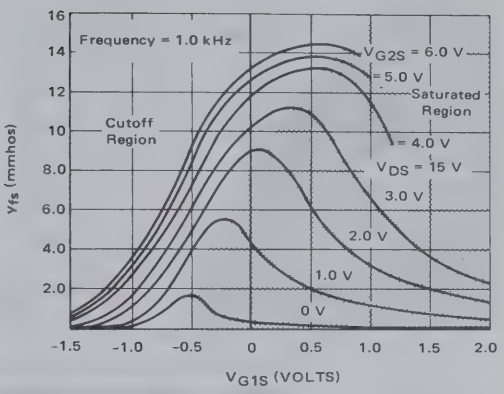


FIGURE 3 – y_{fs1} versus Bias Point of MFE3007 Dual-Gate MOSFET

In theory, either gate can be used for the signal input gate as both exhibit sufficient gate-to-drain transconductance (Figures 3 and 4). However, due to device design and certain practical considerations, gate 1 functions best as the input gate. When gate 2 is used for signal injection, the channel resistance controlled by gate 1 acts as an unbypassed source resistance as shown in Figure 5. Since it is impossible to bypass this degenerative source impedance, the device gain is lowered. Figure 5 also shows an equivalent representation of the device when the signal is injected at gate 1 with gate 2 bypassed to ground for ac. In this mode of operation, the device is equivalent to a common-source–common-gate cascode amplifier. The common-gate portion serves as a variable-impedance buffer stage between the input and output. The variable drain resistance in Figure 5 is controlled by the dc voltage applied to gate 2; its value decreases with increasing gate-2-to-source voltage. This configuration is analogous to the common-cathode–common-grid cascode amplifier often employed in vacuum tube circuits for high isolation between input and output. Both the grounded-gate buffer and the physical separation between gate 1 and drain help achieve an extremely high degree of input-output isolation. The feedback capacitance between drain and gate 1, C_{rss}, is typically only 0.02 pF. Unless otherwise stated, all further references to transconductance or amplifier characteristics will assume a common-source configuration with signal injection at gate 1, and gate 2 ac-bypassed to ground.

DESIGN APPROACH

Design of small-signal RF amplifiers using two-port networks has achieved excellent results with FET as well as bipolar-transistor and integrated circuit RF amplifiers. This method is described in detail in references 2 and 3.

Basically, it consists of characterizing the active device as a linear active two-port network (LAN) with admittances (y parameters), and using these parameters to solve exact design equations for stability, gain, and input and output admittances. A y parameter is an expression for admittance in the form

$$y_{is} = g_{is} + jb_{is},$$

where g_{is} is the real (conductive) part of the admittance and b_{is} is the imaginary (susceptive) part. These admittances

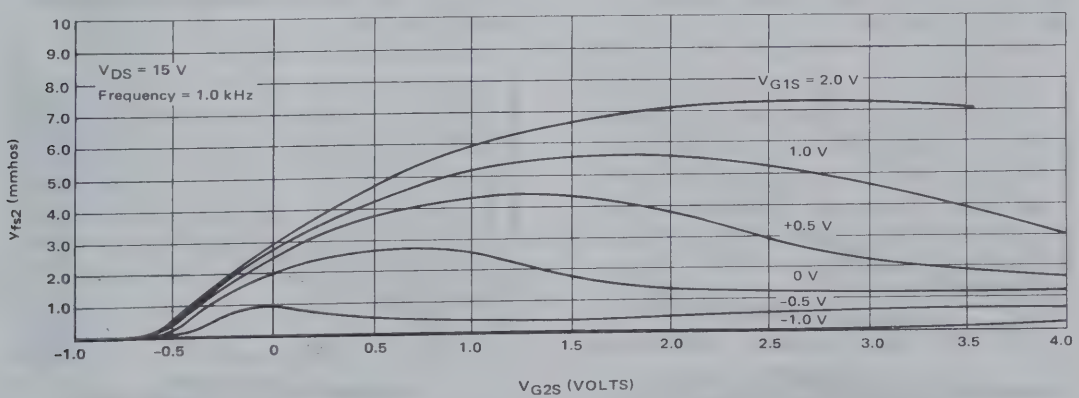


FIGURE 4 – y_{fs2} versus Bias Point

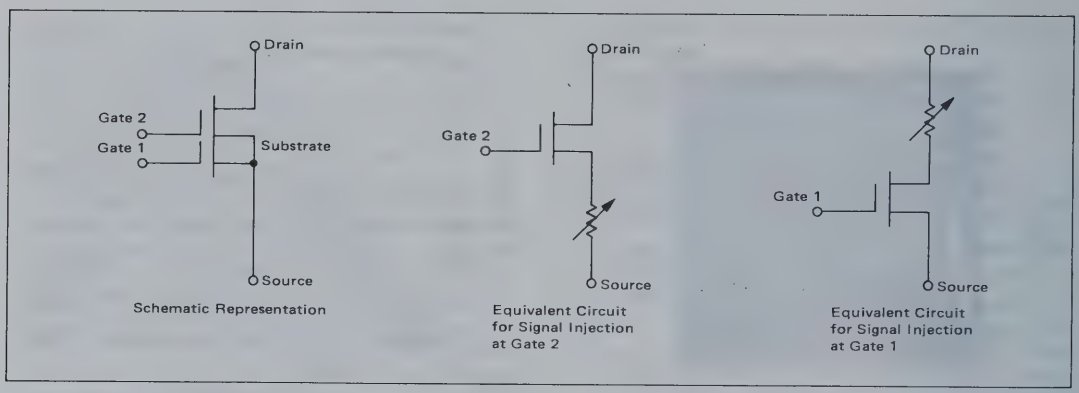


FIGURE 5 – Equivalent Dual-Gate MOSFET Circuits with Signal Injection at Gates 1 and 2

are used instead of the more common impedances (z parameters) because they greatly simplify the measurements and calculations.

Equally satisfying results have been achieved using this approach to the design of RF-amplifier circuits using dual-gate MOSFETs.

Y PARAMETERS

Common-source admittance (y) parameters for the MFE3007 are shown in Figures 6 through 9. RF Designers have traditionally used the nomenclature y_{11}, y_{12}, y_{21}, and y_{22} for all active devices – bipolar transistors, integrated circuits, and other devices. However, y parameters for FETs are registered using descriptive lettered subscripts:

y_{is} (input admittance) = y_{11}
y_{rs} (reverse transadmittance) = y_{12}
y_{fs} (forward transadmittance) = y_{21}
y_{os} (output admittance) = y_{22}

The "s" refers to common-source operation. As these lettered symbols appear on data sheets, they are used in this application note. In a dual-gate device, the subscript 1 can be included to indicate admittance between gate 1 and the source, for example, y_{fs1}. However, all references to admittances in this note will be those concerning gate 1 unless otherwise indicated.

Parameters y_{is}, y_{os}, and y_{fs} were measured on a General Radio Transfer Function and Immittance Bridge. When measuring the extremely low input and output conductances, appropriately high valued carbon resistors were also measured to insure the accuracy of the readings. The dc conditions for all measurements were V_{DS} = 15 V, V_{G2S} = 4 V, and V_{G1S} adjusted for an I_{DS} of 10 mA. Care was taken to provide an effective ac ground at gate 2 since this is especially important in achieving circuit stability in a practical design.

Both the real and imaginary parts of the feedback admittance, y_{rs}, are too small for measurement on the G.R. bridge over the useful frequency range of the device. For all practical purposes, the real part of the feedback admittance can be assumed to be zero. The imaginary part of this admittance was measured at 1 MHz on a Boonton Capacitance Bridge. It is typically 0.02 pF. For admittance values at higher frequencies this capacitance is assumed to be a constant. In a practical design application, however, the effect of parasitic capacitance upon the feedback admittance should be considered. Even in a reasonably well-shielded amplifier, the stray capacitance may turn out to have a value greater than the small feedback capacitance of the dual-gate FET. The amplifiers described in this report had total feedback capacitances (device plus stray) of 0.075 to 0.1 pF.

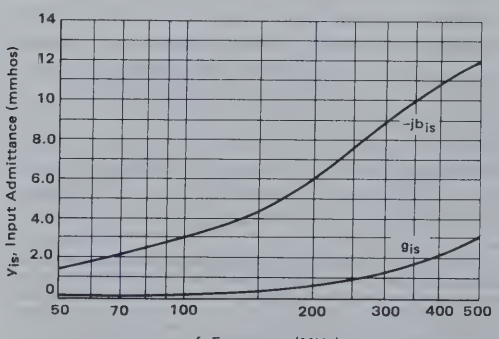


FIGURE 6 – Input Admittance, $y_{is} = g_{is} + jb_{is}$, of MFE3007

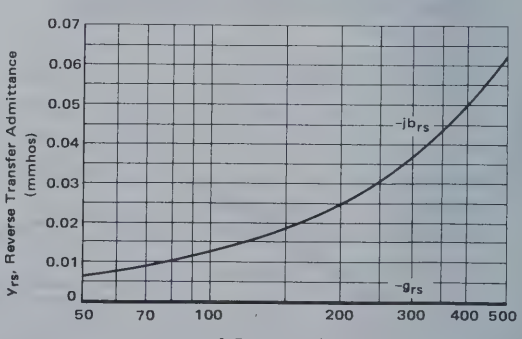


FIGURE 7 – Reverse Transfer Admittance, $y_{rs} = g_{rs} + jb_{rs}$, of MFE3007

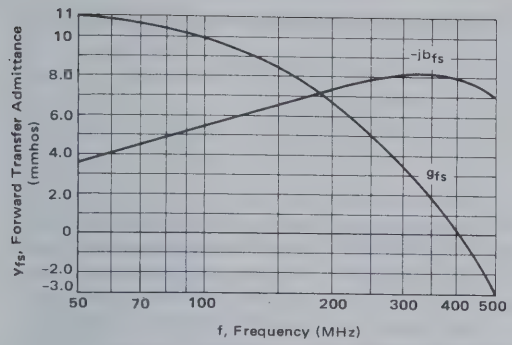


FIGURE 8 – Forward Transfer Admittance, $y_{fs} = g_{fs} + jb_{fs}$, of MFE3007

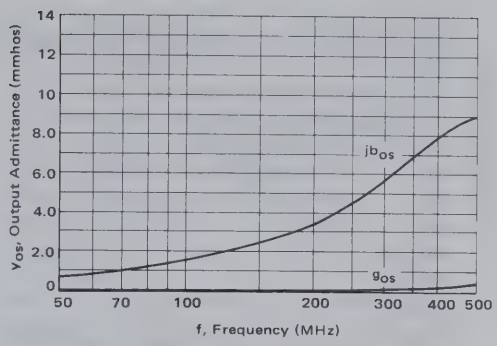


FIGURE 9 – Output Admittance, $y_{os} = g_{os} + jb_{os}$, of MFE3007

Admittance parameters for the common-gate configuration were also measured. Although the lower input impedance of the device in this configuration ($g_{is} \approx 12$ mmhos at 50 MHz to 200 MHz) may be advantageous for matching at the input, the attendant reduction in the available power gain renders this type of operation undesirable in most applications. Analyses show the unneutralized power gain of this configuration to be 10 to 15 dB lower than the common-source power gain.

DESIGN DATA

For convenience in designing with the MFE3007, several significant equations have been solved by computer. Their solutions are plotted in Figures 10 through 13. An explanation of these curves is given below. For additional examples of the use of such computer-derived circuit design curves, see reference 4.

The reverse transadmittance used to generate this design data was $0\text{-}j\omega\ (0.1 \cdot 10^{-12})$ mhos, which represents a composite feedback capacitance of 0.1 pF. This value can be obtained in a circuit with careful layout, and is a more practical value than the 0.02 pF feedback capacitance of the device alone.

The Linvill stability factor, C, which is a measure of device open-circuit stability, is plotted in Figure 10. C is greater than 1 below 250 MHz, thus the device is potentially unstable below 250 MHz and unconditionally stable above 250 MHz.

Figure 11 shows transducer power gain for the MFE3007 in both the unilateralized (neutralized) and the unneutralized (no negative feedback) configurations. The higher gain curve represents unilateralized operation. The lower gain curve shows G_{max} (the maximum possible transducer gain without negative feedback) in the unconditionally stable region above 250 MHz.

In the potentially unstable region (below 250 MHz), mismatching must be used to guarantee stability if negative feedback is not used. The design equations were solved for the highest gain per degree of circuit stability. Circuit stability is measured by the Stern circuit stability factor, k, which is discussed in Reference 2.

The portion of the unneutralized gain curve below 250 MHz in Figure 11 represents a circuit stability factor of 3.

To further aid in circuit design with the MFE3007, the design equations to achieve the unneutralized performance shown in Figure 11 for complex source and load admittances

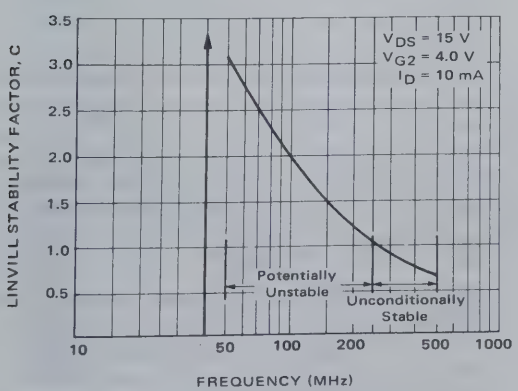


FIGURE 10 – Linvill Stability Factor, C, for the MFE3007 Between 50 and 500 MHz

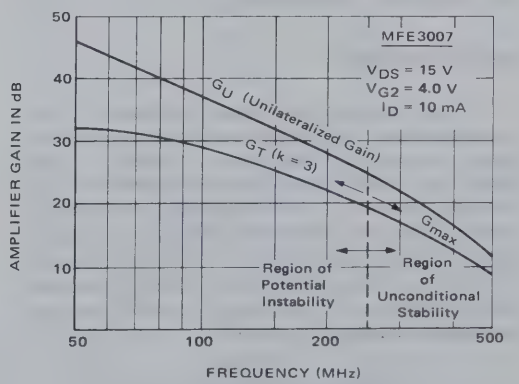


FIGURE 11 – Amplifier Gain Characteristics in Common Source Configuration

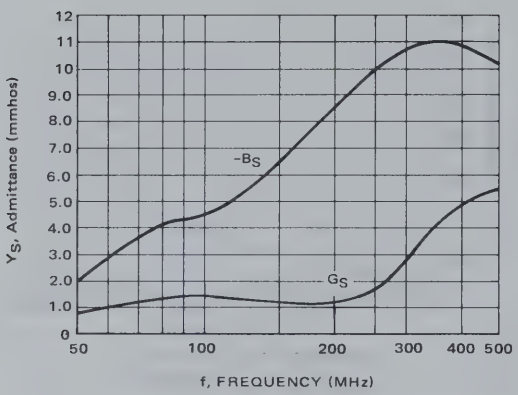


FIGURE 12 – Optimum Source Admittance, $Y_S = G_S + jB_S$, for Unneutralized G_T of Figure 11

have also been solved by computer. The results are given in Figure 12 and 13. Thus the design of an unneutralized amplifier may be greatly simplified by first checking Figure 11 to determine the expected gain and then obtaining the optimum device complex source and load admittances from Figures 12 and 13. The only remaining step would then be network synthesis to calculate the required source and load admittances at the gate 1 and drain terminals to the FET, as determined above. The peculiar shape of the load and source conductance curves of Figures 12 and 13 can be explained as follows:

As the frequency increases, $|y_{fs}|$ decreases, permitting a closer match of the source conductance (G_S) to g_{is}, and the load conductance (G_L) to g_{os}, while still maintaining the same circuit stability. Since the degree of mismatch is decreasing faster than g_{os} is increasing, the load conductance continuously decreases until the device approaches unconditional stability. For the region above conditional stability (above 250 MHz), both source and load conductances increase, matching the increasing input conductance (G_{IN}) and output conductance (G_{OUT}).

DESIGN PROCEDURE

To demonstrate the use of Figures 10 through 13, the design procedure for a 100-MHz common-source amplifier will be discussed. The circuit is shown in Figure 14. From Figure 10, the Linvill stability factor C is seen to be 2.0, therefore mismatching or neutralization is necessary to prevent oscillation. Mismatching will be used in this example. Figure 11 shows that for a circuit stability factor of 3.0, the transducer gain will be 29 dB. The load and source admittances for the required mismatch and gain are found from Figures 12 and 13:

$$Y_L = 0.35 - j2.1 \text{ mmhos},$$
$$Y_S = 1.30 - j4.4 \text{ mmhos}.$$

At this frequency, y parameters for the MFE3007 are:

$$y_{is} = 0.15 + j3.0$$
$$y_{fs} = 10 - j5.5$$
$$y_{rs} = 0 - j0.012$$
$$y_{os} = 0.04 + j1.7$$

Assuming the load and source impedances are both 50 ohms, networks can be designed to match the MOSFET to the load and source. The calculations are more easily performed with impedances rather than admittances. The procedure will first be discussed for the output matching.

The 50-ohm load impedance must be transformed to the optimum load for the transistor ($Y_L = 0.35 - j2.1$). This transformation can be performed by the network shown in Figure 15A. The 50 ohms must be transformed to

$$R_L = \frac{1}{G_L} = \frac{1}{0.35 \times 10^{-3}} = 2.86 \text{ k}\Omega$$

The series capacitive reactance required for this matching can be found by

$$X_{C4} = X_S = R_S\sqrt{\frac{R_P}{R_S} - 1}$$

where R_P is the parallel resistance and
R_S is the series resistance.

$$X_{C4} = 50\sqrt{\frac{2.86 \times 10^3}{50} - 1} = 372\Omega$$

The capacitance that provides this reactance at 100 MHz is

$$C4 = \frac{1}{2\pi f X_{C4}} = \frac{1}{2\pi(10^8)(372)} = 4.3 \text{ pF}.$$

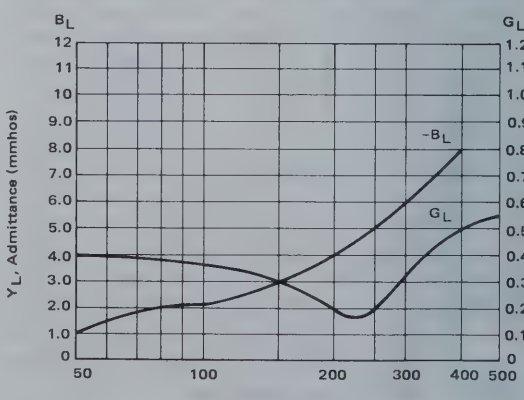
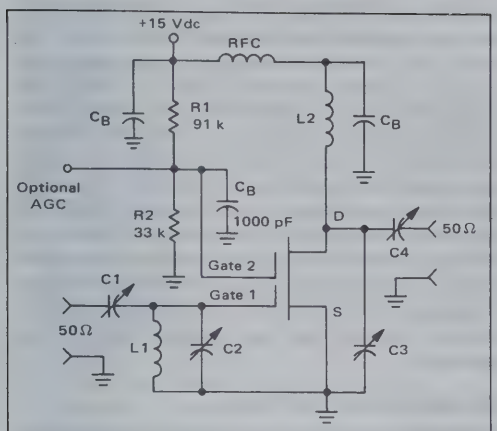


FIGURE 13 – Optimum Load Admittance, $Y_L = G_L + jB_L$ for Unneutralized G_T of Figure 11



Circuit Performance	100 MHz	200 MHz	400 MHz
Theoretical Power Gain from Figure 11	29 dB	22 dB	12.5 dB
Measured Power Gain	27.5 to 31.6 dB	21.2 to 24 dB	10.5 to 13.0 dB
Measured Bandwidth	3.5 to 5.5 MHz	4.0 to 5.2 MHz	11.0 to 15 MHz
Component Values			
C1	8.4 pF	4.6 pF	4.5 pF
C2	2.0 pF	6.0 pF	1.5 pF
C3	1.5 pF	1.0 pF	2.8 pF
C4	4.3 pF	2.0 pF	1.2 pF
L1	150 nH	47 nH	16 nH
L2	280 nH	110 nH	22 nH
C_B	1000 pF	500 pF	250 pF

FIGURE 14 – VHF Amplifiers Using MFE3007

The parallel equivalent of this capacitance is needed for determining the bandwidth and resonance later in the design:

$$X'_{C4} = X_P = X_S \left[1 + \left(\frac{R_S}{X_S}\right)^2\right],$$

$$= 372 \left[1 + \left(\frac{50}{372}\right)^2\right]$$

$$= 378\,\Omega.$$

and the equivalent parallel capacitance is therefore

$$C'4 = 4.2 \text{ pF}.$$

An equivalent circuit for the output tank after transformation of the load is shown in Figure 15B. Since the resistance across the output circuit is fixed by the parallel combination of R_{OUT} and R_L (after transformation) the desired bandwidth of the output tank will be determined by C2.

It should be noted that the output admittance (Y_{OUT}) of the device will not equal y_{os} under most conditions. Only when the input is terminated in a short circuit or the feedback admittance is zero does Y_{OUT} equal y_{os}. When y_{rs} is not zero, and the input is terminated with a practical source admittance, the true output admittance is found from the following:

$$Y_{OUT} = y_{os} - \frac{y_{fs}\, y_{rs}}{y_{is} + Y_S}$$

$$= 0.04 + j1.7 - \frac{(10 - j4.5)(0 - j0.012)}{(0.15 + j3.0) + (1.3 - j4.4)}$$

$$= -0.066 + j2.05 \text{ mmhos}.$$

Therefore,

$$R_{OUT} = \frac{1}{G_{OUT}} = \frac{1}{-0.066 \times 10^{-3}} = -15.2 \text{ k}\Omega, \text{ and}$$

$$C_{OUT} = \frac{B_{OUT}}{2\pi} = \frac{2.04 \times 10^{-3}}{2\ 10^{8}} = 3.2 \text{ pF}$$

The negative output impedance indicates the instability of the unloaded amplifier.

Now the total impedance across the output tank can be calculated:

$$R_T = \frac{1}{G_{OUT} + G_L}$$

$$= \frac{1}{-0.066 \times 10^{-3} \times 0.35 \times 10^{-3}} = 3.51 \text{ k}\Omega$$

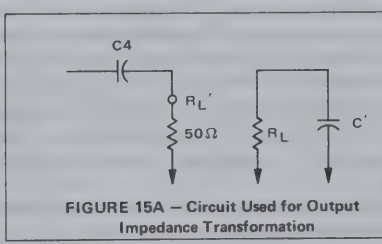


FIGURE 15A – Circuit Used for Output Impedance Transformation

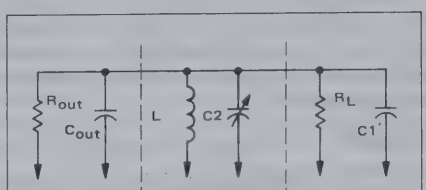


FIGURE 15B – Equivalent Output Circuit

Since the output impedance is several times higher than the input impedance of the device, amplifier bandwidth is primarily dependent upon output loaded Q. For a bandwidth of 5 MHz (3-dB points),

$$C_T = \frac{1}{2\pi R_T (BW)}$$

$$= \frac{1}{2\pi (3.52 \times 10^3)(5 \times 10^6)} = 9 \text{ pF}$$

hence

$$C3 = C_T - C_{OUT} - C4' = 9.0 - 3.2 - 4.2 = 1.6 \text{ pF}$$

The output inductance that resonates with C_T at 100 MHz is 280 nH. This completes the output circuit design.

Input calculations performed in a similar manner yield the following results:

$Y_S = 1.30 - j4.4$ mmhos.

$X_{C1} = 190\Omega$; therefore, C1 = 8.4 pF

$X'_{C1} = 203\Omega$; therefore, C1′ = 7.8 pF

$$Y_{IN} = y_{is} - \frac{y_{fs}\, y_{rs}}{y_{os} + Y_L} = -0.25 + j4.52 \text{ mmhos; therefore,}$$

$$R_{IN} = -4 \text{ k}\Omega, C_{IN} = 7.2 \text{ pF}.$$

$R_T = 950\Omega$.

The bandwidth of the input tuned circuit was chosen to be 10 MHz. Hence

$C_T = 17$ pF; therefore, L = 150 nH.

$C2 = 17 - 7.2 - 7.8 = 2$ pF

This completes the design of the tuned circuits. The results, plus those for similar 200-and 400-MHz amplifiers, are shown in Figure 14. To set the proper bias, resistors R1 and R2 are adjusted for 4 Vdc at gate 2. They have high values to minimize current drain. It is very important that gate 2 be well bypassed at the signal frequency as only a small impedance to ground may cause instability or loss in gain.

This 100-MHz amplifier was built and tested with different MFE3007's covering the I_{DSS} range. After tuning, all devices exhibited gains of 27.5 to 31.6 dB (theory predicted 29 dB), and bandwidths of 3.5 to 5.5 MHz (5-MHz design).

Similar amplifiers were designed, built and tested at 200 and 400 MHz. The component values and results are also shown in Figure 14.

NOISE FIGURE

An important consideration for many low-level amplifiers is noise figure. It is often necessary in bipolar designs to sacrifice power gain to obtain the optimum noise figure. Figure 16 shows the behavior of the noise figures and power gains of the MFE3007 versus source resistance at 100 MHz and 200 MHz. The dual-gate MOSFET offers two important advantages over most bipolar devices: very little, if any, power gain is sacrificed in achieving the best noise figure and both parameters are relatively independent of source resistance in the optimum region. These properties help alleviate the critical tuning and empirical adjustments usually required in front-end design. As a result, the designer has a great deal of flexibility in choosing a source impedance. In particular, it can be seen from Figure 16 that a 3:1 change in source resistance (300 ohms to 1000 ohms) results in only a 1-dB change in noise figure. If minimum cross modulation is a prime consideration, this 3:1 change in source resistance implies a 3:1 improvement in cross modulation and total harmonic distortion for the stage.

AUTOMATIC GAIN CONTROL

Most RF receivers have some means of controlling the overall receiver gain to accommodate a wide range of input signal levels. This is usually done by reducing the gain of the low-level RF and IF amplifier stages. Four different methods can be used to reduce the gain of the dual-gate MOSFET: (1) forward AGC (increasing voltage) at gate 1, (2) reverse AGC at gate 1, (3) forward AGC at gate 2, and (4) reverse AGC at gate 2. As will be shown, reverse AGC applied at gate 2 is superior to the other methods, but for completeness, each method will be discussed. Figure 3 shows y_{fs} as a function of the bias voltages at gates 1 and 2. As can be seen, y_{fs}, and therefore the gain, can be varied by changes in the bias voltage, on either gate. Three of the AGC methods reduce gain by lowering the transconductance between gate and drain. The fourth method of gain reduction, forward AGC at gate 2, reduces the output impedance of the device.

The maximum attenuation an unneutralized RF transistor (bipolar or FET) can achieve is limited by the feedback admittance (reverse transadmittance) of the device. Due to the very low C_{rss} of the dual-gate MOSFET, gain reductions greater than 50 dB are possible at 200 MHz. Because of the increasing reactance of the feedback capa-

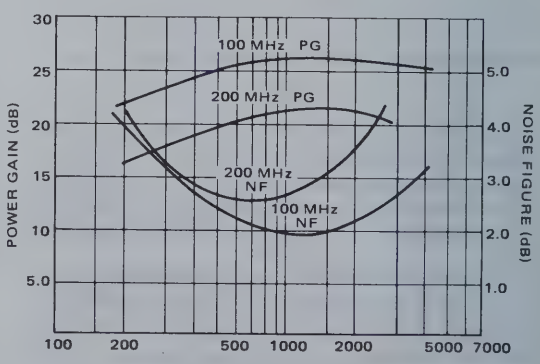


FIGURE 16 – Noise Figure (NF) and Power Gain (PG) of the MFE3007 at 100 and 200 MHz

citance with decreasing frequency, 85-dB gain reduction has been achieved in a 1-MHz amplifier.

AGC APPLIED AT GATE 1

With a constant gate-2 voltage, the transconductance can be reduced by varying the gate-1 voltage to either the left or the right of the peak-transconductance bias point indicated by the dashed line in Figure 3. The region to the left exhibits very rapid reduction in y_{fs} with decreasing bias between gate 1 and source. The sharp decrease in y_{fs} in this region is due to a rapidly approaching cutoff of that portion of the channel controlled by gate 1. This sharp cutoff introduces large third- and higher-order nonlinearities in the transadmittance at gain reductions greater than 10 dB. These nonlinearities induce distortion and degrade cross modulation and total harmonic distortion.

Forward AGC on gate 1 is a result of reduction in the transconductance when the bias point is shifted to the right of the dashed line in Figure 3 (the saturation region). Saturation results when the majority of the channel electrons adjacent to the gate have been ionized. Therefore, to modulate the conductivity, it is necessary to ionize the electrons farther from the gate. Since the capacitive charge-inducing capability of the gate is inversely proportional to distance, greater voltage changes are necessary for equivalent changes in conductivity, and therefore y_{fs} decreases. This method of AGC is limited to relatively small reductions due to excessive device dissipation at gain reductions greater than 10 dB. The increased device dissipation is due to the rapid increase in drain current with increasing forward bias on gate 1.

AGC APPLIED AT GATE 2

The best method of AGC is reduction of the gate-2 bias voltage from its initial optimum-gain bias point (greater than 4 Vdc). Application of the AGC signal to gate 2 results in a remote-cutoff characteristic (remote cutoff refers to a gradual reduction in I_d with decreasing gate bias). This type of I_d–V_G characteristic contrasts with the relatively abrupt cutoff of the drain current (and transconductance) when reverse AGC is applied to the gate of a single-gate MOS or junction FET. This sharp cutoff produces signal clipping, increasing distortion and cross modulation. Figure 17 shows the gain reduction when the AGC signal is applied to gate 2. The test circuit used for obtaining the gain-reduction curves is also shown. It is an unneutralized 100-MHz amplifier with a 3-MHz bandwidth. As the curves show, the initial gain-reduction rate is higher with a slight forward bias on gate 1 than for $V_{G1S} = 0$. This is due to the faster decrease in y_{fs} with decreasing V_{G2S} in the saturation region. This aspect of the gain-reduction rate may be useful in receiver designs where the RF AGC is delayed with respect to the IF to improve overall receiver distortion.

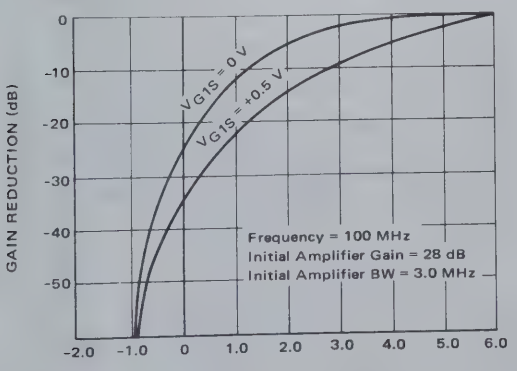


FIGURE 17 – Gain Reduction versus V_{G2S} (AGC Control)

The fourth method of gain reduction is by an increase in the dc bias voltage on gate 2. Unlike the previous methods cited, AGC in this manner is not the result of a reduction in y_{fs}. It can be said in fact, that any increase in V_{G2S} will always result in an increase in y_{fs} regardless of the bias point. The reduction in amplifier gain when forward AGC is applied to gate 2 is a result of the lower output impedance of the device as V_{G2S} approaches the supply voltage. This method is also limited to small gain reductions due to a limiting of the minimum value of the output impedance. The value of the output impedance at which this limiting occurs is about one order of magnitude less than the value at $V_{G2S} = 4$ V. Using the equation,

$$G_{max} = \frac{(y_{21})^2}{4(g_{11}g_{22})} = \frac{(y_{fs})^2}{4(g_{is}g_{os})},$$

a maximum gain reduction of approximately 10 dB can be obtained with this type of AGC. Another disadvantage of this method is the attendent increase in bandwidth when the output impedance of the device is reduced.

BANDWIDTH AND DETUNING

Forward AGC is usually used in bipolar amplifier designs when cross modulation and signal-handling capability are prime considerations. When this type of AGC is used, gain reduction is accompanied by a considerable increase in bandwidth and a shift in center frequency unless elaborate circuit techniques are employed. The increase in bandwidth is a result of the reduced output impedance of the bipolar device at high currents, while detuning is caused by the change in feedback and output capacitances as the output bias voltage is altered. When the AGC signal is applied to gate 2 of the dual-gate MOSFET, the output voltage, and therefore the C_{oss}, remains constant. The output impedance does increase slightly but the output circuit is usually loaded sufficiently that its effect on the bandwidth is small. In a 200-MHz amplifier with 5 MHz bandwidth (–3 dB points), 50-dB gain reduction was accompanied by only 1.25-MHz shift in center frequency and 0.75-MHz decrease in bandwidth.

DISTORTION CHARACTERISTICS

The most attractive feature of the field-effect transistor, at least to the RF designer, is its low distortion. The square-law transfer function of the field-effect transistor

results in a significant improvement in signal-handling capabilities and modulation and cross modulation distortion over that of bipolar transistors with their exponential transfer function. These transfer functions are shown in Figure 18. These characteristics are the products of theoretical first-order analyses and are usually inadequate for completely describing a practical device, but a qualitative comparison explains the low distortion of field-effect transistors:

The output current of a practical amplifier can be expressed in a power series about the operating point.

$$I_{OUT} = I_{dc} + \alpha V_g + \frac{\beta V_g^2}{2!} = + \frac{\gamma V_g^3}{3!} + \ldots \quad (1)$$

where,

I_{dc} = dc bias current
V_g = input signal voltage at the gate
α = first derivative of transfer function (transconductance)
β = second derivative of transfer function
γ = third derivative of transfer function
(all derivatives evaluated at the dc bias point)

The second-and higher-order terms of this expansion account for signal distortion. Specifically, the second-order term ($\beta V_g^2/2!$) explains the sum and difference frequencies in a product mixer. Cross modulation, intermodulation, and modulation distortion are results of the third– and higher-odd-order curvature of the transfer characteristics.[2]

For the ideal linear amplifier, the second- and higher-order derivatives are zero, resulting in distortionless operation. On the other hand, practical amplifiers using both field-effect and bipolar transistors exhibit second-and higher-order curvature over the normal range of operation. However, due to the exponential nature of the transfer characteristic of bipolar transistors, distortion resulting from the third- and higher-order nonlinearities is usually much more severe in bipolar than in FET amplifiers. It is for this reason that most FM receivers are now being designed with field-effect transistors in their front ends.

SIGNAL-HANDLING CAPABILITY AND CROSS MODULATION

There are various methods of comparing the distortion characteristics of different devices. One of these methods is the overload or signal-handling capability of the device. Although signal-handling capability is frequently referenced as a device characteristic, the author has found in the literature no standard procedure for defining the exact point at which overload occurs. For the signal-handling curves shown in Figure 19, overload is defined as the signal level at the input required to produce 5% total harmonic distortion in the output waveshape. The test setup is also shown in Figure 19. The test circuit was a 1-kHz common-source amplifier with the AGC signal applied at gate 2. The 1-kHz frequency was used instead of a modulated RF signal to eliminate the need for a detector in the test setup.

The signal-handling capability is a function of the gain reduction and is therefore usually plotted as such for transistors designed for automatic gain control. This dependence is due to the changing analytic character of the transfer function as the bias point is altered during AGC. When constant gate-1 bias load lines are drawn through the curves of Figure 3, the order of the curvature chiefly responsible for the distortion can be seen. For zero bias between gate 1 to source, the reduced signal-handling capability at the 15-dB gain-reduction level is due to the high third-order curvature of the transfer characteristic in that region. For V_{G1S} = 0.55 V, increasing distortion is due mainly to second-order distortion in the 5-to-20-dB gain-reduction portion of the curves. For any load line, an increase in gain reduction reduces the transconductance, which contributes to an increase in distortion.

Another distortion curve often needed to evaluate the performance of RF amplifiers is the cross-modulation characteristics. Cross modulation is the transfer of modulation from one RF signal to another, when both signals

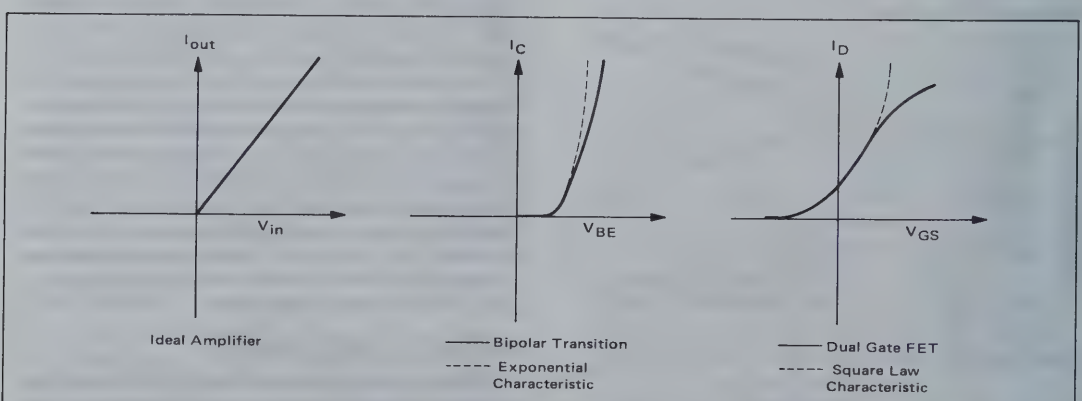


FIGURE 18 – Transfer Characteristics of Amplifiers

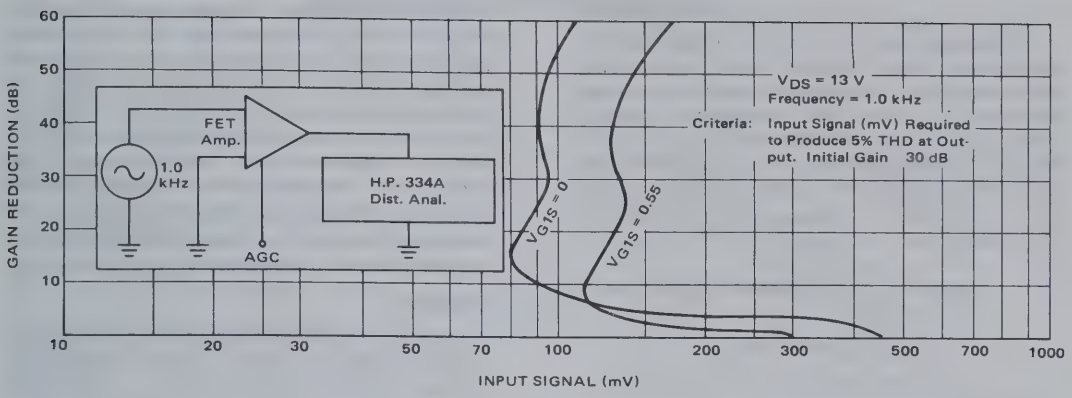


FIGURE 19 – Signal-Handling Capability

are present at the input of an amplifier. The precise definition for the cross-modulation index plotted in Figure 20 is the level of undesired signal necessary to transfer 0.03% modulation to the desired signal when the undesired signal is modulated 30% at 1 kHz. The frequencies of the desired and undesired signals are 200 MHz and 150 MHz. For meaningful results the input to the amplifier should provide no selectivity and the desired signal level should not overload the amplifier. Measurements were made for two different V_{G1S}-bias conditions. As the curves show, forward bias on gate 1 significantly improves cross-modulation performance.

MIXER OPERATION

Two basic methods of local-oscillator injection can be used with a MOSFET mixer. One uses gate 1 for both the local-oscillator and signal injection. The second uses gate 1 for signal injection with the local oscillator applied to gate 2. A third possibility, local-oscillator injection at the source acts as a particular case of the first method and will not be discussed further. Both methods of injection have been investigated and will be discussed briefly.

LOCAL OSCILLATOR INJECTION AT GATE 1

When both the signal and local-oscillator are injected at gate 1, optimum mixer performance will occur with a particular gate-1-to-source bias. The reason for this becomes evident when one examines the mechanism of the conversion process for this type of mixer operation. When the sum of two cosinusoidal signals is substituted for V_g in Equation (1), the power expansion previously presented, the second-order term $\beta(V_2)^2/2!$, is seen to produce the desired sum and difference products. More specifically, the difference term is

$$i_{S\text{-}LO} = \frac{\beta}{2} V_S V_{LO} \cos(\omega_S - \omega_{LO})t \qquad (2)$$

the conversion transconductance, usually denoted g_C, is defined as

$$g_C = \frac{i_{S\text{-}LO}}{V_S} = \frac{\beta}{2} V_{LO} \text{ mhos} \qquad (3)$$

where spurious responses (i.e., frequencies in the output other than those desired) are obtained when a similar pro-

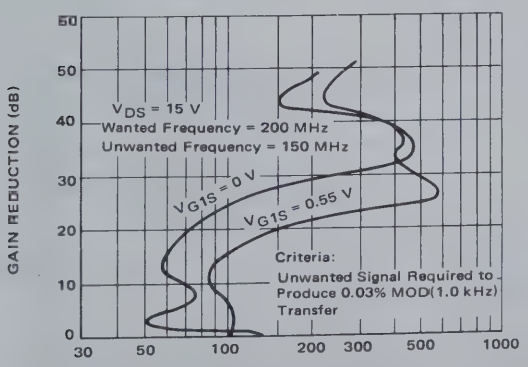


FIGURE 20 – Cross Modulation Curves

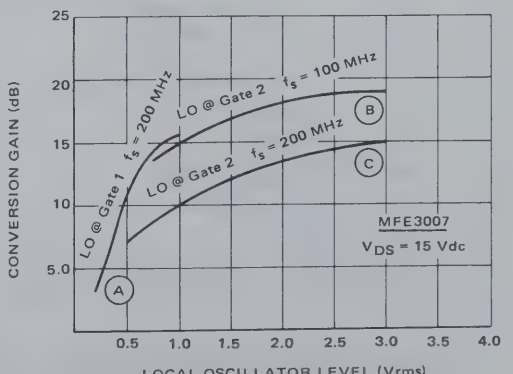


FIGURE 21 – Conversion Power Gain versus Local Oscillator Injections

cedure is carried out for the third- and higher-order terms.

In selecting a bias point, then, two things should be kept in mind: high g_C, and good linearity. A large g_C requires either a high β or a large peak-to-peak local oscillator voltage or both. With these considerations in mind an examination of Figure 3 shows that a bias of $V_{G1S} = -0.5$, $V_{G2S} = 4$ V yields an optimum β for a large peak-to-peak local-oscillator voltage. By Equation (3) the conversion gain for a straight-line approximation of y_{fs} between V_{G1S}'s of 0 V and -1 V, is seen to be:

$$g_C = \frac{12 - 2.5}{2} V_{LO} = 4.75\ V_{LO}\ \text{(Peak Volts)}$$

$$= 6.65\ V_{LO}\ \text{(rms) mmhos}$$

Figure 21 shows conversion gain versus local-oscillator injection voltage when the local-oscillator is applied to gate 1 (Curve A). Test conditions for the mixer curve are signal frequency of 200 MHz, local-oscillator frequency of 230 MHz, IF frequency of 30 MHz, V_{DS} of 15 Vdc, V_{G1S} of 0.5 Vdc, and V_{G2S} of 4 Vdc (ac bypassed to ground). As can be seen, the conversion gain reaches a maximum of 15 dB for an local-oscillator voltage of approximately 1 Vrms. For a local-oscillator injection in excess of 1 V (rms), the device begins to saturate on the positive peaks of the local-oscillator voltage. In addition to limiting the conversion gain, this clipping action also increases spurious responses.

LOCAL-OSCILLATOR INJECTION AT GATE 2

When the local oscillator is applied to gate 2, somewhat higher injection levels are required for conversion gains comparable to the previous method. The reason for this is the lower gate-to-drain transconductance of gate 2. However, this type of injection may serve well in mixer applications where it is desirable to isolate the local oscillator from both the input and output networks. Figure 21 also shows conversion gain versus local oscillator injection for this method of local oscillator injection for mixers with signal input frequencies of 100 MHz (Curve B) and 200 MHz (Curve C). The local oscillator frequencies were 130 MHz and 230 MHz, and in both cases the 30-MHz difference frequency serves as the IF. The test conditions for both mixers were $V_{DS} = 15$ V, V_{G1S} and $V_{G2S} = 0.3$ V to 0.5 V.

SUMMARY

In summary, the dual-gate MOSFET should be considered for small-signal RF applications where signal-handling and distortion characteristics are important. It is especially attractive in low-level amplifiers where AGC is used. This application note has included data for the MFE3007 that permits rapid evaluation and design of low-level RF amplifiers in the 50-to 500-MHz range.

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2. "RF Small-Signal Design Using Two-Port Parameters," Motorola Application Note AN-215.
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4. "UHF Amplifier Design Using Data Sheet Design Curves," Motorola Application Note AN-419.
5. Deketh, j., Fundamentals of Radio Valve Techniques, N. V. Philips Gloeilampenfabricken, Eindhoven, Netherlands, 1949.

15 TO 60 WATT AUDIO AMPLIFIERS USING COMPLEMENTARY DARLINGTON OUTPUT TRANSISTORS

INTRODUCTION

Recently developed silicon monolithic darlington power transistors permit significant simplification of audio power amplifier circuitry. The amplifiers described in this note use complementary power darlington output transistors, eliminating the two driver transistors used in previous methods. A significant cost savings should be realized since, in addition to the driver devices, the driver heat sinks and output biasing resistors are also eliminated. Also, the printed circuit board for the amplifier could become very compact.

Three circuits will be discussed: a 15 to 20 watt, medium performance amplifier, a 15 to 60 watt high performance amplifier with ac-coupled output, and a 15 to 60 watt high performance amplifier with dc-coupled output.

15-20 WATT AMPLIFIER

The circuit of the 15-20 watt amplifier is shown in Figure 1. To ensure maximum signal swing, the dc "center" voltage (the point between R8 and R9) must be one-half of V_{CC}. This is accomplished by dc feedback from this point to the base of Q1, through R3. Resistors R3 and R2 also form a voltage divider which provides dc bias to the base of Q1. Loading of this divider by the base current of Q1 could cause the center voltage to vary with changes in

TABLE I

Parts List				
RMS Power	15 W		20 W	
Load	4 Ω	8 Ω	4 Ω	8 Ω
V_{CC}	32 V	40 V	36 V	46 V
R2	4.3 k	5.6 k	5.1 k	4.3 k
R3	82 k	120 k	100 k	130 k
R6	3.3 k	3.9 k	3.3 k	4.7 k

Typical Performance

Idle Current (Adj. with R_V)	20 mA
Nominal Input Sensitivity for Full Rated Output	1 Vrms
Total Harmonic Distortion @ Rated Output, 50 Hz to 20 kHz	0.5%
Total Harmonic Distortion @ 1 W Output, 1 kHz	0.2%
Input Impedance	10 kΩ

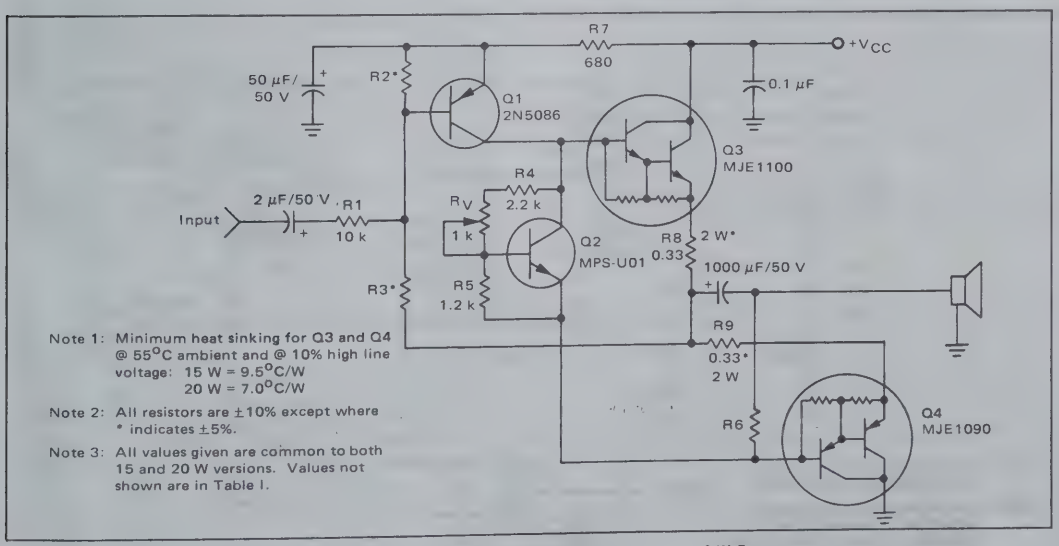


FIGURE 1 – Four Transistor Audio Amplifier for 15 to 20 W Output

Circuit diagrams external to Motorola products are included as a means of illustrating typical semiconductor applications; consequently, complete information sufficient for construction purposes is not necessarily given. The information in this Application Note has been carefully checked and is believed to be entirely reliable. However, no responsibility is assumed for inaccuracies. Furthermore, such information does not convey to the purchaser of the semiconductor devices described any license under the patent rights of Motorola Inc. or others.

h_{FE} of Q1. To prevent this change, the direct current in the R2, R3 divider is made at least ten times greater than the maximum base current of Q1.

Transistor Q2 is used to forward bias the output darlington devices. Resistors R4, R_V and R1 form a resistive divider which sets the collector to emitter voltage of Q2 at approximately 2.4 V for biasing of the output. R_V is made variable so that the V_{CE} of Q2 can be adjusted and consequently the dc "idle current" in the output transistors can be set to minimize cross-over distortion. Twenty milliamps of idle current is sufficient to eliminate this distortion.

The V_{CE} voltage of Q2 tracks the $V_{BE(on)}$ temperature characteristics of Q3 and Q4 adequately. Therefore, if Q2 were mounted on the heat sink with the output transistors, the dc idle current would remain within practical limits over the temperature range.

To ensure maximum swing during peak negative signal excursions, R6 is connected to the speaker side of the output coupling capacitor. This makes use of the dc charge riding on the output coupling capacitor to provide drive current to the base of Q4 thru R6 (bootstrapping).

Parts values and typical performance characteristics for the 15 to 20 watt circuit are shown in Table I.

THE 15-60 WATT AC COUPLED CIRCUIT

The 15 to 60 watt ac-coupled circuit is shown in Figure 2. As in the previous circuit, the center voltage must be one half V_{CC} for maximum output swing. Resistors R1, R2 and R3 form a voltage divider which sets the dc voltage on the base of Q1 at approximately 1.5 volts above 1/2 V_{CC}. This will maintain the center voltage at 1/2 V_{CC} since there is a constant 1.5 volt drop from the base of Q1 to the output center point. This drop is caused by the base-emitter diode voltage of Q1 and the voltage drop across R6 due to the collector current of Q1. The dc voltage across R4 is set by the $V_{BE(on)}$ voltage of Q2. The collector current of Q1 and the current thru R6 is thus

$$\frac{V_{BE(on)}\ Q2}{R4} \approx \frac{0.6}{1.8\ k\Omega} = 0.33\ mA$$

The ac closed-loop gain of the circuit is

$$A_V = \frac{R6}{R5}$$

The input impedance is set by the parallel equivalent resistance of R2 and R3.

Transistor Q2 has approximately 60 dB of voltage gain and determines the dominant pole in the amplifier. A 50 pF capacitor is used in this stage to compensate the amplifier to prevent high frequency oscillations.

Transistor Q3 is used, as in the previous circuit, to forward bias the output devices to prevent cross-over distortion.

A constant current source, Q4, is used to eliminate the need for bootstrapping the base of Q6. This eliminates the effects of the bootstrap capacitor on frequency, providing

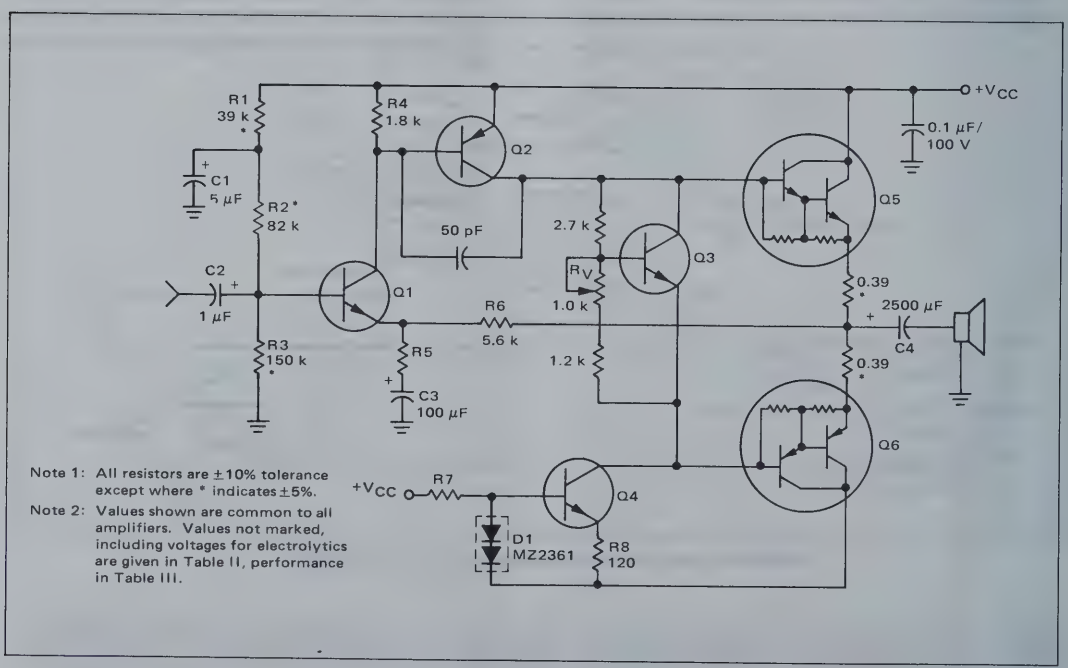


FIGURE 2 – 15 to 60 Watt Power Amplifier With AC Coupled Output

TABLE II – Parts List of 15 to 60 Watt Circuit of Figure 2

Power Watts (RMS)	15		20		25		35		50		60	
Load Impedance	4	8	4	8	4	8	4	8	4	8	4	8
V_{CC}	32 V	38 V	36 V	46 V	38 V	48 V	44 V	56 V	50 V	65 V	56 V	72 V
R5 (ohms)	620	510	560	470	560	390	470	330	390	270	330	220
R7 (ohms)	33 k	39 k	39 k	47 k	39 k	47 k	47 k	56 k	47 k	68 k	56 k	68 k
Q1	MPS A05	MPS A05	MPS A05	MPS A05	MPS A05	MPS A05	MPS A05	MPS A06	MPS A05	MPS A06	MPS A06	MPS A06
Q2	MPS A55	MPS A55	MPS A55	MPS A55	MPS A55	MPS A55	MPS A55	MPS A56	MPS A55	MPS A56	MPS A56	MPS A56
Q3	MPS U01	MPS U01	MPS U01	MPS U01	MPS U01	MPS U01	MJE 520	MPS U01	MJE 520	MJE 520	MJE 520	MJE 520
Q4	MPS A05	MPS A05	MPS A05	MPS A05	MPS A05	MPS A05	MPS A05	MPS A06	MPS A05	MPS A06	MPS A06	MPS A06
Q5	MJE 1100	MJE 1100	MJE 1100	MJE 1100	MJE 1102	MJE 1100	MJ 3000	MJ 1001	MJ 3000	MJ 3001	MJ 3001	MJ 3001
Q6	MJE 1090	MJE 1090	MJE 1090	MJE 1090	MJE 1092	MJE 1090	MJ 2500	MJ 901	MJ 2500	MJ 2501	MJ 2501	MJ 2501
Voltage rating on C1	35 V	40 V	40 V	50 V	40 V	50 V	45 V	60 V	50 V	65 V	60 V	75 V
Voltage rating on C2, C3	20 V	25 V	25 V	30 V	25 V	30 V	25 V	35 V	30 V	35 V	35 V	40 V
Voltage rating on C4	40 V	45 V	45 V	55 V	45 V	55 V	50 V	65 V	60 V	75 V	65 V	80 V
Min. heat sink for outputs @ 55°C ambient temperature and 10% high line voltage	9.5°C/W		7.0°C/W		5.0°C/W		6.0°C/W	5.5°C/W	4.0°C/W		3.0°C/W	

TABLE III – Typical Performance of Circuit in Figure 2

Idle Current (Adjusted with R_V)	20 mA
Input Impedance	50 kΩ
Nominal Input Sensitivity for Rated Power Output	1.0 Vrms
Total Harmonic Distortion at 1.0 kHz and any Power up to Full Rated Output (See Figure 3)	0.2%
Intermodulation Distortion kHz and kHz Mixed 4:1 at 1/2 Maximum Rated Output Power	0.2%
Frequency Response (-1 dB Points)	20 Hz and 50 kHz
Maximum Safe Operating Frequency at Full Rated Power – 20 Watt Amplifier:	50 kHz
60 Watt Amplifier:	30 kHz

lower distortion at low frequencies. The collector-emitter voltage of Q3 is a function of its collector current. Therefore, to eliminate cross-over distortion when a poorly regulated supply is used for V_{CC}, it is necessary to make the current source, Q4, independent of supply voltage variations. Diode D1 is used for this purpose since its forward voltage and, consequently, the voltage across R8 are relatively constant with respect to current changes in D1. Hum and noise from the power supply are filtered out by R1 and C1.

Table II lists the parts used for the 15 to 60 watt circuits. Table III and Figure 3 show typical performance of the amplifier.

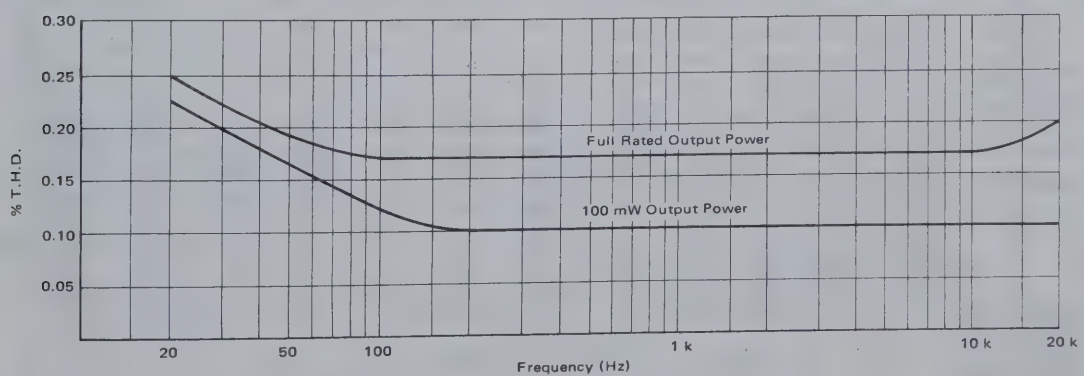


FIGURE 3 – Typical T.H.D. versus Frequency for Amplifier of Figure 2

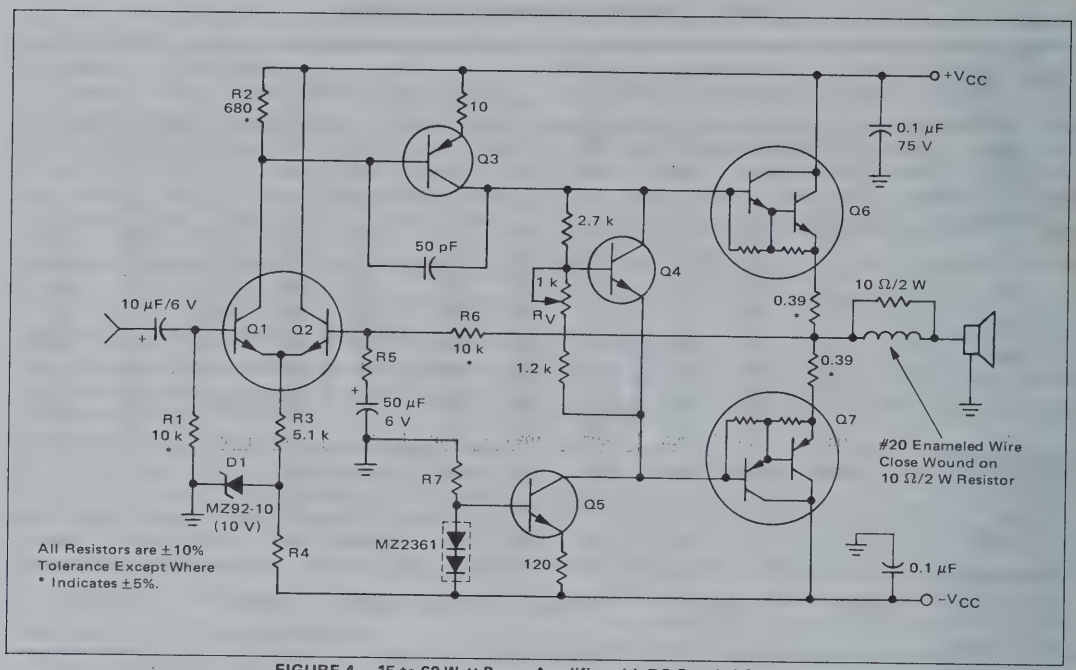


FIGURE 4 – 15 to 60 Watt Power Amplifier with DC Coupled Output

THE 15 TO 60 WATT DC-COUPLED CIRCUIT

The 15 to 60 watt dc-coupled circuit is shown in Figure 4. The output center voltage must be maintained at zero volts dc not only to ensure maximum signal swing but also to prevent dc from appearing at the speaker. The zero center voltage is obtained by using a split power supply and a differential amplifier on the input of the circuit. The signal input base of the dif-amp (Q1) is referenced to 0

TABLE IV – Parts List for 15 to 60 Watt Circuit of Figure 4

Power Watts (RMS)	15		20		25		35		50		60	
Load Impedance	4	8	4	8	4	8	4	8	4	8	4	8
V_{CC}	± 16 V	±19 V	±18 V	±23 V	±19 V	±24 V	±22 V	±28 V	±25 V	±33 V	±28 V	±36 V
R4 (ohms)	3.9 k	4.7 k	4.3 k	5.6 k	4.7 k	5.6 k	5.6 k	6.8 k	5.6 k	8.2 k	6.8 k	8.2 k
R5 (ohms)	1.2 k	820	1.0 k	750	1.0 k	680	820	560	680	470	620	430
R7 (ohms)	15 k	18 k	18 k	22 k	18 k	22 k	22 k	27 k	22 k	33 k	27 k	33 k
Q1,Q2 Dual Transistors	MD 8001	MD 8001	MD 8001	MD 8001	MD 8001	MD 8001	MD 8001	MD 8001	MD 8001	MD 8002	MD 8001	MD 8002
Q3	MPS A55	MPS A55	MPS A55	MPS A55	MPS A55	MPS A55	MPS A55	MPS A56	MPS A55	MPS A56	MPS A56	MPS A56
Q4	MPS U01	MPS U01	MPS U01	MPS U01	MPS U01	MPS U01	MJE 520	MPS U01	MJE 520	MJE 520	MJE 520	MJE 520
Q5	MPS A05	MPS A05	MPS A05	MPS A05	MPS A05	MPS A05	MPS A05	MPS A06	MPS A05	MPS A06	MPS A06	MPS A06
Q6	MJE 1100	MJE 1100	MJE 1100	MJE 1100	MJE 1102	MJE 1100	MJ 3000	MJ 1001	MJ 3000	MJ 3001	MJ 3001	MJ 3001
Q7	MJE 1090	MJE 1090	MJE 1090	MJE 1090	MJE 1092	MJE 1090	MJ 2500	MJ 901	MJ 2500	MJ 2501	MJ 2501	MJ 2501
Min. heat sink for outputs @ 55°C ambient temperature and 10% high line voltage	9.5°C/W		7.0°C/W		5.0°C/W		6.0°C/W	5.5°C/W	4.0°C/W		3.0°C/W	

TABLE V – Typical Performance of Circuit in Figure 4

Idle Current (Adjusted with R_V)	20 mA
Input Impedance	10 kΩ
Nominal Input Sensitivity for Rated Power Output	1.0 Vrms
Total Harmonic Distortion at any Frequency Between 20 Hz and 20 kHz and at any Power from 100 mW to Full Rated Output (See Figure 5)	0.15%
Intermodulation Distortion kHz and kHz Mixed 4:1 at 1/2 Maximum Rated Output Power	0.1%
Frequency Response (–1 dB Points)	10 Hz and 50 kHz
Square Wave Response	See Figure 6
Maximum Safe Operating Frequency at Full Rated Power – 20 Watt Amplifier:	50 kHz
60 Watt Amplifier:	30 kHz

volts dc thru R1. · One-hundred per cent dc feedback is accomplished thru R6 to the base of Q2. Since the amplifier is dc coupled throughout, any offset voltage that trys to appear at the output will be corrected by the differential action of Q1 and Q2. It is essential that Q1 and Q2 be matched very closely since any difference in base current and $V_{BE(on)}$ will be reflected as an error voltage on the output. Transistors Q1 and Q2 are biased at 1 mA of collector current each. A 10 V zener diode in conjunction with R3 is used to set this current. The zener diode also provides filtering to prevent hum and noise on the $-V_{CC}$ line from getting into the input stage. The value of R4 is chosen for 4 mA; 2 mA of current for the zener diode and the diff amp's 2 mA:

$$\left(R4 = \frac{-V_{CC} \ -10\ V}{4\ mA}\right)$$

The closed-loop ac gain of the amplifier is determined by:

$$A_V = \frac{R6}{R5}$$

The remainder of the circuit operation is identical to the previously described ac coupled approach of Figure 2.

The choke used on the output is to prevent high-frequency oscillations that might occur with capacitive loading.

Table IV lists the parts used for the dc-coupled amplifiers. Table V, Figure 5 and Figure 6 show the typical performance of these amplifiers.

OVERLOAD PROTECTION

A circuit for overload protection applying to all the darlington amplifiers discussed in this note, is shown in Figure 7. This circuit holds the darlington output devices within their dc safe-operating area in the event the output is accidentally shorted.

Resistors R1 and R2 form a voltage divider which senses the peak current flowing through the output transistor and R_E. This divider is set to turn Q1 and Q2 "ON" when the output current goes above the maximum normal operating level. When Q1 and Q2 conduct, they limit the

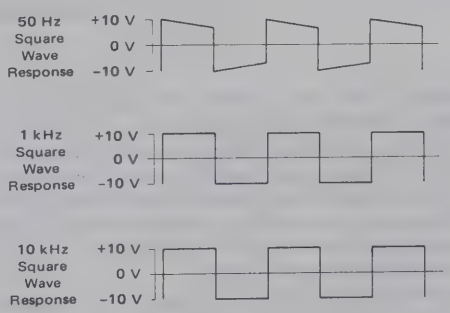


FIGURE 6 – Square Wave Response for Amplifier of Figure 4

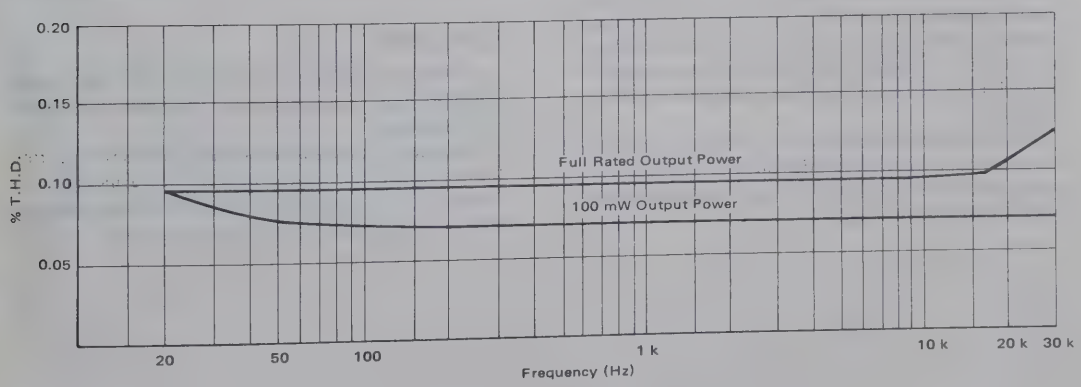


FIGURE 5 – Typical T.H.D. versus Frequency for Amplifier of Figure 4

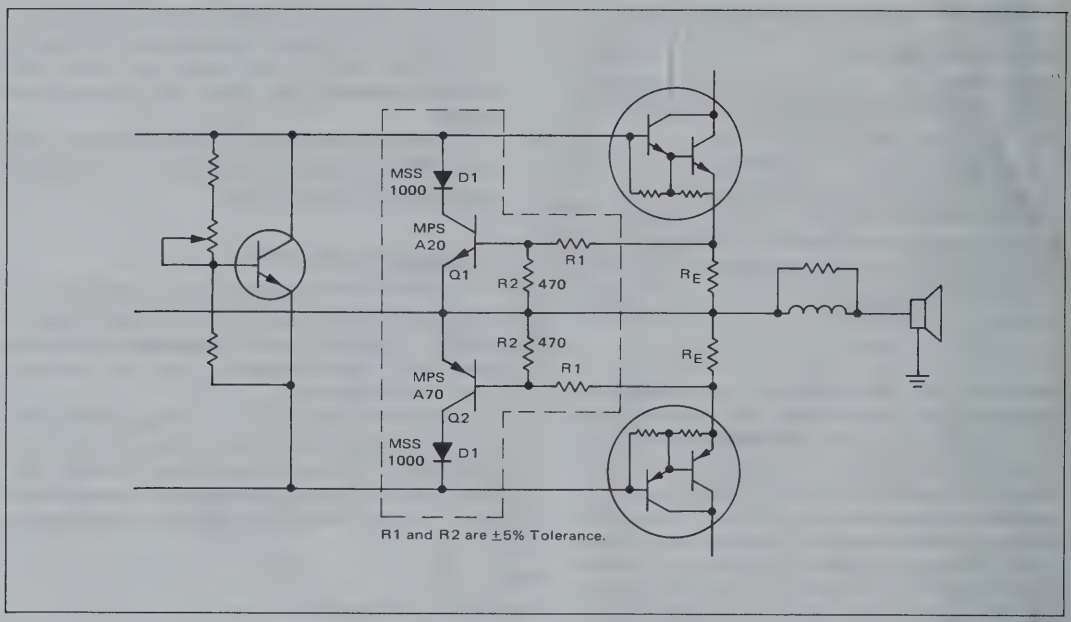


FIGURE 7 – Overload Protection Circuit for Amplifiers of Figures 1, 2 and 3

amount of drive to the base of the output and, consequently, limit the amount of output current. Transistor Q1 and its associated circuitry function for the positive half of the waveform; Q2 and its associated circuitry, for the negative half of the waveform. Diode D1 prevents the collector-base junction of Q1 and Q2 from being forward biased during normal signal conditions and creating distortion in the output waveform.

During shorted output, the average power dissipation in the output devices increases about four times over the normal operating dissipation. The length of time a shorted condition can be tolerated is strictly a function of the size and capability of the output heat sinks. When the minimum heat sinks specified in Tables I, II and IV are used, and the circuit is operated in a 25°C ambient, the output devices can drive a shorted load for a few minutes without any damage. "Load line" protection circuits can also be used with the darlington amplifiers for long term overload protection.

Table VI gives the values of R1 in Figure 7 which, in the event of an overload, provide adequate safe operating area protection on the output devices for all of the amplifiers described in this note.

TABLE VI

Power Watts (RMS)	Load Impedance (ohms)	Value of R1 (ohms)
15	4	330
	8	150
20	4	470
	8	180
25	4	510
	8	220
35	4	750
	8	390
50	4	910
	8	560
60	4	1.0 k
	8	620

CONCLUSION

This note has described 15 watt to 60 watt audio power amplifiers using silicon monolithic darlington power output transistors.

The circuits illustrate the simplification resulting from the use of these darlington devices. The achievable performance of these amplifiers is equal to that previously obtained using the best silicon discrete devices.

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